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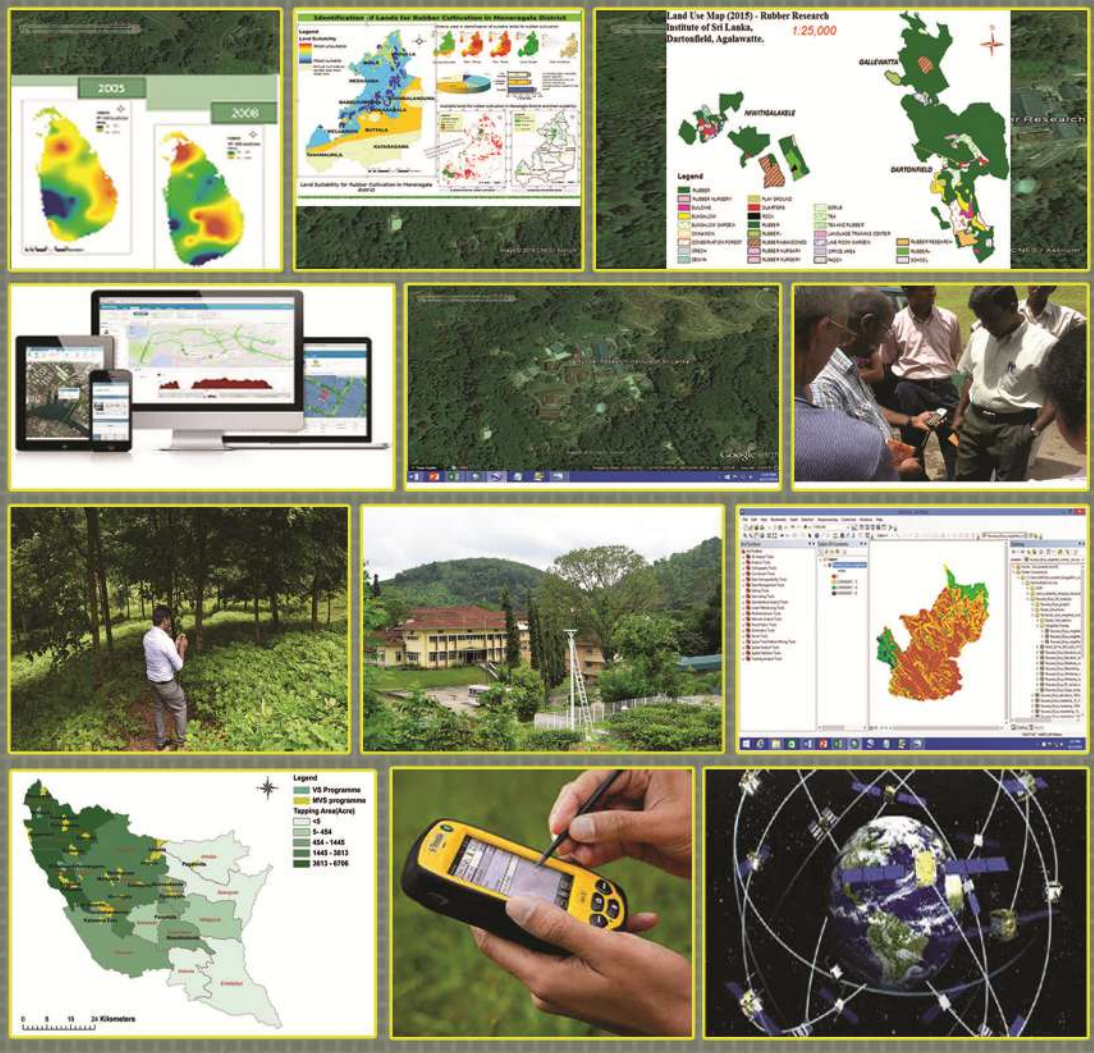
RUBBER RESEARCH INSTITUTE OF SRI LANKA



Annual Review 2015

Cover Story

GIS becomes indispensable in the rubber sector

As a technology, GIS has greatly advanced from its initial use in the 1960s by cartographers who wanted to adopt computer techniques in mapping, to a versatile toolkit today. However, application of GIS is yet to be taken up in full potential in Agriculture where there is a massive potential especially in agricultural planning. Agricultural scientists are always looking at ways to produce crops in a profitable way, manage soils while respecting the environment and protect them from diseases and pests. Further, there is an ongoing challenge to cope with the changing climate and needs of today and GIS can play a vital part in tackling these challenges.

GIS is being used in virtually all sectors of development and is helping thousands of organizations and individuals answer the “what”, “where”, or “what if” questions of their discipline. RRISL entered into GIS research very recently. The first attempt was to develop a spatial database on its own Dartonfield rubber estate. This study developed various kinds of maps based on productivity of rubber lands and their nutrient status. From this initial involvement, the interest was focused on selecting suitable lands in non-traditional rubber growing areas where the climatic conditions are not very conducive for rubber growing. This involvement developed a land suitability model for the expansion of rubber in Moneragala district, which used soil and climate and physiographic variables. Later with the focus of introducing rubber into Eastern and Northern areas, several studies were undertaken to identify suitable areas using GIS in these areas.

Potential drought hazard mapping is another area on which RRISL focuses at present. Appropriate drought indicators have been identified and they have been used in the GIS environment to produce maps to identify both temporal and spatial variabilities of droughts. It is intended to forecast drought indicators employing statistical tools to derive drought hazard maps for the future to assist the decision makers in the rubber sector.

Another area which RRISL employs GIS is for extension planning. This attempt coupled the databases on details of extension programmes carried out throughout the country with the GIS environment. The map outputs assist the extension managers to make proper decisions *viz.* where to give high priority and identifying the extension gaps to efficiently plan their routine activities.

The recent programme on mapping of rubber and tea lands in the country initiated by the Ministry of Plantation Industries with the assistance of Department of Land Use Policy Planning and Department of Survey is a positive move towards the state involvement in GIS. This programme will probably produce outputs for the researchers of RRISL to work on GIS in diverse disciplines. Further it will be an informative platform for the policy makers to arrive at appropriate decisions.

Rubber Research Institute of Sri Lanka

Annual Review – 2015

1st January 2015 to 31st December 2015

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

Head Office & Laboratories
Dartonfield
Agalawatta

Board Office & Laboratories
Telewela Road
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CONTENTS

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Ms M K D N Madampe, Treasury Representative (w.e.f. 13.03.2015)
Mr S S Poholiyadda, Director Operations, Kegalle Plantations Ltd.
Mr R C Peiris, Chief Executive Officer, Kotagala Plantation Ltd.
Mr R A D S Ranatunge, Representative of Ministry of Plantation Industries (up to 19.02.2015)
Mr D M L Bandaranayake, Ministry Representative (w.e.f. 20.02.2015)
Mr U K S Mihindukulasooriya, Ministry Representative (w.e.f. 26.11.2015)
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Mr Justin Seneviratne, Director, Lalan Rubbers (Pvt.) Ltd.
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* Mr J Y Peries (up to 20.01.2015)
Mr P B Goonawardane (from 12.02.2015 to 14.10.2015)

Ex-Officio Members

Dr W M G Seneviratne, Director, Rubber Research Institute
Mr R B Premadasa, Director General, Rubber Development Department
Mr P G Rajadurai, Chairman, Planters Association of Ceylon

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Dr W M G Seneviratne, Director, Rubber Research Institute
Dr V H L Rodrigo, Additional Director, RRI
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Mr Nissanka Seneviratne, Deputy General Manager, Eladuwa estate, Matugama
Mr Jagath Hettiarachchi, Senior Manager, Delkieth estate, Baduraliya
Mr Tony Bertus, General Manager (Rubber), Agalawatta Plantations Ltd., No.10, Gnanartha Pradeep Mawatha, Colombo 8
Mr Sanjaya Doranegama, Manager, Pallegoda estate, Dharga Town
Mr P A Lukshaman, Senior Manager - Estate, Dartonfield estate
Mr S A R Samarasekera, Manager - Estate, Kuruwita Sub-station
Mr A M Lasanthi, Accountant, RRI (In attendance)

Audit and Management Committee

Ms M K D N Madampe, Treasury Representative (w.e.f. 13.03.2015)
Dr W M G Seneviratne, Director, Rubber Research Institute
Mr R B Premadasa, Director General, Rubber Development Department
Mr R A D S Ranatunge, Representative of Ministry of Plantation Industries (up to 19.02.2015)
Mr D M L Bandaranayake, Ministry Representative of Plantation Industries (w.e.f. 20.02.2015)
Mr U K S Mihindukulasooriya, Ministry Representative of Plantation Industries (w.e.f. 26.11.2015)

In attendance

Mr K Kandage, Audit Superintendent, MPI
Ms Lasanthi Munasinghe, Accountant, RRI
Ms S Senadheera, Internal Auditor, RRB
Ms B H P Balasooriya, Acting Secretary to the Board (up to July 2015)

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Dr N M C Nayanakantha, Principal Research Officer, Plant Science Dept., RRI
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Mr T U K Silva, Research Officer, Plant Science Dept., RRI
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* Mr J Y Peries (up to 20.01.2015)
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Mr N V T A Weragoda, Chairman, Rubber Research Board (w.e.f. 15.10.2015)*
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Mr A H Kularatne, Acting Deputy Director Administration, Rubber Research Institute
Mr T B Dissanayake, Elected Committee Member
Mr R A D Ranawaka, Elected Committee Member
Mrs Lasanthi Munasinghe, Accountant, RRI (In-attendance)
* Mr J Y Peries (up to 20.01.2015)
Mr P B Goonawardane (from 12.02.2015 to 14.10.2015)

Chairman's Office & Board Secretariat

Chairman	- Mr N V T A Weragoda (w.e.f. 15.10.2015)*
	* Mr J Y Peries (up to 20.01.2015)
	Mr P B Goonawardane (from 12.02.2015 to 14.10.2015)

Acting Secretary to the Board (Personal Assistant to the Chairman)	- Mrs B H P Balasooriya (up to July 2015)
Acting DDA & Secretary, RRB	- Mr A H Kularatne (w.e.f. 19.06.2015)
Management Assistants	- S A T Senaratne - K V D H S Kalutharawithana, BSc (SL) - Mrs K Y G M P Kumari, BA (SL),

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RUBBER RESEARCH INSTITUTE OF SRI LANKA

STAFF

DIRECTORATE

Director	W M G Seneviratne, BSc (SL), PhD (Essex)
Additional Director	V H L Rodrigo, BSc Agric (SL), MSc (Essex) PhD (Wales)
Deputy Director – Research (Bio.)	G P W P P Seneviratne, BSc (SL), PhD (Bath)
Deputy Director – Research (Tech.)	S Siriwardene, BSc (SL), MSc (Australia) PhD (Malaysia)
Acting Deputy Director (Administration)	A H Kularatne, BSc (SL), MSc (Reading), MSc (SL) (from 19.06.2015)

RESEARCH DEPARTMENTS

Genetics and Plant Breeding	*(at Nivithigalakele Substation, Matugama)*
Head of Department	Mrs S P Withanage, BSc Agric (SL), MSc (India), PhD (Malaysia) (w.e.f. 20.03.2015)
Senior Research Officers	*K K Liyanage, BSc Agric (SL) MPhil (SL)
	P K S G Senarath Bandara, BSc (SL), PhD (Japan)
Research Officer	Miss P V A Anushka, BSc Agric (SL)
Experimental Officers	I D M J Sarath Kumara
	L S Kariyawasam
	T B Dissanayake
	T M S K Gunasekera
	H P Peries, Dip. Agric (Kundasale)
	Mrs A K Gamage, BSc (SL)
Technical Officers (Research & Development)	B W A N Baddewithana, BSc Agric. (SL)
	Miss W D A R Tharanga, BSc (SL) (w.e.f. 24.04.2015)
Management Assistants (Clerical)	Mrs S D P K L Peiris
	Miss K D Piyumi Hasara
Plant Science	*(at Dartonfield, Agalawatta)*
Head of Department	A M W K Senevirathna, BSc (SL), MSc (SL), PhD (Wales) (from 20.03.2015 to 31.12.2015)
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Research Officers	Mrs D S A Nakandala, BSc Agric (SL)
	K A G B Amaratunga (up to 03.09.2015)
	T U K Silva, BSc Agric (SL), MPhil (SL)
Experimental Officers	Mrs G A S Wijesekera
	Mrs R K Samarasekera
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	P D Pathirana, BSc (SL)
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	Miss N C Jayawanthi, BSc (SL) (from 24.04.2015)
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	Nihal Gamage, Dip. Agric. (Angunakolapelessa)
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	G D N Seneviratne
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	Miss E A K E Edirisinghe, BSc (SL) (w.e.f. 24.04.2015)
	M T D C Perera, BSc (SL) (w.e.f. 24.04.2015)
Management Assistant (Clerical)	M A W K Tillekeratne

Raw Rubber and Chemical Analysis	*(at Telewela Road, Ratmalana)*
Research Officers	Mrs A P Attanayake, BSc (SL)
	Mrs I H K Samarasinghe, BSc (SL)
Experimental Officers	Mrs L Wanigatunga
	Mrs H V K Gamage
	Mrs C S Lokuge
	Miss D M S Wijesekera, Dip. Rubber Tech. (PRI)
	L P P Vitharana
Technical Officers (Research & Development)	Miss S P Wijewardena, BSc (SL)
	Miss W M I Nuwangi, Dip. in Chem. (up to 27.10.2015)

Technical Officers (Research & Development)	Miss A C C Jayasinghe, BSc (SL) (from 24.04.2014 - 02.12.2015)
	Miss J A Jayamuthu, BSc (w.e.f. 13.05.2015)
Management Assistants (Clerical)	Miss W D D Samanmali
	G N K Gunasena

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

Head of Department	Mrs D G Edirisinghe, BSc (SL), MSc (SL) MPhil (UK), PhD (SL) (w.e.f. 20.03.2015)
Senior Research Officers	*Mrs G D D Seneviratne, BSc (SL), MSc (Malaysia)
Research Officer	W D M Sampath, BSc (SL)
Experimental Officers	Mrs M K Mahanama, Dip. Rubber Tech. (PRI)
	Mrs S I Yapa, Dip. Rubber Tech. (PRI)
	Mrs P C Wettasinghe, Dip. in Science
	S L G Ranjith, Dip. Rubber Tech. (PRI), BSc (SL)
	P L Perera
	Mrs G M Priyanthi Perera, BSc (SL), MSc (SL)
Technical Officers (Research & Development)	V G M J Abeywardena, NDT
	Miss S G P Bhagayawedha, NDT
	K I D P Perera, BSc (SL) (w.e.f. 27.05.2015)
Management Assistant (Clerical)	Miss S M D S R de A Wijeratne

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

Head of Department	R M U N Ratnayake, BSc (SL), PhD (Loughborugh) (w.e.f. 20.03.2015)
Experimental Officers	Mrs W K C Nalinie, Dip. Rubber Tech. (PRI)
	Mrs U M S Priyanka, BSc (SL), MSc (SL)
	Mrs V C Rohanadeepa
	A K D W Prasad
Technical Officer (Research & Development)	Miss K G P M Dharmatilleke, BSc (SL)
	A S Ghouse, Graduate Chemist (w.e.f. 24.04.2015)
	Miss B P Kannangara, BSc (SL) (w.e.f. 24.04.2015)
	B D J H Perera, BSc (SL) (w.e.f. 24.04.2015)
	Dinesh Balasooriya, BSc (SL) (w.e.f. 24.04.2015)
Management Assistants (Clerical)	Miss H A Janani Lakshika, BA (SL)
	Mrs U K Akila Tharinduni, BSc (SL)
	Miss A R M de Alwis
	Mrs K K Geetha BA (SL)
	Miss P D S Dilhani

Biometry Section	*(at Dartonfield, Agalawatta)*
Principal Research Officer	Mrs B W Wijesuriya, BSc Agric (SL), MPhil (SL), PhD (SL)
Experimental Officers	Mrs H K D C S Munasinghe, NCT Polymer (Moratuwa), Dip. Rubber Tech. (PRI), Dip. Computer Science (IDM)
	O V Abeyawardene, Dip. Agric. (Kundasale)
Adaptive Research Unit	*(at Dartonfield, Agalawatta)*
Principal Research Officer	S M M Iqbal, BSc Agric. (SL), MPhil (SL) PhD (Essex)
Senior Research Officer	Mrs E S Munasinghe, BSc Agric (SL), PhD (SL)
Research Officer	Mrs B M D C Balasooriya, BSc Agric (SL)
Technical Officer (Research & Development)	P M M Jayatilleke, NDT (Agric.)
	T B K H Neranajan, HND (Agric.) (up to 31.10.2015)
Management Assistants (Clerical)	Mrs M A Randima Srimalee
Agricultural Economics Unit	*(at Dartonfield, Agalawatta)*
Research Officer	J K S Sankalpa, BSc (SL), MSc (SL)
Management Assistants (Clerical)	Miss W W L S Shashikala, BA (SL)
Library and Publications Unit	*(at Dartonfield, Agalawatta)*
Librarian	S U Amarasinghe, BSc (SL), MA (SL), ASLLA
Library Assistant & Assistant Publications Officer	Mrs R M Amaratunga, Intermediate; Lib. Sci. Doc. & Info. (SLLA)
Management Assistants (Clerical)	P M P Jayantha
	N W E C Maduranga
Administration Department	*(at Dartonfield, Agalawatta)*
Administrative Officers	L P K W Weliwatta, BA (SL), Dip. in HRM
	Mrs P Mandalawatta, (Dip. in HRM)
Management Assistants (Clerical)	Mrs P W Neelamanie
	Mrs S K Handunge (up to 26.10.2015)
	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
	Miss H N Kanchana
	Mrs B Chandralatha, BA (SL)

Management Assistants (Clerical)	Mrs W V A S Ariyawansha (up to 30.12.2015)
	Miss M G L Niroshani
Management Assistant (Stenography)	Mrs J A H S Kumarie
Translator	Mrs D N Senevirathna, Dip. Agric. (Kundasale), BSc (SL)
Telephone Operator	Mrs J A D C Preethika

Medical Center

Assistant Medical Practitioner	M Subasinghe
Pharmacist	S Lankeshwara

Administration Unit (Ratmalana) *(at Telewela Road, Ratmalana)*

Management Assistant (Clerical)	D P N P Dissanayke

Internal Audit Unit *(at Dartonfield, Agalawatta)*

Internal Auditor	Mrs M S I Senadeera, AFA, IIPF, IRCA, LICA
Internal Audit Officer	K C Fernando
Management Assistants (Clerical)	Mrs S N Munasinghe
	R G A S Dharmaratne
	Udaya Samantha Munindradasa, BA (SL)

Works Section *(at Dartonfield, Agalawatta)*

Technological Officer (Civil)	M A D K Jayasumana, NCT
Transport Officer	U L D R L Gunasinghe
Technological Officer (Mech.)	H J P Fernando, HNDE
Management Assistants (Clerical)	Mrs K C S Wickremasinghe
	Mrs J A S Dharshanie (Dip. in Management)
	Mrs K K D K P Ranaweera
	Mrs M S W H Kumari, BSc (SL)
Work Supervisor (Electrical)	T M R P Tennakoon

Accounts Section *(at Dartonfield, Agalawatta)*

Accountant	Mrs A M Lasanthi, BSc (SL)
Accounting Assistant	D D R Lankatilaka, BCom (SL)
Management Assistants (Accounting)	Mrs Irene Perera
	Mrs M Gunawardene
	Mrs R Handungoda
	Mrs G P Kukulewithana
Management Assistants (Clerical)	A V Nandasena
	Mrs K J M C R Fernando
	Mrs C Dissanayake
	A K D A Wickremasinghe

Management Assistants (Clerical)	Mrs S I K Pathirage
	Miss K T D Jayawathi
	Mrs S A Niluka Harshani
	Mrs K K D Y L Ranaweera
	Miss K K T L Jayasekera
	J A J R Lakmal, BA (SL)
	Miss R P Thilini
	Mrs M N D Perera
	K A Dilan Sampath
	Mrs Erandi Kanchana Jayasinghe, BA (SL)
	Miss S R Sinhabahu
Cashier	Mrs G A D D Jayawardena

DARTONFIELD GROUP

Senior Manager - Estate	P A Lakshman, BSc (SL)
Experimental Officer	S S Warnapura (up to 31.03.2015)
Management Assistants	K K P Gunawardena
	H D D Achinda
	M A N Sachith Pawinda
	T D Harsha
Field Officer (Nivitigalakele)	B M Siriwardena
Field Officer (Gallewatta)	A B Nakandala (up to 29.06.2015)
Kuruwita Sub-Station	*(at Kuruwita)*
Manager	S A R Samarasekera
Management Assistants (Clerical)	D S Jayasinghe
	K D P Senaratne
Polgahawela Sub-Station	*(at Narampola Estate, Nungamuwa, Yatigaloluwa)*
Management Assistant (Accounting)	Mrs W A C Weeramanthree
Moneragala Sub-Station	*(at Kumbukkana, Monaragala)*
Research Officer	H D S P Perera, BSc (SL), MSc (SL) (up to 24.11.2015)
Field Officers	V G D Nishantha Gunaseela
	N V U S Vijitha Kumara
Management Assistant (Clerical)	Mrs D M P Sandun Kumari
	M M Chamath Kumara

* On study leave overseas

Awards

Dr (Mrs) D G Edirisinghe, Head of the Rubber Technology and Development Department, RRISL received the Merit Award from the Plastics and Rubber Institute of Sri Lanka for the significant contribution made towards the development and growth of the polymer industry of Sri Lanka.

Research work conducted for developing low frequency harvesting systems to address the tapper shortage, high bark consumption rate and to reduce cost of production in the rubber industry in Sri Lanka by Dr (Mrs) K V V S Kudaligama leading to her PhD degree has won the GRC Postgraduate award 2015 awarded by the Sri Lanka Association for Advancement of Science.

Dr N M C Nayanakantha, Principal Research Officer attached to the Plant Science Department of RRISL, received the Award for the "Best Oral Presenter" for his paper entitled "Differential expression of defense-related genes in *Sinapis alba* and *Brassica juncea* upon the infection of *Alternaria brassicae"* under the category of "Biotechnology" at the Twenty Seventh Annual Congress of Postgraduate Institute of Agriculture (PGIA), Peradeniya, held from 19th to 20th November 2015 at Plant Genetic Resources Centre (PGRC), Gannoruwa.

Dr N M C Nayanakantha also received a Merit Certificate for his paper entitled "Identification of differentially expressed genes in *Brassica juncea* and *Camelina sativa* upon challenge inoculation with *Alternaria brassicae"* under the category of Biotechnology, Molecular Biology and Microbiology at 4th Young Scientists Forum Symposium held on 23rd January 2015, at Hector Kobbekaduwa Agrarian Research and Training Institute (HARTI), Colombo.

RUBBER RESEARCH INSTITUTE OF SRI LANKA

DIRECTOR'S REVIEW

W M G Seneviratne

This review consists of Research and Development activities conducted by six Agronomy departments and four units at Head Office, Dartonfield, Agalawatta and four Technology departments at Ratmalana along with the progress reviews of Library and Publication unit, the two estates Dartonfield Group and Kuruwita and the two substations at Moneragala and Polgahawela.

Details of Research and Development activities of each Department/Unit are given under each department and summaries of each department and overview of the local and global rubber industry is given here.

Rubber industry of Sri Lanka

Rubber production

The natural rubber production in the country in 2015 has decreased further by 10% from the previous year from 98,573 tonnes to 88,600 tonnes. Poor rubber prices prevailed in the market and continuous decline of rubber price since year 2011 would have resulted in reduction of tapping days, and thus low production.

Two largest contributors to the total rubber production in the country, RSS and Crepe rubber reduced further from 48,500 tonnes to 44,400 tonnes, a reduction of 8.5% and from 15,200 tonnes to 11,100 tonnes which accounted for a reduction of a 27%, respectively. Concentrated latex production in the country was estimated to be 25,500 tonnes in the year 2015. Average price of RSS1 was around Rs.285.76 per kg at the end of 2014 reduced further to Rs.248.55 per kg at the end of 2015, which is a 13% decrease. Latex Crepe 1X price dropped by 3% from Rs.309.90 in 2014 to Rs.301.15 in 2015 (Source: RDD, Sri Lanka).

Rubber extent

Total rubber extent in the country at the end of 2015 was around 134.8 thousand hectares against 134 thousand hectares at the end of 2014 while the tapping area was around 119 thousand hectares. The increase in rubber extent was due to the extent of new planting which accounted for 800 ha and replanting of 1000 ha of lands.

NR consumption, exports and imports

NR consumption in the country in 2015 reduced to 73,200 tonnes from 85,600 tonnes in 2014. Sri Lanka has exported around 15,800 tonnes of natural raw rubber in 2015 which was a decline of 44% against the year 2014.

Rubber manufacturing sector

Earnings through raw rubber exports was Rs.3,548 million in year 2015 against the Rs.5,915 million in year 2014. The total CESS collection from the rubber sector was Rs.2,355 million in 2015, an increase of about 6% against the previous year. Export earnings from finished products was recorded as Rs. billion 102 in 2015 (Sri Lanka Customs), a decrease of about 9% against the previous year. This was mainly due to unexpected economic slump faced by most of the major consumers in the world.

Global rubber industry review

Natural rubber supply

Total world NR production increased to 12,267 thousand tonnes in 2015 against the year 2014 NR production which was around 12,111 thousand tonnes. World NR production has increased by 1.3% according to IRSG statistics. Nevertheless, the provisional data received from the member countries of ANRPC indicated a drop of 0.6% year-on-year. This is mainly due to the impact of El Nino condition on the rubber growing areas in the Asia Pacific region. Table 1 gives the annual natural rubber production of major producers in the world and their year-on year growth against the previous year.

Table 1. *Trends in NR supply in major producing countries*

	Quantity (000 tonnes)		Annual growth (%)
	2014	**2015**	
Thailand	4,324.0	4,473.4	3.5
Indonesia	3,153.2	3,175.4	0.7
Malaysia	668.1	695.4	4.1
India	704.5	575.0	-18.4
Vietnam	953.7	1,017.0	6.6
China	840.1	794.0	-5.5
Cote d Ivoire	317.3	337.6	6.4
Brazil	193.3	194.4	0.6
Sri Lanka	98.7	91.3	-7.5
Myanmar	198.0	227.5	14.9
Philippine	113.2	111.1	-1.9
Guatemala	96.4	90.7	-5.9
Cambodia	97.1	126.8	30.6
Liberia	59.9	60.0	0.2
Others	293.5	297.2	1.3
World total	12,111.0	12,266.8	1.3

(Source: IRSG, 2016)

Table 2 gives the annual average yield and mature area in the ANRPC group in years 2014 and 2015. While the average yield declines, the mature area expands in all the countries during 2015. The expansion in mature area reflects the large scale planting undertaken during the period from year 2005 to 2012. Average annual yield figures reflect the achievements made by producing countries in clone improvements, crop management and adoption of harvesting technologies have not been translated into improvement in average yield. The sharp fall in rubber prices especially during the year 2015 has aggravated the yield performance further.

Table 2. *The annual average yield per hectare in ANRPC member countries and extents under tapping*

Country	Total area ('000 ha)		Tapped area ('000ha)		Yield (kg/ha/year)	
	2014	**2015**	**2014**	**2015**	**2014**	**2015**
Cambodia	357.8	388.9	90.5	111.2	1072	1140
China	1161	1159	695	711	1209	1117
India	795	811	447	391	1576	1513
Indonesia	3606	3621	2995	3016	1053	1058
Malaysia	1065.6	1078.6	600	650	1370	1410
Philippines	217.7	-	120.2	-	942	_
Sri Lanka	134.1	134.8	110.9	119	889	744
Thailand	2816.6	_	2775	_	1566	_
Vietnam	981	972	563.6	600	1692	1695

(ANRPC, 2016)

Total rubber demand

Total rubber consumption was 26,779 thousand tonnes in 2015 compared to 26,404 thousand tonnes, in the previous year. This increase accounted for an increase of 1.4% year-on-year growth. World NR consumption is being dominated by China with 4820 thousand tonnes followed by India with 991.6 thousand tonnes and USA with 936.5 thousand tonnes. China was the highest SR consumer in 2015 followed by USA and European Union countries. China consumed 4,067.2 thousand tonnes of SR and USA consumed 1,963.3 thousand tonnes in 2015 (IRSG, 2016).

Natural Rubber demand

Apart from economy's dominant role, the demand for NR is greatly influenced by geographical shifting of manufacturing base, capacity expansion in auto tyre industry, substitution between natural and synthetic rubber and change in consumption basket. Table 3 shows the trends in NR consumption and their annual growth of demand for major consumers in the world.

Table 3. *Trends in NR demand by major consumers*

	Consumption ('000 tonnes)			Annual growth (%)	
	2013	**2014**	**2015**	**2014**	**2015**
China	4,210	4,760	4,820	7.1	1.3
Total EU-28	1,060	1,139	1,174	5.5	3
India	962	1,012	991	5.3	-2
U.S.A.	913	932	936	2.1	0.4
Japan	710	709	721	-0.1	1.7
Thailand	521	541	606	3.3	0.1
Indonesia	509	540	568	3.3	5.1
Malaysia	434	447	475	3.0	6.2
Other countries	2,067	2,054	2,057	-1	0.1
World	11,386	12,134	12,348	4.1	1.8

(Source: IRSG, 2016)

China consumed 39% of the total consumption of natural rubber globally during 2015. Other major consuming countries or regions are the European Union (9.5%), India (8%), the US (7.6%), Japan (5.8%), Indonesia (4.6%), Thailand (4.9%) and Malaysia (3.8%). In all these countries, the annual growth rate of demand for NR has increased except for India. The unsatisfactory performance reflected through continued growth deceleration in emerging and developing economies is seen including China.

NR demand and supply gap

Global demand experienced a growth of 1.8% in 2015 while the supply has headed for a 1.3% increase. The resultant demand supply position for 2015 is shown in Table 4 in comparison with the previous two years. Global market at the end of year 2015 was in a deficit of 81,000 tonnes.

Table 4. *Outlook for the demand supply gap*

	Quantity ('000 tonnes)			Annual Growth (%)	
	2013	**2014**	**2015**	**2014**	**2015**
Production	12,281	12,111	12,267	-1.4	1.3
Consumption	11,430	12,134	12,348	6.2	1.8
Gap	851 Surplus	-23 Deficit	-81 Deficit		

(Source: IRSG, 2016)

World NR price movement

Natural rubber prices follow a decline in world market over the last two years. Sri Lankan annual average RSS3 price was US$ 1.78 per kg in year 2015. At the end of year 2015, the average price of RSS3 dropped to US$ 1.59 in Bangkok, well below the sustainable level of US$ 2.00 per kg. SMR20 also declined to US$ 1.37 and latex 60% to US$ 1.08 per kg in Kuala Lumpur. By the end of the year, average Indian RSS4 has decreased to US$1.91 from US$ 2.24 per kg against the previous year. It was a drastic fall of about 15% in the Kottayam market. According to many Economic Experts, China's economic slowdown, weak downstream demand and the slow pace of economic recovery in Europe with their consequent impacts on the automobile and tyre markets are adding to the dampening sentiments of the NR market. Demand for natural rubber continues its declining state with no obvious signs of improvement with prices, which are also falling accordingly.

Research and development activities

Genetics and Plant Breeding

To develop new genotypes to the breeding pool the annual hand pollination programme was carried out and seventy new genotypes were raised. Following long evaluation process of previously developed genotypes, twenty HP entries from 1997 hand pollinated progeny were selected after evaluating around fifteen years under small scale level. Ten new genotypes selected from 1995 hybridization programme where non Wickham clone GPS I was used as a male parent, showed good genetic diversity and performed well.

To evaluate suitability of new promising clones for sub optimal conditions, thirteen new smallholder trials at Uva, Central North Western and North Central provinces were established. Around 1400 non Wickham accessions were multiplied and established at Nivitigalakele Sub station. Few accessions which showed good performances were taken to large scale evaluation.

Plant Science

Seed production survey revealed a satisfactory seed production from some newer clones. Seeds treated with nitric oxide (NO) donor sodium nitroprusside (SNP) improved germination dynamics. Seedlings irrigated with sprinkler system followed by drip system showed improved growth characteristics. An experimental trial was commenced at Vishwamadu and Akkarayankulam in Kilinochchi district to study the growth performance of rubber clones. The highest yield per hectare (YPH) was recorded in the highest density (800 trees/ha). Mango, guava and pomegranate showed a rapid growth than rambutan when intercropped with rubber. An intercropping trial of Rubber with Agarwood was established at Dartonfield Estate of RRISL. All nurseries were inspected for quality assurance and reports were submitted.

Plant Pathology and Microbiology

Department of Plant Pathology & Microbiology reported a mild to moderate incidence of secondary leaf fall disease in Sri Lanka except for a few sites. Application of sulphur was successfully carried out. The incidence of abnormal leaf fall was also reported to be mild. Corynespora leaf fall disease was reported on the field plants of RRIC 121 during the year 2015 for the second time. The screening of clones against CLFD revealed that the clone Centennial 3 is susceptible. A series of experiments on the biology of White Root Disease was completed. Projects on the new application technology; tree injection, were also in progress. Several alternative plant types which can tolerate white root disease have been identified to be used in Fomes patches. Brown root disease was becoming significant in the non-traditional rubber growing areas and studies for the biology of the disease were continued. Adhesive properties of the repellant were improved. Three alternative chemicals for mancozeb are tested for the management of Patch canker. Four new chemicals are being tested against cockchafer grub attack under field conditions. Studies were continued to isolate and identify the beneficial soil micro-flora from the main rubber growing areas and also from non-traditional rubber growing areas. Evaluation of native antagonistic fungi: *Trichoderma, Penicillium* and *Aspergilllus* as bio control agents for White Root Disease was undertaken. Compost based medium was formulated to produce *Trichoderma* inoculum.

Soils and Plant Nutrition

Ten research and development programmes in relation to improvement of soil fertility, increasing fertilizer use efficiency, soil, water and nutrient conservation and weed control were planned, promoted, implemented and monitored. The biofim solubilized significantly high amount of phosphorus in liquid medium containing CaHPO4 compared to their alone cultures and was observed synergistic effect for Acetylene reduction assay (ARA). Production of IAA of biofilm was higher than that of bacteria alone cultures and synergistic effect was observed for Acetylene reduction assay (ARA). Production of biofilm formation was higher than that of bacteria alone cultures. Thus the biofilm formation of rhizosphere microbes seems to be very important for improved soil fertility. The field experiment results seems to suggest that it may have a possibility of improving soil fertility and plant growth of immature *Hevea* by combined use of biofilm biofertilizers (BFBF) with inorganic fertilizers. Studies on weed control suggested that combination of new weedicide Gluphosinate ammonium with Diuron was more effective than their alone applications. Application of slow release fertilizers gave comparable growth assessments compared to conventional fertilizer application for rubber nursery plants dealing with a number of management problems associated with repeated application.

Site specific fertilizer recommendation programme provided 30 fertilizer recommendation reports for 2215 ha of mature rubber. Six land suitability reports

were issued for 300 ha under land selection programme. The department analyzed approximately 1000 samples (7500 parameters) for outside organizations including 80 fertilizer samples for rubber growers to assure application of good quality fertilizers to their rubber lands.

Biochemistry and Physiology

A new tapping field from Galewatta division of Dartonfield estate was selected to investigate the adaptability of S/2 d4 and S/4 d3 systems at commercial scale. In addition, a weekend harvesting system was also being tested commercially to cater to the needs of smallholder sector in Sri Lanka. Experimental fields with five different genotypes *i.e.* RRIC 100, RRIC 121, RRISL 203, RRISL 2001 and PB 260 were established at Dartonfield, Pasyala, Vauniya, and Kandakaduwa to investigate the sustainability of different genotypes in different agro climates.

Investigations on different commercial ethephon mixtures on latex physiology and yield of trees harvested with different harvesting systems have been continued. Identification of physical properties and biochemical composition of rubber wood of different genotypes were in progress to promote rubber wood as an alternative to forest timber.

Postgraduate research work conducted by Dr (Mrs) K V V S Kudaligama leading to her PhD degree has won the GRC Postgraduate award 2015 awarded by the Sri Lanka Association of Advancement of Science.

Advisory Services

Nineteen Group extension programmes called "*Vihidum Sathkara*" were effectively conducted providing advisory and extension services for 931 rubber smallholdings. Seventy two medium scale rubber lands were inspected and the owners were given necessary advice for improvements needed, under this programme. In total, 5019 advisory visits were carried out to solve problems in technology adoption in the rubber smallholder sector.

Two thousand three hundred and one rubber smallholdings were inspected in the Monaragala district by REOs and necessary advice were given for improvements under the Smallholders Plantation Entrepreneurship Development Programme (SPEnDP). Under this 60 awareness programmes were also conducted for the benefit of 2,346 rubber farmers in Monaragala district. Special awareness programmes were conducted in Ampara and Baticoloa districts (Nuwaragalatenna, Warapitiya and Mangalagama) for the benefit of new rubber cultivators.

The extension strategy focused on farmer participatory development of selected rubber units in each REO divisions was continued with the upgrading of 249 rubber lands as model rubber holdings. Status of 245 immature substandard rubber holdings and 233 mature substandard rubber holdings were rehabilitated successfully. Sixty four rubber processing centers were developed as models and construction of 33

new RSS processing centers and rehabilitation of 21 substandard centers were attended. As a solution to the tapper shortage, 317 new harvesting assistants were introduced through 18 Tapping Training Schools (TTS) and 734 semi skilled harvesting assistants were trained on tapping quality improvement in 55 skills development programmes.

Forty four farmer training programmes were conducted to educate 1054 rubber growers on general cultivation and processing aspects of rubber. Data collection and GIS based mapping was carried out in relation to all field training and advisory programmes for effective planning of extension programmes.

Rubber Technology and Development

Properties such as micro-organism growth in the low ammonia centrifuged latex prepared with a readily available, non-toxic, low cost chemical was evaluated. Also, ageing resistance, protein content and release of nitrosamines from cast films produced with this newly developed latex were assessed and all these properties were in accordance with the requirements for infant items and toys. Cast films were produced with compounded natural rubber latex containing citronella oil, with the aim of manufacturing rubberized-coir based fenders to protect immature plants against animal attack and properties of the films were tested. NR latex foam with antioxidant as well as antimicrobial effects was produced successfully at laboratory scale as well as factory scale using aloe-vera.

Calcium carbonate filled NR/LDPE/waste PE composites were produced using a titanate coupling agent and a peroxide. Pyrogenic carbon filled 80:20 NR/SBR composites suitable for tyre treads were developed. NR/SBR composites were prepared with Palmyra fibers coated with different latices or chemical substances and physico-mechanical properties were evaluated. Compounded nitrile rubber (NBR) latex waste based reclaimed rubber was produced mechano-chemically using an amino based chemical with the aim of partially replacing virgin NBR with modified waste in oil seal compounds. Carbon black as well as calcium carbonate filled NR/LDPE/recycled PE composites were produced and properties were evaluated. A paving material was developed with ground rubber tyre (GRT) and bitumen. Experiments were conducted to develop NR based solid tyre compounds with coconut shell powder at the request of a coir processing company.

NR/EPDM stopper band compound, required for an agricultural purpose was developed. Trials were conducted to produce low resilient and high abrasion resistant rubber balls for cricket practicing purpose. Initial trials on the development of a NR based all-purpose basket were conducted. Work on development of NR latex based moulds suitable to produce herbal soap pieces was initiated. A NR latex compound was developed using a combination of non-toxic fungicides to eliminate mould growth in infant items.

Twenty six training programs/workshops on rubber based products manufacture were conducted. Also, the staff was actively involved in transferring the technology of rubber based products manufacture to SME's via five "Krushi FM" live, web radio programs. Further, the staff was involved in transferring knowledge on rubber based products manufacture to the public at five exhibitions and to postgraduate students by conducting practical classes. Two hundred and thirty eight tests on dry rubber compounds and 166 tests on products were conducted. Two hundred and seven crepe rubber samples were also tested for hardness.

Polymer Chemistry

A tire paint was developed for inner heal of the solid tyre using synthetic resins and natural rubber. Several thermal and mechanical properties were achieved such as heat resistance, crack resistance and high peel strength to tolerate pressure developed during rim mounting process. Technology was transferred to the industry and a patent was applied for this new product. Introduction of plant based preservative system to eliminate TMTD from latex preservation was continued. New screen printing inks were developed for Natural rubber and Nitrile rubber surfaces. Industrial trails with newly developed inks are progressing. More than one thousand samples of polymer materials and compounding ingredients were tested to analyze of their constituents using FTIR. Analysis of thermal properties of polymers using DSC and material properties using DMA was carried out throughout the year. One workshop on manufacture of natural and synthetic rubber based adhesives was conducted for 15 numbers of SME's in collaboration with Industrial Development Board.

Raw Rubber and Chemical Analysis

The department mainly offers testing, analyses and certification services of raw natural rubber and rubber chemicals to all sectors of the rubber industry including raw rubber process industries. These services are also extended to rubber traders, researchers of other departments of the institute and various local institutions such as Universities, other research institutes as well as individuals including postgraduate students, consultants and inventors. One thousand one hundred and eighteen samples of natural rubber latex, dry rubber, rubber processing chemicals and polythene samples were tested for their quality during the year under review. Forty raw rubber analysis certificates for Technically Specified Rubber (TSR) were also issued on requests received from the respective parties for their quality assessment and marketing purposes. In addition, the department carried out miscellaneous analytical tests, trouble shooting activities and four research projects during the year. The department staff continued to provide training on raw rubber and natural rubber latex testing for laboratory personnel, industrialists, research students and university undergraduates.

Raw Rubber Process Development and Chemical Engineering

Construction of pilot scale Ultra fast dryer developed for drying different types of rubber with the financial assistance from National Science Foundation (NSF) was completed. Trials carried out showed that drying time of crepe rubber, skim rubber and brown crepe could be reduced by approximately 33%, 80% and 60% against the conventional drying periods respectively.

Development of rubber compound suitable for High Performance Lighter Weight Prosthetic Foot based on Hybrid Nanomaterial Filled Natural Rubber Nanocomposite was completed with financial assistance from the NSF and in collaboration with Ranaviru Sevena Army Rehabilitation Center. The performance of the foot was tested and the results have indicated high customer satisfaction.

Natural rubber compound containing functionalized filler derived from modification of NR latex sludge which is generated as a by-product form latex centrifuging process was developed. A novel rubber nanocomposite based on hybrid filler (nanomaterials) with enhanced properties was developed for the use of value added rubber product manufacture. Studies on value addition to different raw rubbers through nanotechnology applications were carried out. A nanotechnology enabled raw rubber with improved/unique properties for different applications was developed.

The staff of the department continued to provide trouble shooting, routine technical assistance, analytical services and training to large scale raw rubber producers, small and medium scale sheet rubber producers and various government institutions and non-government organizations.

Adaptive Research Unit

A study was conducted in Padiyathalawa area to assess the microclimatic conditions in a mature rubber field with compared to natural forest and chena cultivated land. In the Eastern province a study was conducted to assess the benefits of anti-transpirant application in sustaining leaf physiology of rubber plants under dry climatic condition. Annual girth increment rate of 8.0 cm was achieved in adaptive research plots established in the Northern Province.

Biometry

Biometry section conducts research and development activities based on three aspects; *viz.* statistical methods, research support and meteorology and climatology. On statistical methods, the Biometry section was involved in research, focusing on Biometrical aspects especially on development, modification and application of statistical methodologies to suit the needs of the rubber sector. The research studies carried on climatology were mainly focused on drought analysis and rainfall anomalies. During the year under review, research support provided to other departments included data analysis, 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, Polgahawela and Kuruwita were updated and provided the data for scientific purposes on request.

Agricultural Economics Unit

Agricultural Economics Unit is mainly involved in various economic analyses on economic viability of rubber planting. The studies conducted during the year were focused on Survey and Analysis cost of production of Natural Rubber (NR) in the estate sector and smallholder sector in Sri Lanka. Analysis of productivity in the Kalutara district was conducted using Geographic Information System (GIS) based on survey data. Databases on Local and International rubber prices, growth performance indicators of NR and Rubber finished products were updated. Agricultural Economics unit was engaged in a variety of outreach activities during this year in collaboration with the Biometry Section and Advisory Services Department. Also, a research on multi criteria decision approach on land suitability evaluation in the Vavuniya district was conducted using GIS in collaboration with the Biometry Section.

Library and Publications

One hundred and two books were added to the reference section of the Library bringing the total collection up to 6034. The Library purchased the entire set of Legislative Enactments of Democratic Socialist Republic of Sri Lanka, Establishment Code: Vol.1 & 2 and Financial Regulations. While eight journals were purchased, thirty titles were received on exchange basis.

During the year, the current content page service was changed to on-line system using e-mail facilities to make this service more effective and efficient. Meanwhile, the initial stage of the Library automation project at Ratmalana Library was completed.

Dartonfield Group

A total crop of 161,670 kg has been harvested during this year which is only 81% of the estimated crop. When comparing with the previous year, 9% crop decrease is recorded. The crop harvested from the rainguarded area was 27,852 kg which amounts to 17% of total harvested crop. The YPH for the year was 892 kg, 72 kg less than the YPH for last year.

The average intake per tapper recorded during the year was 6.9 kg from an average tapping task of 242 trees. Highest intake per tapper (IPT) of 8.01 kg was recorded from the 1998 field from 298 trees of clone RRIC 121 tapped at 1/2 S d3 without etheral in Gallewatta division.

The total number of Normal, Late, Rainguard and No tapping days recorded during the year were 204, 12, 70 and 79 days respectively.

Rainfall recorded in three divisions were Dartonfield 4,168 mm, Gallewatta 4,224 mm, Nivitigalakale 3,651 mm, and the number of wet days were 248, 224 and 159 respectively.

The COP and NSA achieved for the year were Rs.270.57 and Rs.255.26 respectively recording a loss of Rs.15.31 per kg and a total loss of Rs.2.4 million. Loss per hectare recorded for the year was Rs.13,653.84.

Out of total Latex crepe manufactured during the year, 73% was graded as No. 01.

Kuruwita Sub Station

The mature and immature extents of the Kuruwita Sub Station were 73.26 and 8.9 hectares respectively for the year under review.

A total crop of 100,170 kg has been harvested during the year. The actual crop harvested was 99% of the estimated crop. When comparing with the previous year, 1% crop increase is recorded. The actual yield per hectare (YPH) and the average intake per tapper were 1,367 kg and 8.9 kg respectively.

The total number of Normal, Late, Rainguard, Rain interfered and No tapping days recorded for the year were 174, 32, 140, 02 and 17 days respectively. Total rain fall recorded for the year was 4,002.14 mm with 251 wet days. When compared with the same period last year rainfall is less by 1,090.9 mm but wet days is more by 12 days.

The cost of production (COP) and the net sale average (NSA) for the year were Rs.191.21 and Rs.207.86 respectively, giving a profit margin of Rs.16.65 per kg and a total profit of Rs.1.6 million. Profit per hectare recorded for the year was Rs.22,765.91.

GENETICS AND PLANT BREEDING

S P Withanage

DETAILED REVIEW

Staff

Dr (Mrs) S P Withanage, Head of the Department, Dr P K G S Bandara, Senior Research Officer, Experimental Officers, Mr L S Kariyawasam, Mr I D M J Sarath Kumara, Mr H P Peiris, Mr T M S K Gunasekera, Mrs A K Gamage, Mr B W A N Baddewithana, Mrs S D P K L Peiris, Clerk/Typist and Miss K D Piyumi Hasara Kapuge, Management Assistant were on duty throughout the year.

Senior Research Officer, Mr K K Liyanage continued his postgraduate studies, at Kunming Institute of Botany, Chinese Academy of Science China and Research Officer Mrs P V A Anushka was reported duty on 20th April after her maternity leave. Miss W A D R Tharanga was assumed duty as a Technical Officer with effect from 24th April and Mr T B Dissanayaka, Experimental Officer, was transferred to the Department with effect from 30th April.

Seminars/Training Programmes/Workshops/Exhibitions conducted

The department staff provided the necessary training for the NIPM trainees, undergraduate students and stakeholders of various categories.

Meetings/Seminars and Workshops attended

Name of the Officer	Seminars/Training Programmes/ Workshops/Exhibitions	Date/Place and Organizer
SP Withanage KK Liyanage PKGSS Bandara	Clone Identification Workshop	25th February, RRI, Dartonfield
SP Withanage PKGSS Bandara	Scientific Committee Meeting	13th March RRI, Ratmalana
SP Withanage	Meeting on Germplasm Multiplication Project Evaluation	26th March MIP, Colombo
SP Withanage PKGSS Bandara PVA Anushka	File Management Work Shop	29th April , RRI, Dartonfield
S P Withanage S P Withanage	Progress Review Meeting NCPB* Meeting and Progress Review of NARP** Projects	27th May, MPI , Colombo 8th June, CARP, Colombo

Name of the Officer	Seminars/Training Programmes/ Workshops/Exhibitions	Date/Place and Organizer
SP Withanage PKGSS Bandara PVA Anushka	Workshop on Organizational Behavior and Administrative Personality	24th June, RRI, Dartonfield
SP Withanage PKGSS Bandara PVA Anushka	Scientific Committee Meeting	12th June, RRI, Ratmalana
SP Withanage	NCPB*Meeting and Progress Review of NARP Projects	15th June, CARP, Colombo
SP Withanage	NCPB*Meeting and Progress Review of NARP** Projects	17th June, CARP, Colombo
SP Withanage	NCPB* Meeting and NARP** Projects Evaluation	3rd July, CARP, Colombo
SP Withanage	NCPB* Meeting and NARP** Projects Evaluation	17th July, CARP, Colombo
S P Withanage P V A Anushka	NCPB* Meeting, NARP** Projects Evaluation and Proposal Presentation	29th July, RRI, Batalagoda
PKGSS Bandara	Training Programme on Basic Mutation Breeding Techniques for Crop Improvement	20-24 July, Field Crop Research and Development Institute, Mahailluppallama
S P Withanage	NCPB* Meeting, NARP** Projects Evaluation and Proposal Presentation	28th August, CARP, Colombo
S P Withanage P V A Anushka	Workshop on Gene/QTL Mapping in Plants	8th -9th September, Wayamba University, Gonawila, Makandura
S P Withanage PKGSS Bandara PVA Anushka	Scientific Committee Meeting	11th September, RRI, Ratmalana
SP Withanage	Progress Review Meeting	23th September, MPI, Colombo
S P Withanage	National Consultative Workshop on Strengthening and Road Mapping of Emerging Technology Innovation Systems of Sri Lanka	17th – 19th November, Colombo
SP Withanage	NCPB* Meeting	24th November, CARP, Colombo
PKGSS Bandara PVA Anushka	Scientific Committee Meeting	11th December, RRI, Ratmalana

*****National Committee of Plant Breeding
**National Agricultural Research Plan

Lectures/Training and Workshops conducted

Name of the Officer	Lectures Training and Workshops	Date/Place and Organizer
S P Withanage P K G S S Bandara P V A Anushka	Clone Development and Recommendation - Technology Update	11th February, RRISL, Dartonfield
P V A Anushka	Lectures to NIPM students on introduction to Plant Breeding & Clone Recommendation (Theory & Practical)	21st July, RRISL, Dartonfield
P V A Anushka	Lectures to Aquinas Collage students on Recommended clones	01st December, RRISL, Dartonfield
S P Withanage P K G S S Bandara P V A Anushka	Lectures to new RDO's on Clone development, Clone Recommendation, Clone Identification and Molecular Biology applications in *Hevea* breeding	29th December to 30th December NIPM Colombo

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

Nine Microsaterllite molecular markers were screened with whole progeny and found the polymorphism. The screening is needed to carry out with more molecular markers to develop a marker for early identification of CLF disease resistant genotypes.

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

Ten genotypes were selected from 1995 hybridization programme where non-Wickham clone GPS 1 was used as a male parent. Six Microsaterllite molecular markers were screened with whole progeny and found the polymorphism (Fig. 1). The screening is needed to carry out with more molecular markers (S P Withanage, L S Kariyawasam, A K Gamage and W A D R Tharanga).

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

TPD affected trees were selected for antioxidant treatment and TPD severity was calculated for each selected tree (P K G S S Bandara, S P Withanage, I D M J Sarath Kumara, B W A N Baddewithana and T M S K Gunasekara).

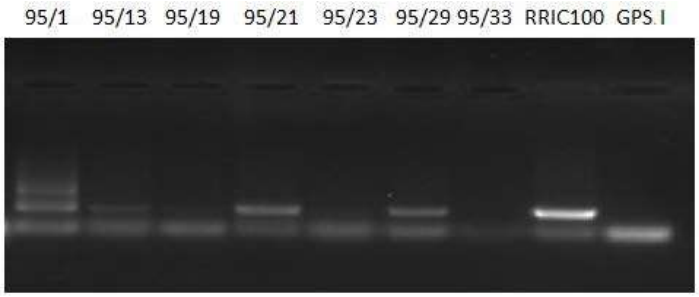


Fig.1. Polymorphism of *Hevea brasiliensis* Microsaterllite Molecular Marker HB 9 in Seven Selections *i.e*. 95/1, 95/13,/95/19,95/21,95/23,95/29 and 95/33 with their female parent RRIC100 and male parent GPS I which has developed from1981 IRRDB expedition to the Amazon

Hand pollination programme

The annual hand pollination programme was done at Neuchatle estate and seventy new genotypes were raised. Three promising clones were used as female parents with an aim to develop high yielding vigorous genotypes. Details of new genotypes and crosses made are given in Table 1.

Table 1. *Details of 2015 hand pollination programme*

Cross	No. of genotypes obtained
RRISL 208 x RRISL 2006	20
RRISL 208 x RRISL 203	06
RRISL 203 x RRISL 208	10
RRISL 211 x RRISL 2006	-
RRISL 211 x RRISL 203	02
RRISL 203 x RRISL 2006	14
RRISL 203 x RRISL 201	13
RRISL 208 x RRISL 219	-
RRISL 208 x RRISL 201	03
RRISL 211 x RRISL 201	02
RRISL 211 x RRISL 208	-
Total	70

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

Developing rubber (*H. brasiliensis* Muell. Arg.) breeding garden

A land of 2.88 ha was selected for establishing a *Hevea* breeding garden at Neuchatel estate and the map of the proposed breeding garden was developed by GPS technique. Rubber trees were trained by bending branches towards the ground for easy and safe access to flower inflorescences for future breeding programmes.

Annual hand pollination programme was conducted with these trees in the year under review (P K G S S Bandara, S P Withanage, K K Liyanage, P V A Anushka, I D M J Sarath Kumara, T M S K Gunasekara and B W A N Baddewithana).

Evaluation of previous hand pollinated (HP) progenies

Small Scale Clone Trials

The details of the small scale clone trials which maintained and monitored during the year under review are given in Table 2. However, due to heavy rainfall received throughout the year, the yield data collection in most of the trials was not possible.

Table 2. *Details of Small Scale Clone Trials*

HP year	Site	Planting season	Current status
1990	Kuruwita Sub station	July 2002	Made selections
1991	Pallegoda	August 2000	Made selections
1996	Kuruwita Substation – I & II	May 1999	Made selections
1997	Clyde – I & II	June 2000	8th year of tapping
1998	N'kele I, II & III	June 2001	7th year of tapping
	Kuruwita Substation I, II & III	July 2001	7th year of tapping
1999	Kuruwita Substation I, II & III	June 2002	5th year of tapping
2000	Arappalakande I-III	May 2003	5th year of tapping
	Delkeith IV & V	June 2003	5th year of tapping
	Elston VIII & IX	July 2003	5th year of tapping
	Nivithigalakele VI & VIII	July 2003	5th year of tapping
2001	Paiyagala I	June 2006	3rd year of tapping
	Kuruwita Substation II	July 2006	3rd year of tapping
2002	Pallegoda I	July 2007	1st Year of tapping
2002	Eladuwa II	May 2009	Tapping marked
2004	Eladuwa Trial I	July 2009	Tapping marked
2004	Neuchatel Trial II	November 2009	Tapping marked
2007	Kuruwita Sub station (seedlings)	July 2009	Immature
1995	Yatadola I		
	Katandola II	July 2011	Immature
2006	Payagala	July 2011	Immature
		July 2012	Immature
2008	Oakwell	November 2013	Immature
2005	Monaragala	November 2014	Immature

(S P Withanage, P K G S S Bandara, P V A Anushka, L S Kariyawasam, I D M J Sarath Kumara, T B Dissanayake, H P Peiris, T M S K Gunasekara, A K Gamage and B W A N Baddewithana).

Evaluation of 1990 HP clones at Kuruwita estate (GPB/BST/HPS/90/01)

The 12th year girth measurements and 6th year yield data were analyzed (Table 3). The HP entry 90-20 showed the highest girth and yield compared to control clones. The HP entry 90-21 showed second highest yield followed by the control clone RRISL 121.

Table 3. *Mean girth and yield of top most HP entries of the 1990 HP progeny planted at the Kuruwita Substation in 2002*

Mean girth (cm)		Mean yield (g/t/t)	
Clone	**Girth**	**Clone**	**Yield**
90-20	74.71^{a}	90-20	53.09^{a}
90-8	71.37^{ab}	90-21	51.88^{ab}
90-21	69.35^{ab}	RRIC 121	43.02^{abc}
90-4	68.00^{abc}	90-4	37.37^{bcd}
90-10	67.71^{abc}	90-10	33.97^{cd}
90-11	67.37^{abc}	90-13	33.26^{cd}
90-19	65.94^{abc}	90-11	30.53^{cde}
90-27	65.50^{abc}	90-17	29.83^{cde}
RRIC 121	65.18^{abc}	RRISL 205	29.79^{cde}
90-6	64.78^{abcd}	90-29	29.45^{cde}

(S P Withanage, P V A Anushka, I D M J Sarath Kumara and H P Peiris)

Evaluation of 1991 HP clones at Pallegoda and Vogan estates (GPB/BST/HPS/91/01 & 91/2)

1991 HP clones at Vogan estate (GPB/BST/HPS/ 91/2)

DMRT grouping was done with 15th year girth. Only high performing HP entries were selected and evaluated while leaving other entries out. Yield was not analyzed due to insufficient data. Selected genotypes and their mean girth are given in Table 4. None of the genotypes was significantly different from the control clone RRIC 121.

Table 4. *Mean girth, of the DMRT grouping of the best performing HP entries of the 1991 HP progeny planted at Vogan estate*

Mean girth (cm) of 91-02 trial	
Clone	**Girth**
91-86	97.50[a]
RRIC 121	84.21[a]
97-58	80.50[a]
97-73	80.50[a]
91-57	78.50[a]
91-58	74.44[a]

(S P Withanage, P V A Anushka, P K G S S Bandara, B W A N Baddewithana and L S Kariyawasam)

Evaluation of 1996 HP seedlings - Kuruwita estate (GPB/BST/HPS/96 -01 and 96-02)

In both trials 15th year girth measurements and 9th year yield data were grouped using DMRT and first ten superior genotypes were listed accordingly. In trial 01, highest mean yield and girth are recorded by HP entry 96-14 followed by HP entries 96 - 65 and RRISL 205 (Table 5a). In trial 02 (Table 5b) the control clone RRIC 121 obtained the highest girth, while HP entry 96-44 recorded the highest yield followed by RRIC 121.

Table 5a. *Mean girth, yield and the DMRT grouping of top most HP entries of the 1996-01 HP trial planted in 1999*

Mean girth (cm)		**Mean yield (g/t/t)**	
Clone	**Girth**	**Clone**	**Yield**
96-14	92.62[a]	96-14	66.34[a]
96-59	91.75[a]	96-65	52.05[a]
96-15	83.00[ab]	RRISL 205	51.57[a]
96-5	81.00[abc]	RRIC 121	50.46[abc]
96-17	79.14[abcd]	96-8	46.68[abcd]
RRIC 121	78.29[abcd]	96- 12	44.34[abcd]
96-13	70.56[bcde]	96-59	43.48[abcd]
96-16	68.71[bcde]	96-58	42.71[abcd]
RRISL 205	67.50[bcde]	96-57	37.93[bcd]
96-7	67.14[bcde]	96-15	36.5[abcd]

Table 5b. *Mean girth, yield (third year tapping) and the DMRT grouping of the top most HP entries of the 1996-02 HP trial planted in 1999*

Mean girth (cm)		**Mean yield (g/t/t)**	
Clone	**Girth**	**Clone**	**Yield**
RRIC 121	81.60[a]	96-44	46.09[a]
96-45	79.13[ab]	RRIC 121	45.38[ab]
96-37	72.37[abc]	96 -47	41.36[abc]
96-54	71.65[abc]	96-26	40.81[abc]
96-44	71.10[abc]	96-20	38.25[abc]
96-47	70.82[abc]	96-39	34.95[abc]
96-33	70.22[abc]	RRISL 205	34.50[abc]
RRISL 205	70.17[abc]	96-33	33.23[abc]
96-26	69.17[abc]	96-45	33.20[abc]
96-50	63.75[abcd]	96-63	31.94[abc]

(S P Withanage, P V A Anushka and H P Peiris)

Evaluation of 1997 HP clones at Clyde estate (GPB/BST/HPS/97/01 & 97/2)

Girth measurements in 15th year were taken for both trials. HP entry 97- 9 was ranked at top in term of girth (Table 6) whereas HP entry 97-67 was the highest in trial 2 (Table 6). Data of both trials were not analyzed for yield as data available was not sufficient. However, nearly one third of population, around twenty genotypes were selected for estate RRI collaborative trials to evaluate their commercial level performances.

Table 6. *Mean girth of top most HP entries of the 97 HP progeny planted at Clyde estate in 2000 (Trial 01 and trial 02)*

Mean girth (cm) of 97-01 trial		**Mean girth (cm) of 97-02 trial**	
Clone	**Girth**	**Clone**	**Girth**
97-9	76.50[a]	97-67	77.47[a]
97-19	75.10[ab]	RRISL 205	76.54[ab]
97-40	72.85[abc]	97-66	74.82[abc]
97-2	71.47[abcd]	97-61	72.50[abcd]
RRISL 205	71.43[abcd]	97-56	72.36[abcd]
97-10	71.13[abcde]	97-53	71.11[abcde]
97-23	69.93[bcdef]	97-55	70.68[abcde]
RRIC 121	68.93[bcdefg]	97-60	70.27[bcde]
97-36	68.29[bcdefg]	97-79	70.10[bcde]
97-26	67.50[cdefg]	97-44	69.57[bcdef]

(S P Withanage, P V A Anushka, P K G S S Bandara and T M S K Gunasekara)

Evaluation of 1998 HP entries

Fifteenth year girth measurements were analyzed using Duncan's multiple range test for six trials at two sites separately. Yield data were collected only from Kuruwita site.

Nivithigalakele Sub station (GPB/BST/HPS/98/01, 02, 03)

Although six HP entries have achieved higher girth above control clones RRISL 121 and RRISL 205, only the HP entry 98-88 showed significantly higher girth in trial 1998-01 (Table 7). In the trial 1998-02, four HP entries achieved higher girth compared to control clone RRIC 121 but the HP entry 98-86 was significantly higher (Table 7). In trial 1998-03, control clone RRISL 205 showed significantly higher girth followed by HP entry (98-280) (Table 7).

Table 7. *Mean girth and the DMRT grouping of top most HP entries of the trials 1998-01, 1998-02 and 1998-03 planted at Nivitigalakele Substation in 2001*

Mean girth 1998-01	
Clone	**Girth (cm)**
98-88	83.107^{a}
98-134	74.423^{b}
98-147	74.031^{bc}
98-180	72.625^{bcd}
98-112	72.200^{bcd}
98-108	71.133^{bcd}
RRISL 205	70.500^{bcd}
98-123	69.538^{bcd}
RRISL 121	68.536^{bcde}
98-168	68.533^{bcde}

Mean girth 1998-02	
Clone	**Girth (cm)**
98-86	104.0^{a}
98-132	84.23^{b}
98-53	79.21^{bc}
98-96	77.96^{bc}
RRIC 121	74.77^{bc}
98-129	73.25^{bc}
98-117	73.0^{bc}
98-97	72.50^{bc}
98-95	71.0^{bc}
98-277	68.50^{bc}

Mean girth 1998-03	
Clone	**Girth(cm)**
RRISL205	80.50^{a}
98-280	80.50^{a}
98-151	76.04^{ab}
98-133	75.15^{ab}
RRIC 121	72.83^{abc}
98-281	68.76^{bcd}
98-269	66.83^{bcd}
98-225	66.31^{bcd}
RRIC 130	66.30^{bcd}
98-157	65.03^{cd}

(S P Withanage, P V A Anushka, P K G S S Bandara, I D M J Sarath Kumara, L S Kariyawasam and A K Gamage)

Kuruwita Sub station (GPB/BST/HPS/98/04, 05, 06)

Five HP entries were ranked above the clone RRIC121 in girth (trial 1998-04) and girth of HP entry 98-236 was significantly higher compared to others. Similarly, five HP entries were ranked above control clone RRISL 205 in trial 98-05. In trial 1998-06 only one HP entry was ranked above the control clone RRISL 205 as far as girth is concerned (Table 8).

Table 8. *Mean girths and the DMRT grouping of top most HP entries of the **1998-04, 05 and 06** HP trials planted at Kuruwita Substation in 2001*

Trial 98-04 Mean girth (cm)		Trial 98-05 Mean girth (cm)		Trial 98-06 Mean girth (cm)	
Clone	**Girth**	**Clone**	**Girth**	**Clone**	**Girth**
98-276	82.71[a]	98-68	79.29[a]	98-223	82.75[a]
98-219	75.35[ab]	98-50	76.61[ab]	RRISL 205	81.45[a]
98-230	74.14[abc]	98-51	75.63[ab]	RRIC 121	72.81[b]
98-98	73.36[bcd]	98-80	75.07[ab]	98-220	71.37[bc]
98-89	72.54[bcde]	98-58	70.25[bc]	98-154	70.60[bcd]
RRIC 121	70.91[bcdef]	RRISL 205	70.10[bc]	98-224	69.15[bcde]
98-11	70.47[bcdef]	RRIC 121	69.61[bc]	98-30	69.04[bcde]
98-84	70.18[bcdefg]	98-73	69.54[bc]	98-196	67.50[bcdef]
98-207	69.54[bcdefg]	98-54	69.09[bc]	98-278	67.36[bcdef]
RRISL 205	69.47[bcdefgh]	98-71	66.80[cd]	98-200	66.11[bcdefg]

(S P Withanage, P V A Anushka, P K G S S Bandara and H P Peiris)

Evaluation of 1999 HP clones at Kuruwita Substation (GPB/BST/HPS/99/01, 02 & 03)

Girth measurements (13th year) and seventh year yield data were taken for each trial. HP entries which were ranked in first ten positions for girth (Table 9a) and yield in all three trials are given in Table 9b. Almost all entries performed well and all top ranked HP entries had yielded above 40g/t/t up to 66 g/t/t along with good girth.

Table 9a. *Mean girth values of the best performing 1999 HP progeny planted at Kuruwita Substation in 2002*

Trial 99-01 Mean girth (cm)		Trial 99-02 Mean girth (cm)		Trial 99-03 Mean girth (cm)	
Clone	**Girth**	**Clone**	**Girth**	**Clone**	**Girth**
99-139	81.88[a]	99-157	95.06[a]	99-189	85.21[a]
99-73	78.17[ab]	99-167	77.50[b]	99-230	83.56[ab]
99-74	77.33[abc]	99-159	76.50[bc]	99-216	76.63[abc]
99-67	75.94[abcd]	99-47	74.86[bcd]	99-156	75.83[abcd]
99-81	69.08[bcde]	99-272	73-44[bcde]	99-64	75.06[abcd]
99-54	67.44[bcdef]	99-236	70.64[bcdef]	99-92	73.94[bcde]
99-55	67.25[bcdef]	99-161	68.88[bcdefg]	99-166	71.69[cdef]
99-61	66.36[bcdef]	99-178	68.48[bcdefg]	99-63	70.88[cdefg]
99-83	64.37[bcdef]	RRISL 205	66.83[bcdefgh]	RRIC121	70.29[cdefgh]
99-52	66.33[bcdef]	99-194	65.94[bcdefghi]	99-44	69.19[cdefghi]

Table 9b. *Mean yield values of the best performing 1999 HP progeny planted at Kuruwita Substation in 2002*

Trial 99-01		Trial 99-02		Trial 99-03	
Clone	**Mean yield based on nine TTs * (g/t/t)**	**Clone**	**Mean yield based on ten TTs* (g/t/t)**	**Clone**	**Mean yield based on nine TTs* (g/t/t)**
99-73	47.48^{a}	99-167	66.16^{a}	99-64	61.44^{a}
99-139	46.67^{a}	99-159	57.37^{ab}	99-120	48.79^{ab}
99-41	45.73^{a}	RRISL205	46.05^{bc}	99-189	48.75^{ab}
99-61	44.17^{a}	99-47	44.39^{bcd}	99-166	48.28^{ab}
99-81	42.17^{ab}	99-242	43.30^{bcd}	99-216	47.67^{ab}
99-134	42.14^{ab}	99-135	41.68^{bcd}	99-92	42.15^{bc}
99-80	38.96^{abc}	99-197	40.96^{bcde}	RRIC 121	39.16^{bcd}
99-69	36.78^{abcd}	99-185	39.62^{bcdef}	99-44	38.31^{bcde}
99-65	36.56^{abcd}	RRIC 121	37.63^{bcdef}	99-148	37.38^{bcde}
99-106	35.83^{abcd}	99-187	37.01^{bcdef}	99-138	36.19^{bcde}

* TTs - test tappings

(S P Withanage, P V A Anushka, P K G S S Bandara and H P Peiris)

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

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

In this trial, 112 genotypes derived from two families (RRIC 121 × PB 235 & PB 235 × RRIC 121) (56 from each family) were planted in a completely randomized design with three single tree plots per clone. Family mean of tenth year girth measurements are given in Table 10. There was a significant difference between two families in term of girth but not enough data were collected for analysis of the yield.

Table 10. *Mean girth of two families in trial IV at Dalkith estate, planted in 2003*

	Family: Girth (cm)	
	RRIC 121 × PB 235	**PB 235 × RRIC 121**
Mean	60.72^{b}	65.7^{a}
Minimum	41.5	42.5
Maximum	85.5	112.5
Variance	131.47	177.61

(S P Withanage, P V A Anushka, P K G S S Bandara and A K Gamage)

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

In this trial, 98 genotypes from two families [BPM 24 × PB 260 (53) and RRIC 121 × PB 260 (45)] were planted in a completely randomized design with three single tree plots per clone. Family mean, of the eleventh year girth (Table 11) measurements of two families are given below. There is no significant difference observed between two families.

Table 11. *Mean girth of two families at Dalkith estate (2000 hand pollinated progeny) trial V planted in 2003*

	Family: Girth (cm)	
	BPM 24 × PB 260	**RRIC 121 × PB 260**
Mean	56.51[a]	59.13[a]
Minimum	39.5	39.5
Maximum	80.5	93.5
Variance	105.82	146.82

(S P Withanage, P V A Anushka, P K G S S Bandara and A K Gamage)

Nivithigalakele Substation trial VI - (GPB/BST/HPS/2000/06)

In trial VI, 46 genotypes from family BPM 24 X RRIC 121 with three single tree plots were tested in a completely randomized design. Family mean, Variance, Minimum and Maximum derived from the twelfth year girth measurements of trial VI are given in Table 12.

Table 12. *Mean minimum, maximum and variance of girth in two families at Nivitigalakele (2000 hand pollinated progeny) trial VI planted in 2003*

	Results of the trial VI (BPM 24 × RRIC 121)
Mean (cm)	66.3
Minimum (cm)	35.6
Maximum (cm)	87.5
Variance	101.16

(S P Withanage, P V A Anushka, P K G S S Bandara, A K Gamage and B W A N Baddewithana)

Elston estate - (GPB/BST/HPS/2000/08, GPB/BST/HPS/2000/09)

In trial VIII, 103 genotypes from one family (PB 235 × RRIC 121) with three single tree plots are being tested in a completely randomized design. Mean girth of eighth year are given in Table 13. In Trial IX, 52 genotypes are derived from 11 families with six single tree plots per genotype in a completely randomized design. Girth was significantly high in family RRIC 121 × PB 235 (Table 14).

Table 13. *Mean minimum, maximum and variance of trial VIII at Elston estate, planted in 2003*

	Results of the trial VIII Girth (cm) PB 235 X RRIC 121
Mean	59.08
Minimum	19
Maximum	94
Variance	161.8

Table 14. *Mean and variance of families at Elston estate trials IX planted in 2003*

Parentage (Family)	**Mean girth (cm)**
RRIC 121 × PB 235	67.35^{a}
RRIC 121 × PB 260	64.87^{ab}
PB 260 × RRIC 121	64.47^{ab}
PB 235 × PB 260	63.21^{ab}
BPM 24 × PB 235	62.54^{abc}
PB 235 × RRIC 121	62.06^{abcd}
BPM 24 × PB 260	59.44^{bcd}
RRIC 121 × GP 36-147	59.11^{bcd}
BPM 24 × RRIC 121	58.41^{bcd}
PB 260 × PB 260	56.29^{cd}
BPM 24 × GP 36-104	55.52^{d}

(S P Withanage, K K Liyanage, P V A Anushka, P K G S S Bandara and H P Peiris)

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

The mean girth of clones in eighth year were grouped using the Duncan's multiple range test and top most promising HP entries are given in Table 15. Although the control clone RRISL 203 continuously showed poor performance at Payagala estate with compared to Kuruwita estate, overall girthing of all other genotypes were better than those at Kuruwita estate.

Table 15. *Mean girth of top most HP entries of the 2001 HP progeny planted in 2006*

Payagala estate		Kuruwita Sub-station	
Clone	**Girth (cm)**	**Clone**	**Girth (cm)**
2001-249	64.16[a]	2001-185	59.60[a]
2001-110	63.69[ab]	2001-227	58.62[a]
2001-199	63.07[abc]	2001-89	58.40[a]
2001-257	62.13[abc]	2001-220	57.60[a]
2001-224	60.82[abcd]	2001-179	56.12[a]
RRIC121	59.50[abcde]	2001-183	55.80[a]
2001-112	59.21[bcdef]	2001-205	54.70[a]
2001-294	58.29[cdefg]	RRISL 203	54.70[a]
2001-92	58.25[cdefg]	RRIC 121	53.75[a]
2001-189	56.92[defg]	2001-170	53.60[a]

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

Evaluation of 2002 HP clones

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

Eight year girth measurements were taken and the mean girth of clones were grouped using the Duncan's multiple range test and the results are given in Table 16. Around four HP entries performed well compared to control clone RRISL 203.

Table 16. *Mean girth of top most HP entries of the 2002 HP progeny planted in 2007*

Clone	Mean girth (cm)
2002-18	66.30[a]
2002-17	64.31[ab]
2002-11	61.93[abc]
2002-96	61.70[abc]
RRISL 203	61.54[abc]
2002-14	60.80[abcd]
2002-24	60.17[abcd]
RRIC 121	58.00[bcde]
2002-77	57.50[cde]
2002-6	57.13[cde]

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

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

Thirteen genotypes from 2002 hand pollination progeny were planted with

two control clones, RRIC 121 and RRISL 203. Randomized block design was used with four replicates per genotype. Replicate size was six. Eighth year girth is shown in Table 17.

Table 17. *Mean girth of top most HP entries of the 2000 HP progeny planted in 2009 at Eladuwa*

Clone	Mean girth (cm)
2002-138	64.81[a]
2002-20	57.83[b]
2002-30	57.03[b]
2002-66	55.62[bc]
2002-19	52.66[cd]
2002-9	52.50[cd]
2002-93	51.22[cd]
2002-139	49.89[de]
2002-121	49.02[de]
2002-78	48.40[def]

(S P Withanage, P V A Anushka, P K G S S Bandara and L S Kariyawasam)

Evaluation of 2004 HP clones

Twenty two genotypes from 2004 hand pollination progeny were planted to test with two control clones *i.e.* RRIC121 and RRISL 203 at two sites. Randomized block design was used with four replicates per genotype. Replicate size was six in both trials.

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

Sixth year girth was taken. Despite the instructions given to the estate management to take extra care on this trial, the performances of all HP entries as well as control clones were poor and they were not up to the expected level of growth (Table 18). However, it was noticed that the conditions of the surrounding fields established by the estate was also poor in growth possibly owing to substandard ground conditions. However, four HP entries were ranked above control clone PB 260.

Table 18. *Mean girth of top most HP-entries of the 2004 HP-progeny planted in 2009 at Neuchatle*

Clone	Mean girth (cm)
2004-298	50.50^{a}
2004-115	49.16^{ab}
2004-332	48.59^{abc}
2004-228	47.56^{abcd}
PB 260	46^{bcde}
2004-10	45.63^{bcdef}
2004-15	45.10^{cdef}
2004-450	44.55^{def}
2004-341	44.50^{def}
2004-346	44.44^{def}

(S P Withanage, P V A Anushka, P K G S S Bandara and I D M J Sarath Kumara)

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

Sixth year girth was taken. The HP entry 2004–50 showed significantly higher girth and seven entries ranked above the RRIC 121 (Table 19).

Table 19. *Mean girth of top most HP-entries of the 2004 HP- progeny planted in 2009 at Eladuwa estate*

Clone	Girth (cm)
2004-50	62.06^{a}
2004-107	50.17^{b}
2004-347	49.31^{bc}
2004-228	49.22^{bc}
2004-190	49.04^{bc}
2004-48	48.63^{bc}
2004-320	48.63^{bc}
RRIC 121	48.45^{bc}
2004-171	43.66^{bc}
2004-164	43.33^{bc}

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

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

Seventh year girth data were collected for the seedling progeny and family means are given in Table 20. Family **RRIC 130 × GP 22-137** was recorded the highest girth.

Table 20. *Family means of 2007 HP - progeny at the Kuruwita Substation planted in 2008*

Family	Girth (cm)
RRIC 130 × GP 22-137	60.42[a]
RRIC130 × GP 21-163	58.69[a]
RRIC130 × GP 10-154	57.0[a]
RRIC130 × GP 44-24	51.33[a]

(S P Withanage, P V A Anushka, P K G S S Bandara and H P Peiris)

Evaluation of 2008 HP progeny planted in 2013 at Oakwell estate

Forty two genotypes from 2008 hand pollination progeny were established at Oakwell estate to evaluate their adaptability for higher evaluations. Average girth of these two year old plants was between 8-10cm. However, the field was severely damaged by mammalian pests (S P Withanage, P V A Anushka, P K G S S Bandara and B W A N Baddewithana).

Evaluation of 2005 HP progeny planted in 2014 at Monaragala

Thirty five genotypes from 2005 hand pollination progeny which was raised by double selfing of *Corynespora* susceptible clone RRIC 103, were established at Monaragala substation with control clones RRIC 100, RRIC 103, RRIC 52, PB 86 and RRISL 201. Complete randomized block design was used with 10 replicates per genotype. Screening of genotypes against *Corynespora* leaf fall disease was conducted with the help of Plant Pathology and Microbiology Department. Average disease severity index is shown in Figure 2.

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

Annual girth measurements were taken from all the trials. Table 21a (registered clones) and 21b (unregistered clones) show the girth measurements for the year under review and for the previous two years and the planting sites.

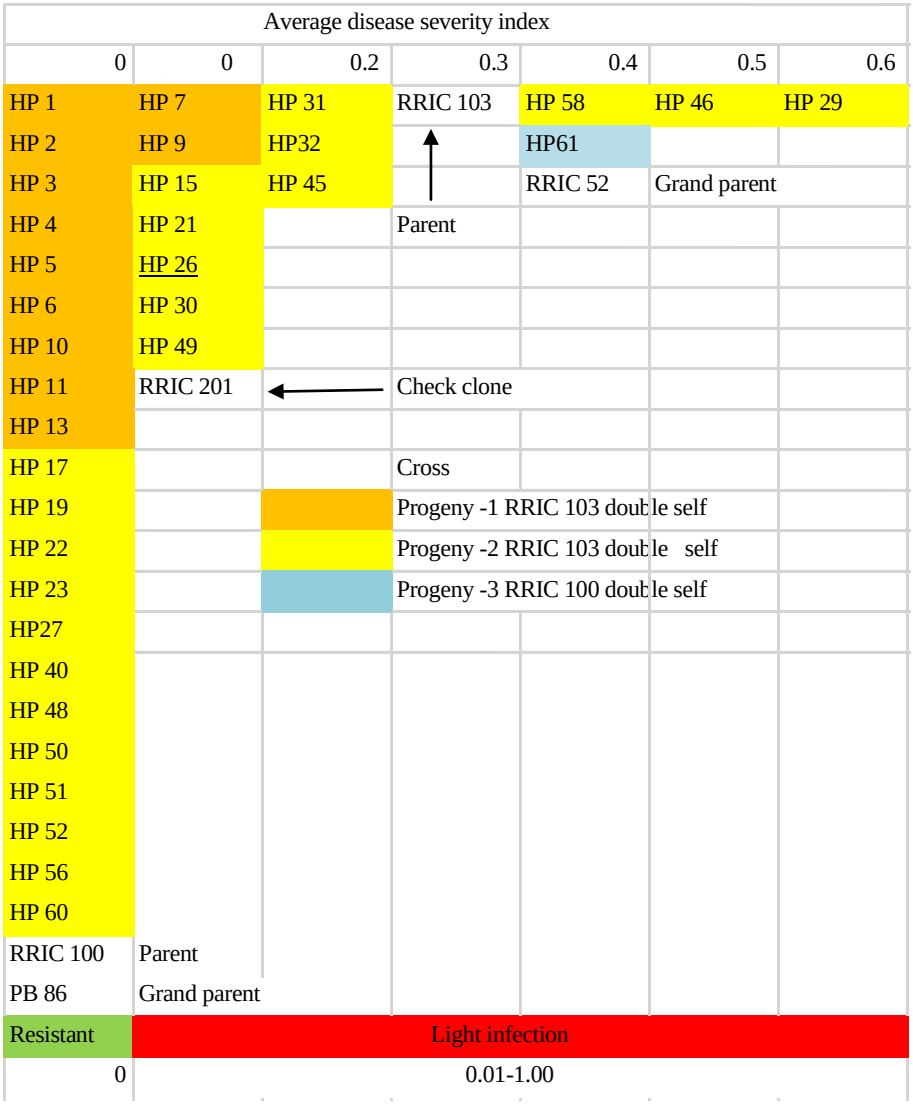


Fig. 2. Average disease severity index of thirty five genotypes from 2005 HP progeny with their Parents, Grand Parents and Clone RRISL 201 for *Corynespora* leaf fall disease

(S P Withanage, L S Kariyawasam, T M S K Gunasekara and W A D R Tharanga)

Table 21a. *Mean annual girth measurements for registered clones of ECTs (Estate/RRISL Collaborative Trials)*

Clone	Site	Year of planting	Girth in cm		
			2013	2014	2015
RRISL 201	Salawa	1999	83.2	-	-
	Eladuwa*	2009	25.9	37.5	45.09
	Dameria B*	2010	14	-	26.55
	Wikiliya*	2011	8.7	Fire damaged	Fire damaged
RRISL 203	Galewatta	1987	78.8	Terminated	Terminated
RRISL 203	Eladuwa*	2009	20.5	31.8	40.62
	Dameria B*	2010	18.5	-	29.22
	Lagos*	2011	15.2	21	39.3
	Wikiliya*	2011	9.5	Fire damaged	Fire damaged
	Wewassa	2011	9.4	17.1	24.54
	Muwankanda	2010	19.95	26.9	38.27
	Kamburupitiya* (University)	2011	19.1	35.15	45.9
RRISL 206	Salawa	1999	70.5	-	-
RRISL 207	Dosert division	2004	57.9	-	62.5
RRISL 208	Dartonfield	1994	74.5	74.8	76.17
	Eladuwa*	2009	27.7	38.2	42.66
	Dameria B*	2010	13.7	-	25.25
	Moralioya*	2010	25	37.8	42.35
	Wikiliya*	2011	9.2	Fire damaged	Terminated
RRISL 210	Payagala	2006	56.8	59.8	62.14
RRISL 211	Dartonfield	1994	70.6	73.1	73.29
RRISL 212	Kuruwita	2006	50	52.6	54.92
RRISL 214	Dosert division	2004	50.5	-	52.36
	Kuruwita	2006	46.2	48.6	49.97
RRISL 216	Dartonfield	1994	77.4		79.29
RRISL 217	Kuruwita	1995	62		
RRISL 219	Dartonfield	1994	76.4	79.6	83.62
	Kuruwita	2008	39.6	45	47.46
RRISL 223	Galewatte	1994	72	Terminated	Terminated
RRISL 2000	Dosert division	2004	61.1	64.5	66.45
	Kuruwita	2005	58.6	61.7	65.09
RRISL 2001	Dosert division	2004	57.9	60.5	61.32
	Dameria B*	2010	23.2		39.15
	Wikiliya*	2011	11.4	Fire damaged	Fire damaged
	Muwankanda	2010	19.56	25.8	38.38
	Wewassa	2011	10.6	19.2	27.53
RRISL 2004	Dosert division*	2004	58.2	60.9	62.02
RRISL 2003	Dosert division*	2004	55.3	57.5	58.83

Clone	Site	Year of planting	Girth in cm		
			2013	2014	2015
RRISL 2004	Dosert division	2004	53.8	55	55.63
RRISL 2005	Dosert division	2004	57	-	60.95
	Dameria B*	2010	13.9	-	Terminated
RRISL 2006	Dosert division	2004	60.8	-	67.1
	Monaragala*	2009	26	37.8	47.15
	Eladuwa*	2009	30.7	39.8	45.62
	Moralioya*	2010	26.7	40.4	44.65
RRISL 2100	Payagala*	2006	57	59.4	61.28
	Edalla*	2010			42.08
	Kuruwita	2011			31.96
	Monaragala*	2009	28.5	41.9	50.47
	Oak-well	2013	-	-	Poor girth
RRII 105	Pallegoda	1998	-	Terminated	Terminated
RRISL Centennial 1	Oak-well	2013	-	Poor girth	Poor girth
RRISL Centennial 2	Oak-well	2013	-	Poor girth	Poor girth
RRISL Centennial 4	Pallegoda	2007	51.5	54.3	64.9
	Kuruwita	2007	46.4	53	53.95
	Eladuwa*	2009	26.6	38.1	46.97
	Eladuwa*	2009	30.1	41.2	46.96
	Monaragala*	2009	27.3	40.5	49.48
	Lagos	2011	13.4	20	36.72
	Oak-well	2013		Poor girth	Poor girth
RRISL Centennial 3	Monaragala*	2009	21.4	34.3	44.78
	Kuruwita	2008	34.9	47.1	-
	Kuruwita*	2009	34.1	46.2	52.42
	Eladuwa*	2009	31.3	47.1	53.69
	We-oya	2010	28.8	41.5	49.52
	Edalla*	2010	28.8		46.62
	Kuruwita*	2010	25.6	41.5	45.83
	Siriniwasa	2011	23.6	38.5	45.89
RRISL Centennial 5	Pallegoda	2007			63.5
	Eladuwa	2009			45.46
	Kuruwita	2007			54.8

Table 22b. *Mean annual girth measurements of un-registered 2004- entries selected to ECTs (Estate/ RRISL Collaborative Trials)*

Clone	Site	Year of planting	Girth in cm		
			2012	2013	2015
78-140	Eladuwa	2006	49.4	51.4	53.25
78-198	Eladuwa	2006	58.6	60.1	63.5
78-150	Nivitigalakele	2006	62.6	69.2	73.50
78-260	Eladuwa	2006	53.2	54.3	57.23
78-278	Kuruwita	2006	52.6	55.6	
78-334	Eladuwa	2006	59.7	60.7	63.19
78-341	Eladuwa	2006	54.5		58.09
78-510	Kuruwita	2006	54.2	56.6	58.64
78-534	Kuruwita	2006	48.8	52.5	54.65
78-689	Eladuwa	2006	52.5	53.3	56.24
78-759	Kuruwita	2006	50.6	53.2	54.93
78-770	Kuruwita	2006	53	54.7	56
78-873	Kuruwita	2006	51.1	53.8	56.16
86-10	Kuruwita	2009	28.1	37.1	42.82
86-87	Kuruwita	2009	30.6	39.5	45.13
87-139	Eladuwa	2009	33.4	45.1	42.82
87-235	Kuruwita	2008	32.1	39.9	42.76
92-129	Pallegoda	2007	55.6	59.0	53.41
	Kuruwita	2007	45.4	52.2	73.5
92-250	Pallegoda	2007	55	59.2	61.5
92-279	Pallegoda	2007	56.6	60.5	59.5
95-33	Kuruwita	2004	-	-	53.27
95-55	Kuruwita	2004	-	-	56.16
GP 12-93	Kuruwita	2006	47.3	50.9	54.93
GP 22-137	Payagala	2006	55.2	60.3	56.00
GP 44-24	Payagala	2006	52.3	55.3	57.95
RRIC 100 seedlings	Kuruwita	2005	56.3	60.5	58.64

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

The estate yields and other data obtained from ECT trials are given in Table 23.

Table 23. *Clone, year of tapping and average yield (g/t/t) of ECT trials*

Clone/Selected HP- entry	Year of tapping	Average (g/t/t)
RRISL 201	14	25.2
RRISL 203	21	-
RRISL 208	13	46.2
RRISL 211 (S2/d 2) *	13	41.0
RRISL 211 (S2/d 3) *	13	43.3
RRISL 216	13	44.5
RRISL 217	14	41.8
RRISL 219	13	34.2
RRII 105	12	-
95-55	7	39.1
95-33	7	30.4
GP 12-93		62.9

(S2/d 2) (S2/d 3) *- Tapping system

(S P Withanage, P K G S S Bandara, P V A Anushka, I D M J Sarath Kumara, L S Kariyawasam,T B Dissanayake, T M S K Gunasekara, H P Peiris, A K Gamage and B W A N Baddewithana)

Evaluation of clones under smallholder conditions

Smallholder/RRI collaborative clone trial 1– GPB/BST/SRT/2001 and trial 2- GPB/BST/SRT/2003

Mean girth of the five clones obtained from three sites planted in year 2001, 2003 and 2009 are given in Table 24a and their mean yields are given in Table 24b.

Table 24a. *Mean girth (cm) of the trees of Smallholder/RRI collaborative clone trial 1 and 2 planted in 2001, 2003 and 2009*

Site	Clone	Planting year	Girth (cm)
Kamburupitiya	RRISL 201	2003	72
	RRISL 205	2003	67.63
	RRISL 121	2003	63.8
	RRISL 206	2003	57
	RRISL 203	2009	55.56
Kegalle	RRISL 201	2001	82.15
	RRISL 203	2001	68.31
Godagama	RRISL 205	2001	75.32
	RRISL 201	2001	74.38
	RRISL 203	2001	66.92

(S P Withanage, L S Kariyawasam, A K Gamage and B W A N Baddewithana)

Table 24b. *Mean yield of the trees of smallholder/RRI collaborative clone trial 1 and 2 planted in 2001 and 2003*

Clone	Site/Expt. No.	Yield (g/g/t)		
		2013	**2014**	**2015**
RRISL 201	Kegalle (SRT/01/01)	45.2	48,1	41.73
	Homagama (SRT/01/03)	49.1	64.7	70.34
RRISL 203	Kegalle (SRT/01/01)	41.2	34.5	46.22
	Homagama (SRT/01/03)	65.8	47.2	40.51
RRISL 205	Kegalle (SRT/01/01)	Terminated		
	Homagama (SRT/01/02)	21.1	24.3	Not tapped

(S P Withanage, L S Kariyawasam and A K Gamage)

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

The project Multiplication and evaluation of the genotypes collection of Hevea obtained from 1981 IRRDB expedition to the Amazon (under new development proposal for Annual budget 2014)

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

Selected 25 accessions were multiplied by bud grafting and the new plants were planted in completely randomized block design with three replicates and each replicate contained 5 plants from each 25 accessions and RRIC 121 and RRISL 203 were used as control clones. These accessions were characterized for their girth (Fig. 3), leaf area, chlorophyll content, leaf color, tree height and inter whorl length and observed their diseases incidence also. All parametric data were analyzed using one-way ANOVA and Duncan's multiple range test and found good performances in some accessions MT 11-76 I, MT 11-76 II, MT 10-146 and MT 11-13 with compared to control clones (Fig. 3). However, further evaluation is needed before selecting accessions.

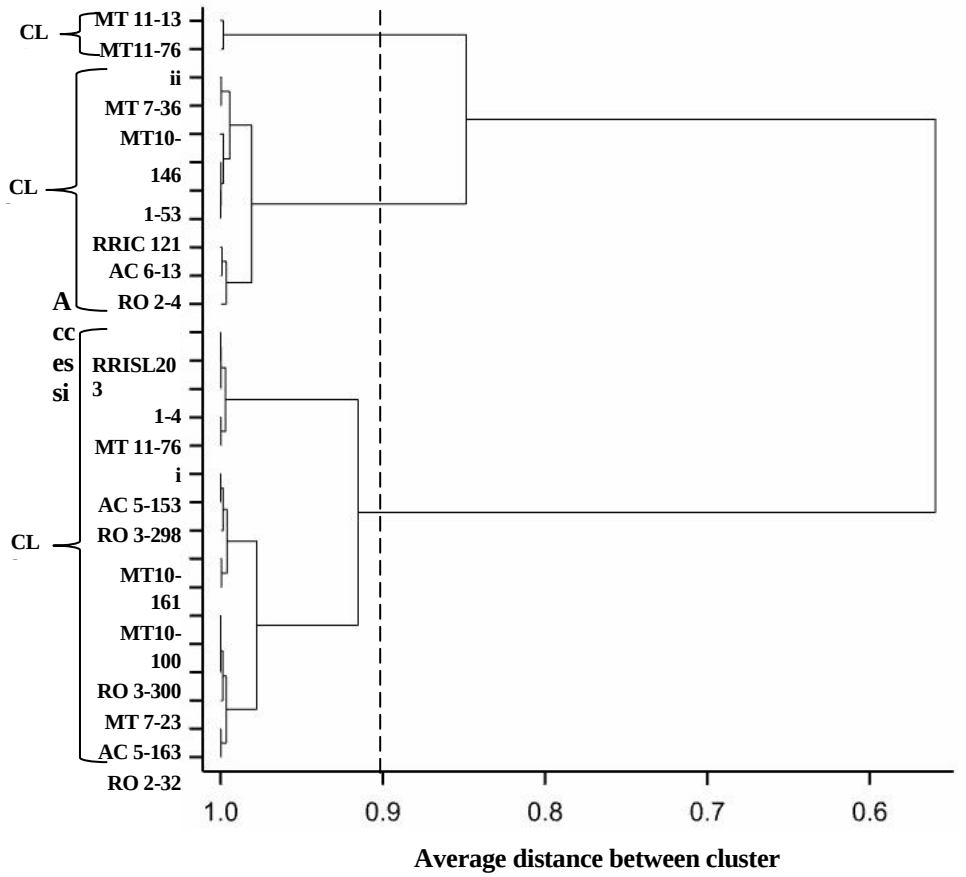


Fig. 3. Dendrogram of 25 accessions and two control clones based on Average Linkage Cluster Analysis using girth values (CL1, CL2 and CL3 are the main clusters) to characterize the accessions

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

Testing of promising clones for sub optimal conditions

Evaluation of adaptability and performance of new promising clones in nontraditional rubber growing areas (sub optimal conditions) is aimed with this project. All trails are conducted as in RRI/smallholder collaborative manner.

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

Seven experimental plots were established at Padiyathalawa/Maha Oya areas

in eastern province. Their control (reference) plot was established at Bandaragama which belongs to traditional rubber growing region. Details of these trials are given in Table 25.

Table 25. *Details of clones planted in 2012 at Eastern Province and their third year girth*

Trial	Smallholder and Location	Agro climatic Region	75% expectancy value of Annual Rainfall (mm)	Clones planted	Third year girth (cm)
SRT-EP 12/1	SM Wirawardana Marawa Padiyathalawa	IL2	> 1600	RRISL 2001	23.32
				RRISL 203	21.7
				RRISL 2005	22.16
				RRISL 2006	19.48
SRT-EP 12/2	Indrani Kusumalatha Marawa Padiyathalawa	IL2	>1600	RRISL 203	31.65
				RRIC 121	29.13
				RRISL 2001	28.9
				RRISL 2006	25.16
SRT-EP 12/3	AM Sumanawathi Helakomana Padiyathalawa	IL2	> 1600	RRISL 203	26.03
				RRIC 100	29.91
				RRISL 2005	23.62
				RRISL 208	18.67
SRT- EP12/4	HM Wimalasena Kudaharasgala Mahaoya	IL2	> 1600	RRISL 208	14.85
				RRISL 2005	18.54
				RRIC 100	15.35
				RRISL 208	14.89
SRT-EP 12/5	YB Thilakarathna Harasgala, Mahaoya	IL2	>1600	RRISL 203	15.33
				RRIC 121	13.5
SRT-EP 12/6	Sakyas Farm Padiyathalawa	IL2	>1600	RRISL 2001	Girth couldn't take due to heavy flood during our visit
				RRISL 2006	
				RRISL 203	
				RRIC 121	
SRT-EP 12/7	Sakyas Farm Padiyathalawa	IL2	> 1600	87 - 370	
SRT-WP 12/8	Ranjith Thambawita Bandaragama Panadura (Kalutara district – Control Trial)	WL 1a	>3300	RRISL 208	30.57
				RRISL CEN 3	28.17
				RRISL 2001	30.01
				95-55	27.41
				RRISL 203	28.19

(S P Withanage, P V A Anushka, L S Kariyawasam and T B Dissanayake)

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

Five experimental plots were established at Ampara area in the Eastern Province. However, two trials were given up due to poor support received from the smallholders (Table 26).

Table 26. *Details of establishment of clones in 2013 at Eastern Province with their second year girth*

Trial	Smallholder and Location	Agro climatic Region	75% expectancy value of Annual Rainfall (mm)	Clone and no: of plants planted	Second year girth (cm)
SRT-EP 13/1	HM Jayarathna 17-1 C Lathugala Warankatagoda	DL2a	> 1300	RRIC 121 (210)	10.9
SRT-EP 13/3	HM Shantha Kumara 51 C Lathugala Warankatagoda	DL2a	> 1300	RRIC 121 (210)	Not taken
SRT-EP 13/4	HM Saman Kumara 17/1 B Lathugala Warankatagoda	DL2a	> 1300	RRISL 203 (210)	8.09
SRT-EP 13/5	M Chandrani Ranasingha 51 B – 2 Lathugala Warankatagoda	DL2a	> 1300	RRISL 203 (210)	Not taken

(S P Withanage, T M S K Gunasekara and L S Kariyawasam)

Smallholder/RRI collaborative clone trial – Eastern Province established 2014

Details of four experimental plots that were established in Mahaoya area, with three RRISL 2000 series clones and clone RRIC 121 in October 2014 are given in Table 27 with their first year girth.

Table 27. *Details of establishment of clones in 2014 at Eastern Province with their first year girth*

Trial	Smallholder and Location	Agro climatic Region	75% expectancy value of Annual Rainfall (mm)	Clones and no: of plants planted	First year Girth (cm)
SRT-EP 14/1	G Senevirathne Mahaoya	IL2	>1600	RRIC 121 (210)	8.74
SRT-EP 14/2	M Senevirathne Mahaoya	IL2	> 1600	RRISL 2001 (210)	7.36
SRT-EP 14/3	A M Jayasekara Mahaoya	IL2	>1600	RRISL 2006 (210)	7.06
SRT-EP 14/4	T M Amarasena Mahaoya	IL2	>1600	RRISL 2005 (210)	7.84

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

Smallholder/RRI collaborative clone trial planted in 2014 - Uva Province

Five experimental plants were established in Monaragala district and their details are given in Table 28.

Table 28. *Details of establishment of clones in 2014 at Uva Province with their first year girth*

Trial	Smallholder and Location	Agro climatic Region	75% expectancy value of Annual Rainfall (mm)	Clones and no. of plants planted	First year girth (cm)
SRT-UP 14/1	DM Arunashantha Siyabalanduwa	DL 1b	>900	RRISL 203 (260)	Not taken
SRT-UP 14/2	UAH Kumara Buttala	IL1c	>1300	RRIC 121 (210)	6.92
SRT-UP 14/3	PTG Newton Etiliwewa	DL 1a	>1100	RRIC 121 (210)	6.38
				RRISL 2100 (210)	4.77
				RRISL 203 (210)	6.03
				RRISL 2001 (210)	5.63
SRT-UP 14/4	SM Ruwansiri Monaragala	IL 1c	>1300	RRISL 2001 (210)	7.23
SRT-UP 14/5	MT Kumarage Sellakataragama	DL5	>600	RRIC 121 (210)	7.07

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

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

Four experimental plots were established in Bibile area in collaboration with World Vision Organization. One trial was established in Kataragama. Details are given in Table 29.

Table 29. *Details of establishment of clones in 2015 at Uva Province*

Trial	Smallholder and Location	Agro climatic Region	75% expectancy value of Annual Rainfall (mm)	Clones and no: of plants planted	Planting season
Bibile (collaborate with World Vision)					
SRT-UP 15/1-WV	HM Punchibanda Ilukpathana	IL1c	>1300	RRISL 2001-(215)	December
SRT-UP 15/2-WV	AM Karunawathie Ilukpathana	IL1c	>1300	RRISL 2001 (215)	December
SRT-UP 15/3-WV	HMW Wijekumara Kudumirisketiya Ilukpathana	IL1c	>1300	RRISL 2001 (430)	December
SRT-UP 15/4-WV	Chandana Kumara Radaliyagoda Ilukpathana	IL1c	>1300	RRISL 2001- (115)	December
Kataragama					
SRT-UP 15/5	GKChaminda Diyawaragmmana Junction, Sella Rd	DL 5	>650	RRISL2001 RRISL 203 (215)	December

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

Smallholder/RRI collaborative clone trial planted in 2015 – Central Province

Three experimental plants were established in Matale district and their details are given in Table 30.

Table 30. *Details of establishment of clones in 2015 at Central Province*

Trial	Smallholder and Location	Agro climatic Region	75% expectancy value of Annual Rainfall (mm)	Clones and no: of plants planted	Planting season
SRT – CP 15/1	W Wekunagoda Palapaththla Seelan Estate Koongahamulla Palapathwala	IM3B	>1200	RRISL 2001 (125)	December
				RRISL2005 (125)	
				RRISL 2006 (125)	
				RRISL 2100 (125)	
SRT – CP 15/2	PM Gunasekera Palapaththla Madawalaulpotha			RRISL 2001(125)	December
				RRISL 2005 (125)	
				RRISL 2006 (125)	
				RRISL 2100 (125)	
SRT – CP 15/3	Willium Bogstoa Hathamunagala Est (A divi) Madawalaulpotha			RRISL 2001 (125)	December-January 2016
				RRISL 2005 (125)	
				RRISL 2006 (125)	
				RRISL 2100 (125)	

(S P Withanage, P V A Anushka, L S Kariyawasam and T B Dissanayake)

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

One experimental trial was established in Polonnaruwa district and details are given in Table 31.

Table 31. *Details of establishment of clones in 2015 at North Central Province*

Trial	Smallholder and Location	Agro climatic Region	75% expectancy value of Annual rainfall (mm)	Clone and no: of plants planted	Planting season
SRT-NCP 15/1	Army camp Kandakaduwa Polonnaruwa	DL1c	>900	RRISL 2001 (500) RRISL 2006 (500)	October 2015

(S P Withanage, P V A Anushka, L S Kariyawasam and T B Dissanayake**)**

Smallholder/RRI collaborative clone trial–established in 2015 North Western Province

Four experimental plants were established in Putalam and Kurunagala districts and their details are given in Table 32.

Table 32. *Details of establishment of clones in 2015 at North Western Province*

Trial	Smallholder and Location	Agro climatic Region	75% expectancy value of Annual rainfall (mm)	Clone and no: of plants	Planting season
SRT –NWP15/1	LA Karunawathie, Uriyawa Anamaduwa	DL3	>800	RRISL2001 (75)	December-January 2016
				RRISL2005 (75)	
				RRISL2006 (75)	
				RRISL2100 (75)	

Trial	Smallholder and Location	Agro climatic region	75% expectancy value of Annual Rainfall (mm)	Clone and No. of plants	Planting season
SRT -NWP 15/2	HM Somalatha Uriyawa, Anamaduwa	DL3	>800	RRISL2001 (75)	December-January 2016
				RRISL2005 (75)	
				RRISL2006 (75)	
				RRISL2100 (75)	
SRT-NWP 15/3	Ven; Dhammananda Tero, Kelegama, Anamaduwa	DL3	>800	RRISL2001 (125)	December-January 2016
				RRISL2005 (125)	
				RRISL2006 (125)	
				RRISL2100 (125)	
SRT-EP 14/4	Ananada Madawila Kotawehera, Nikawaratiya	DL3	>800	RRISL2001 (90)	December-January 2016
				RRISL2005 (90)	
				RRISL2006 (90)	
				RRISL2100 (90)	

(S P Withanage, P V A Anushka, L S Kariyawasam and T B Dissanayake)

PLANT SCIENCE

A M W K Senevirathna and N M C Nayanakantha

DETAILED REVIEW

Staff

Dr A M W K Senevirathna, Principal Research Officer and Acting Head was appointed as the Head of the Department with effect from 20th March, 2015. Dr N M C Nayanakantha, Principal Research Officer, Mrs S A Nakandala, and Mr T U K Silva, Research Officers, Mrs G A S Wijesekera, Mrs R K Samarasekara, Mr M N de Alwis, Mr D L N de Zoysa, Mr P D Pathirana and Mr P K W Karunatilaka, Experimental Officers, R Handapangoda and Mrs E U M de Z Dissanayake Technical Officers, Mrs D E Jayawardena, Mrs P D A H M A de Almeida and Mrs B V H Madhushani, Management Assistants were on duty throughout the year.

Dr A M W K Senevirathna resigned from RRISL on 31st December 2015 and joined the Uwa Wellasa University of Sri Lanka. Mr M K P Perera, Experimental Officer, was transferred to Biochemistry and Physiology Department with effect from 24th April 2015.

Mrs B V H Madhushani, Mr H A U Deshappriya and Miss L A R Amarathunga were appointed as Technical Officer with effect from 24th April, 2015. Miss N C Jayawanthi was appointed as Technical Officer with effect from 6th May, 2015.

Retirements:

Mr K A G B Amaratunga, Research Officer, retired from the services of RRISL with effect from 03.09.2015. Mr Amaratunga, during his long carrier of 38 years spent in the Plant Science Department, was able to contribute significantly towards productivity improvement related activities specially in harvesting. He was an expert in training, specially latex harvesters and also a valuable resource person in advisory work in all aspects of agronomy. He deserves a special appreciation for his commendable contribution to the Plant Science Department and also to rubber industry. Therefore, on behalf of RRISL, we wish him all the best and a happy retirement.

Research students

- Miss K D Madhushani, University of Ruhuna conducted her final year project on "Effect of seed treatment with nitric oxide on growth attributes of polybagged rubber (*Hevea brasiliensis*) seedlings" under the supervision of Dr N M C Nayanakantha.

- Miss E W A Gayani, University of Ruhuna conducted her final year project on "Seed source variation and polybag size on growth of polybagged rubber (*Hevea brasiliensis*) seedlings" under the supervision of Dr N M C Nayanakantha and Dr (Mrs) P Seneviratne.
- Miss M K U L Mirihana, University of Wayamba conducted her final year project on "The effect of nitric oxide pretreatment on growth and root architecture of polybagged rubber (*Hevea brasiliensis*) seedlings" under the supervision of Dr N M C Nayanakantha.
- Mr R M C G Rathnayake, Uva Wellassa university of Sri Lanka conducted his final year project on "Effect of exogenous nitric oxide on growth and physiological parameters of the rubber clone PB 260 subjected to drought" under the supervision of Dr N M C Nayanakantha.
- Miss W K S W Watawala, Uva Wellassa university of Sri Lanka conducted her final year project on "Study on effectiveness of ascorbic acid, DRC+3 and sodium nitroprusside on recovery of tapping panel dryness (TPD) of rubber trees" under the supervision of Dr A M W K Senevirathna
- Mr K H N C De Silva, Faculty of Agriculture, University of Peradeniya, carried out a research project on "Assessment of Tapping Panel Dryness Incidence in Rubber Clones and Identification of Early Detection Indicators" under the supervision of Dr A M W K Senevirathna.

Seminars/Training Programmes/Workshops/Exhibitions conducted

Subject/Theme	Number of programmes	Beneficiary/Client	Officers involved
Tapping	01	Rubber Development Officers	AMWK Senevirathna
Growth improvement and abiotic stress tolerance in rubber plants	03	Rubber Development Officers Members of Scientific Committee	NMC Nayanakantha
Nursery management and immature upkeep	01	Rubber Development Officers	NMC Nayanakantha
Latex harvesting	12	Smallholders (SPEnDP)	KAGB Amaratunga
Intercropping	02	Rubber Development Officers	TUK Silva
Improving Tapping quality	01	RRI Staff	KAGB Amaratunga TUK Silva PKW Karunatilaka
Tapping	01	Millawitiya Estate	MN de Alwis
Tapping	04	Smallholders (SPEnDP)	MN de Alwis

Subject/Theme	Number of programmes	Beneficiary/Client	Officers involved
Planting	01	Haldumulla Estate	MN de Alwis
Planting	15	Ampara, Dambana Smallholders	MN de Alwis
Rainguards	01	Managers, Asst. Managers & Field Officers	P KW Karunatilaka
Latex harvesting	20	Smallholders (SPEnDP)	PKW Karunatilaka
Latex harvesting	05	Field staff & Tappers	PKW Karunatilaka
Latex harvesting	02	NIPM students	PKW Karunatilaka
Latex harvesting	05	University students- Colombo,Wayamba, Uva Wellass and Jaffna	PKW Karunatilaka
Latex harvesting	02	DATC Training students	PKW Karunatilaka
Latex harvesting	04	Agricultural Diploma students	PKW Karunatilaka

Seminars/Conferences/Meetings/Workshops attended

Officer	Subject	Organization
AMWK Senevirathna NMC Nayanakantha SA Nakandala TUK Silva	Workshop on Project Management	Rubber Research Institute
AMWK Senevirathna NMC Nayanakantha SA Nakandala KAGB Amaratunga TUK Silva	Scientific Committee Meeting	Rubber Research Institute
AMWK Senevirathna NMC Nayanakantha	Progress Meeting Development Project Meeting	Ministry of Plantation Industries
AMWK Senevirathna	Board of study Meeting	Wayamba University of Sri Lanka
AMWK Senevirathna TUK Silva	Progress Meeting	National Science Foundation
NMC Nayanakantha	4th Young Scientists Forum (YSF) Symposium	Young Scientists Forum (YSF) of National Science and Technology Commission (NASTEC)
	14th Agricultural Research Symposium	Wayamba University of Sri Lanka
	27th Post Graduate Institute of Agriculture (PGIA) Annual Congress	University of Peradeniya
	Organic Agriculture Meeting	Sri Lanka Standards Institute (SLSI)

Officer	Subject	Organization
TUK Silva	Progress Meeting	Post Graduate Institute of Agriculture, University of Peradeniya
	International Rubber Conference, Vietnam	International Rubber Research and Development Board (IRRDB)

Services

Testing the quality of polythene

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

Supplying the technically specified tapping knives and marking plates

About 5720 technically specified tapping knives were issued to the estates under RPCs, Rubber Development Department and smallholders. Majority of these knives for smallholder sector was issued through the RDD through tapper training schools. 156 marking plates were supplied to stakeholders (P Seneviratne, A M W K Senevirathna, W Karunathilaka and D E Jayawardana).

Issuing authentic budwood and budded plants

Authentic budwood were issued to stakeholders to establish budwood nurseries and details are given in Table 24. 250,000 budded plants were distributed in Badulla, Ampara, Polonnaruwa, Trincomali and Moneragala districts (P Seneviratne, W Senevirathna, M N de Alwis and M K P Perera).

Nursery inspection

Government, RPC and Private nurseries were inspected and details are given in Tables 25, 26 and 27 (A M W K Senevirathna, P Seneviratne, M N de Alwis, L N de Zoysa and R Handapangoda).

Visits

Advisory	-	10
Experimental	-	299
Nursery inspection	-	165
Total	-	**474**

LABORATORY INVESTIGATIONS

Tissue culture

No lab work was done at RRISL due to lack of functioning laboratory equipment (N M C Nayanakantha and P Seneviratne).

FIELD EXPERIMENTS

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

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

Data on wintering and flowering could not be collected as planned due to lack of transport facilities (N M C Nayanakantha, P Seneviratne and P D Pathirana).

Seed production (CC/2003/1/b)

Seeds were collected from 21 clones from five plantation companies and one small holder field as depicted in Fig. 1. A satisfactory seed production was observed from RRISL 201 followed by BPM 24, RRISL 217, RRISL 220 and RRISL 226 irrespective of sites. Although RRIC 100 was a prolific seed producer in previous years, low seed yield from RRIC 100 in the current year was mainly due to *Phytophthora* leaf and pod disease causing premature fall of infected pods. RRISL 201 recorded the highest seed production in current year. Generally RRISL 201 was also a prolific seed producer in most of the previous years. BPM 24 had also shown a satisfactory seed yield in previous years and RRISL 217, RRISL 220 and RRISL 226 seem to be promising for seed production. Since all the sites were found within the wet zone region, there is a positive indication that seed requirements can be fulfilled from wet areas as well provided that high seed producing clones are available for seed collection. Unfortunately the clones such as RRISL 203, RRISL 2001 and RRIC 121 recommended for the small holder sector have recorded a low seed yield in current year similar to that in previous years (N M C Nayanakantha, P Seneviratne and P D Pathirana).

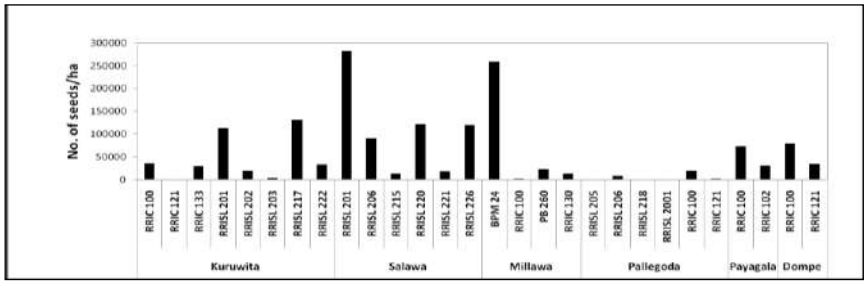


Fig. 1. Total seed production in each clone in different estates

Priming of rubber seeds for improved germination and tolerance to abiotic stresses (SP/2013/DF)

Fresh seeds collected from the clone BPM 24 were treated with nitric oxide (NO) donor sodium nitroprusside (SNP) at different concentrations *viz.,* 20µM, 50µM, 100µM and 200 µM for 6 hours with or without seed coat. Mock treated seeds were soaked in water for 6hrs. Germination percentage was recorded at two-day intervals from 7-21 days after sowing. Treatment with SNP at low concentrations (50-100 µM) accelerated the germination and improved the germination percentage irrespective of seed coat. Seeds devoid of seed coat germinated earlier than seeds with the seed coat irrespective of SNP treatment (Table 1 & 2). Seeds devoid of seed coat and treated with SNP at 100µM showed the highest germination percentage after 7 days from sowing. Seedlings derived from seeds without seed coat showed improved root and shoot characteristics than the seedlings derived from seeds with seed coat. Interaction effects between seed coat and SNP concentrations were also observed for some of the parameters such as leaf chlorophyll content, dry weight of shoot, length of tap root and secondary roots. Soaking of rubber seeds in 100µM SNP was effective for overall growth improvement after three months from transplanting into polybags (Table 3 & 4 and Fig. 2,3 & 4).

Table 1. *Effect of NO donor SNP on percentage germination when the factor 1 (presence or absence of seed coat) is fixed after 7 days from sowing*

Treatment factor 1 (Effect of seed coat)	**Treatment factor 2 (Effects of soaking treatment)**					
	Transformed values (Arc Sin) and % germination (in parentheses)					
	Control	Soaked in water	Soaked in 20µM SNP	Soaked in 50µM SNP	Soaked in 100µM SNP	Soaked in 200µM SNP
With seed coat	0.02 (2%)^{c}	0.03 (3%)^{bc}	0.04 (4.5%)^{b}	0.06 (6.5%)^{a}	0.07 (7.5%)^{a}	0.03 (3%)^{bc}
Without seed coat	0.48 (47%)^{c}	0.55 (53%)^{b}	0.59 (56%)^{b}	0.68 (63.5%)^{a}	0.70 (65%)^{a}	0.36 (36%)^{d}

(Arc sin values with same letter in row wise are not significantly different)

Table 2. *Effect of seed coat on percentage germination when the factor 2 (soaking treatments with SNP) is fixed after 7 days*

Treatment factor 1 (Effect of seed coat)	Treatment factor 2 (Effects of soaking treatment)					
	Transformed values (Arc Sin) and % germination (in parentheses)					
	Control	Soaked in water	Soaked in 20µM SNP	Soaked in 50µM SNP	Soaked in 100µM SNP	Soaked in 200µM SNP
With seed coat	0.02 (2%)[b]	0.03 (3%)[b]	0.04 (4.5%)[b]	0.06 (6.5%)[b]	0.07 (7.5%)[b]	0.03 (3%)[b]
Without seed coat	0.48 (47%)[a]	0.55 (53%)[a]	0.59 (56%)[a]	0.68 (63.5%)[a]	0.70 (65%)[a]	0.36 (36%)[a]

(Arc sin values with same letter in column wise are not significantly different)

Table 3. *Effect of seed treatment with NO donor SNP (irrespective of seed coat) on plant height and stem diameter after three months from transplanting into polybags*

Seed treatment	Stem height (cm/plant)	Stem diameter (mm/plant)
Control	65.36±1.18[d]	8.07± 0.07[c]
Soaked in water	66.86±1.13[cd]	7.88± 0.14[c]
Soaked in 20µM SNP	68.86± 1.11[c]	8.61± 0.16[b]
Soaked in 50µM SNP	69.72± 0.83[c]	8.75± 0.12[b]
Soaked in 100µM SNP	73.01± 1.54[a]	10.63± 0.31[a]
Soaked in 200µM SNP	84.31± 1.82[c]	7.88± 0.19[c]

(Means with same letter in a column are not significantly different)

Table 4. *Effect of seed treatment (without seed coat) with NO donor SNP on number of leaves and leaf area after three months from transplanting into polybags*

Seed treatment	No. of leaves (per plant)	Leaf area (cm^2/plant)
Control	9.8± 0.44[a]	888.55±20.75[c]
Soaked in water	9.8± 0.36[a]	921.71±16.67[bc]
Soaked in 20µM SNP	9.8± 0.36[a]	977.66±19.21[b]
Soaked in 50µM SNP	10.1± 0.46[a]	963.89±19.63[bc]
Soaked in 100µM SNP	10± 0.21[a]	1260.68±14.88[a]
Soaked in 200µM SNP	9.6± 0.43[a]	980.09±33.37[b]

(Means with same letter in a column are not significantly different)

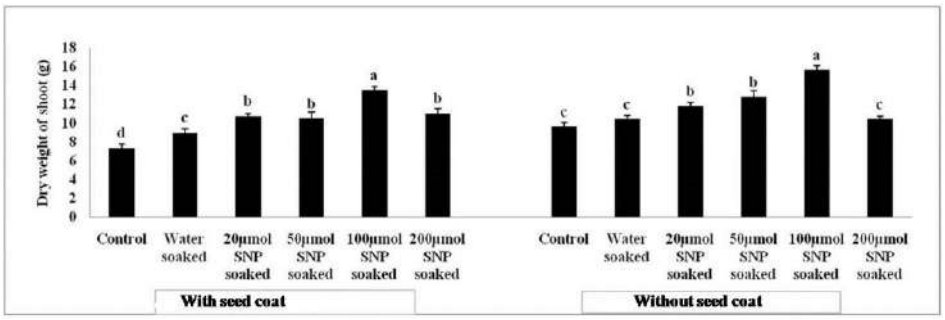


Fig. 2. Effect of seed treatment with NO donor SNP on dry weight of shoot after three months from transplanting into polybags

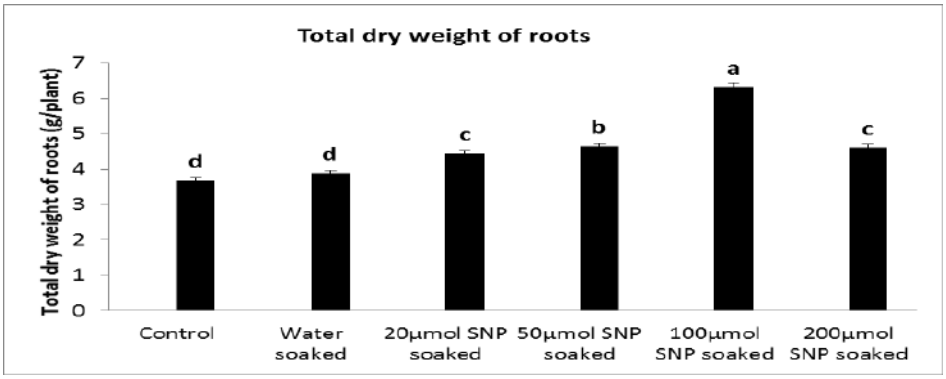


Fig. 3. Effect of seed treatment with NO donor SNP on dry weight of roots after three months from transplanting into polybags

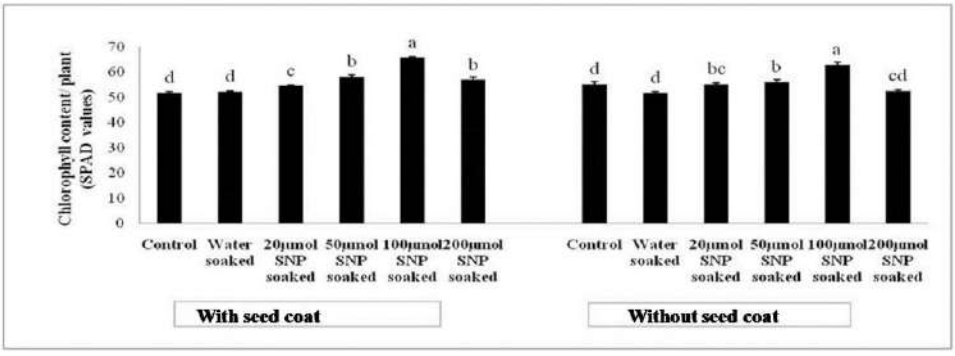


Fig. 4. Effect of seed treatment with NO donor SNP on leaf chlorophyll content after three months from transplanting into polybags

Investigation on the use of sodium nitroprusside (as a nitric oxide (NO) donor) on growth and abiotic stress tolerance in rubber plants (SN/2013/DF)

Glass house experiments at Dartonfield

Budded plants from PB 260 at two leaf whorl stage were subjected to drought conditions (no watering) with or without SNP as follows;

1. Control (continuous watering, 100 ml per plant/day)
2. Treatment 1 (no watering)
3. Treatment 2 (SNP 50 µM + Watering (100 ml per plant/day)
4. Treatment 3 (SNP 50 µM + No watering)
5. Treatment 4 (SNP 100 µM + Watering (100 ml per plant/day)
6. Treatment 5 (SNP 100 µM + No watering)

Physiological parameters *viz.,* net CO_2 assimilation rate (A), stomatal conductance (gs), intercellular CO_2 concentration (C_i), transpiration rate, water use efficiency and chlorophyll content were measured at different time intervals *viz,* 0, 2, 4, 7 and 14 days after imposing the treatments. After two weeks from drought treatment, all the plants were watered normally to attain into normal growth status and growth parameters *viz.,* diameter of stem, length of internodes, number of leaves and leaf area of the new shoots, and dry weight of the new shoots were recorded. Plants treated with 100 µM SNP under drought condition enhanced some physiological parameters (after two days) and growth parameters (after one month) from drought treatment (Table 5, 6, 7 & 8).

Table 5. *Effect of exogenous NO donor SNP on net photosynthesis rate of rubber plants*

	Net photosynthesis rate ($\mu mol^{-1}CO_2m^{-2}s^{-1}$)				
Treatment	**Day 0**	**Day 2**	**Day 4**	**Day 7**	**Day 14**
Control	4.81 ± 0.40^{a}	7.55± 1.34^{ab}	12.56 ± 0.62^{a}	11.46± 0.88^{a}	9.86 ± 0.99^{a}
T1	5.55± 0.82^{a}	2.62± 0.62^{c}	4.52± 1.07^{b}	0.89± 0.23^{b}	0.42 ± 0.09^{b}
T2	5.02± 0.96^{a}	7.50 ± 0.70^{ab}	13.23± 1.07^{a}	12.38± 0.85^{a}	10.26 ± 1.22^{a}
T3	5.23± 0.16^{a}	4.80 ± 0.81^{bc}	6.95± 0.95^{b}	1.52± 0.27^{b}	0.47 ± 0.09^{b}
T4	4.40 ± 0.54^{a}	8.29 ± 0.69^{a}	13.53± 1.02^{a}	12.48± 0.45^{a}	9.90 ± 0.47^{a}
T5	5.89 ± 0.56^{a}	6.28± 1.08^{b}	5.36± 1.34^{b}	1.93± 0.51^{b}	0.63 ± 0.10^{b}

(Means with same letter in a column are not significantly different)

Table 6. *Effect of exogenous NO donor SNP on stomatal conductance of rubber plants*

Treatment	Stomatal conductance (mmol m^{-2} s^{-1})				
	Day 0	**Day 2**	**Day 4**	**Day 7**	**Day 14**
Control	0.037±0.004^{a}	0.058±0.012^{ab}	0.213±0.022^{a}	0.249±0.033^{a}	0.130±0.034^{ab}
T1	0.054±0.009^{a}	0.034±0.009^{b}	0.140±0.004^{b}	0.022±0.004^{b}	0.013±0.002^{c}
T2	0.044±0.007^{a}	0.068±0.012^{a}	0.169±0.048^{a}	0.273±0.033^{a}	0.175±0.053^{a}
T3	0.041±0.004^{a}	0.040±0.007^{ab}	0.032±0.004^{b}	0.038±0.022^{b}	0.015±0.003^{c}
T4	0.045±0.014^{a}	0.072±0.015^{a}	0.222±0.044^{a}	0.261±0.028^{a}	0.083±0.016^{bc}
T5	0.061±0.007^{a}	0.047±0.006^{ab}	0.036±0.003^{b}	0.023±0.003^{b}	0.008±0.001^{c}

(Means with same letter in a column are not significantly different)

Table 7. *Effect of exogenous NO donor SNP on chlorophyll content of rubber plants*

Treatment	Chlorophyll content (SPAD value)			
	Day 0	**Day 7**	**Day 14**	**Two weeks after recovering**
Control	53.28±1.449^{a}	54.85±1.617^{ab}	56.56±1.416^{bc}	59.42±0.490^{ab}
T1	55.35±1.456^{a}	51.21±0.951^{b}	47.74±0.774^{e}	48.46±1.735^{d}
T2	51.96±2.179^{a}	55.95±1.806^{ab}	58.11±0.704^{ab}	60.23±0.619^{ab}
T3	53.95±1.536^{a}	52.36±1.126^{ab}	51.45±0.937^{de}	54.33±1.451^{c}
T4	53.51±0.919^{a}	56.46±1.132^{a}	59.75±0.855^{a}	61.18±0.823^{a}
T5	56.18±2.232^{a}	54.94±1.592^{ab}	52.41±2.396^{dc}	57.44±1.221^{bc}

(Means with same letter in a column are not significantly different)

Table 8. *Effect of exogenous NO donor SNP on growth parameters of rubber plants*

Treatment	**Number of leaves**	**Dry weight of shoots**	**Internodal lengths**	**Leaf area**
Control	12.7 ± 0.615^{abc}	11.40 ± 0.751^{ab}	17.56 ± 0.610^{a}	1520.8 ± 151.87^{ab}
T1	10.3 ± 0.715^{d}	8.74 ± 1.001^{c}	13.96 ± 1.642^{a}	1153.5 ± 113.78^{b}
T2	13.8 ± 0.563^{a}	12.53 ± 0.864^{a}	18.71 ± 1.724^{a}	1742.5 ± 196.50^{a}
T3	11.3 ± 0.919^{cd}	9.24 ± 0.625^{bc}	15.35 ± 1.178^{a}	1239.3 ± 78.40^{b}
T4	13.3 ± 0.703^{ab}	12.08 ± 0.6732^{a}	18.63 ± 1.536^{a}	1661.6 ± 80.78^{a}
T5	11.8 ± 0.428^{bcd}	9.07 ± 0.674^{c}	15.63 ± 3.264^{a}	1160.5 ± 124.43^{b}

(N M C Nayanakantha, R M C G Rathnayake, W Senevirathna, W Karunathilake, Amila Udayanga, Akila Amarathunga, Chamani Jayawanthi, B V Hasangi Madhushani and P Seneviratne)

Open nursery experiment at Dartonfield

Seedlings obtained after treatment of seeds with SNP or after soaking with SNP were grown in a polybag nursery as explained under the heading *SP/2013/DF* and under "*Soaking of rubber seedlings in SNP solution".*

Open nursery experiments at Galewatta and Nivithigalakele

Growth improvement was observed in terms of stem diameter, number of roots, dry weight of roots/shoots with SNP treatment at low concentrations (50-100). There was no significant difference in growth parameters after imposing SNP treatment as a single application or in one month or two months intervals. However, application of SNP at two weeks interval was resulted in no significant growth improvement as compared to control.

Open nursery experiment at Moneragala

An experiment was set to see the effect of SNP under open nursery condition at Moneragala (under hot and dry whether condition). A range of SNP concentrations (low to high (0.05-3mM) was tested at different application intervals (single, 2, 3, 7 and 14 days). Imposing of SNP treatment at high concentrations negatively affected growth and development of rubber seedlings under hot and dry weather conditions irrespective of application intervals. When low SNP treatments were imposed concomitantly with high SNP treatments, the beneficial effect of SNP obtained at low concentrations could not be achieved (N M C Nayanakantha and P D Pathirana).

Soaking of rubber seedlings in SNP solution

Rubber seedlings were soaked in SNP solution at different concentrations overnight and transplanted into polybags. Growth parameters were recorded after four and ten weeks from transplanting into polybags. Soaking of rubber seedlings in SNP solutions improved some shoot and root characteristics as compared to control (Table 9 and Fig. 5).

Table 9. *Effect of soaking treatment with SNP on shoot and root characteristics of rubber seedlings after 12 weeks from transplanting into polybags*

Treatment	DW of PR	DW of ESR+SR	DW of total root
T1 (Control)	0.74 ± 0.06	0.52 ± 0.12	1.26 ± 0.06
T2 (Soaked in water)	0.81 ± 0.05	0.59 ± 0.10	1.40 ± 0.07
T3 (Soaked in 20 µM SNP)	0.81 ± 0.05	0.73 ± 0.09	1.54 ± 0.5
T4 (Soaked in 50 µM SNP)	0.85 ± 0.05	0.87 ± 0.13	1.72 ± 0.12
T5 (Soaked in 100 µM SNP)	0.72 ± 0.04	0.56 ± 0.12	1.28 ± 0.15

DW: Dry weight; PR: Primary root; ESR: Early secondary roots

(N M C Nayanakantha, M K U L Mirihana and P Seneviratne)

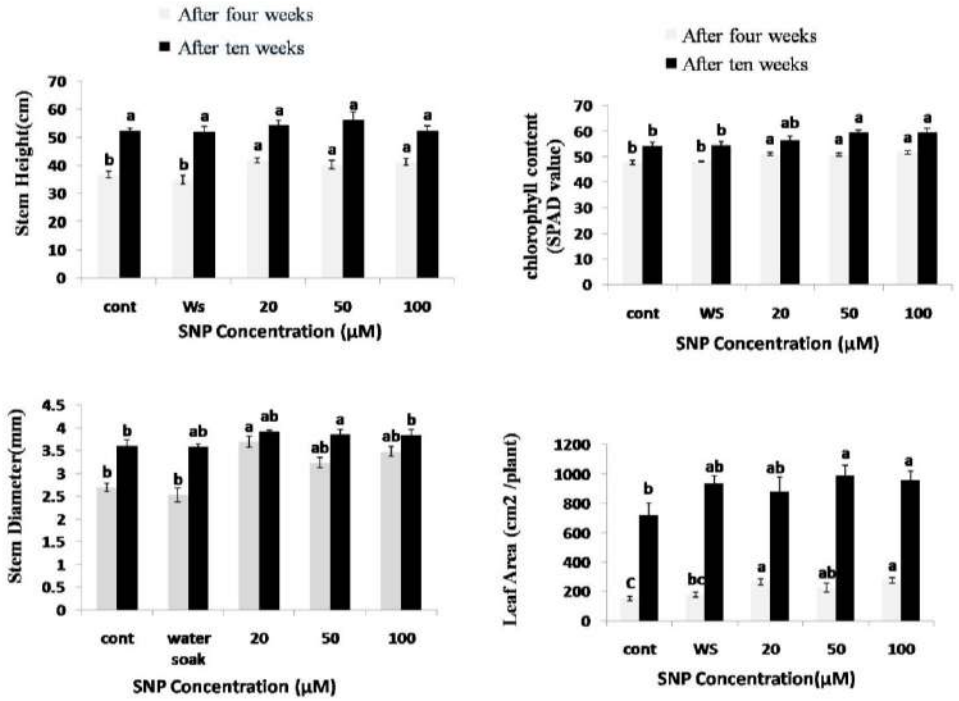


Fig. 5. Effect of soaking treatment with SNP on shoot characteristics of rubber seedlings after 4 and 12 weeks from transplanting into polybags. (N M C Nayanakantha, M K U L Mirihana and P Seneviratne)

Field experiment at Nottinghill Estate, Mawathagama

A filed experiment was set to see the effect of foliar application of SNP on growth of rubber plants under stress condition (high temperature and low soil water status). One year old rubber plants from RRISL 2001 were spray treated with SNP at two concentrations, 50 µM or 100 µM. Each treatment had 25 plants and each treatment block was separated by untreated plants with a distance of about 30m. Control plants were devoid of SNP treatment. Plant girth and leaf chlorophyll contents were recorded before imposing the treatments (N M C Nayanakantha).

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

Seeds collected from 8 clones *viz*., PB 86, RRIC 100, RRISL 201, RRISL 206, RRISL 217, RRISL 220, BPM 24 and PB 260 were established in germination beds. Germinated seedlings were transplanted into polybags arranged in a Randomized Completely Block Design (RCBD with four blocks and each treatment

had 30 plants and thereby a clonal seedling nursery was established. Results revealed that there was no significant difference in stem diameter of the seedlings derived from different clones, although some differences were observed for stem height and root characteristics after three months from transplanting into polybags (Fig. 6 & 7 and Table 10).

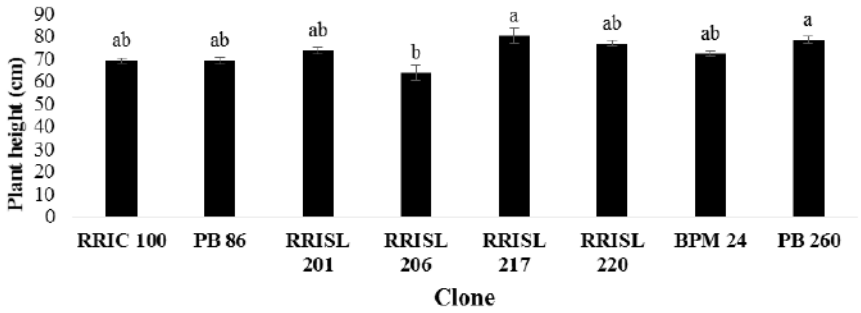


Fig. 6. Effect of clone on height of the seedlings after 3 months from transplanting into polybags

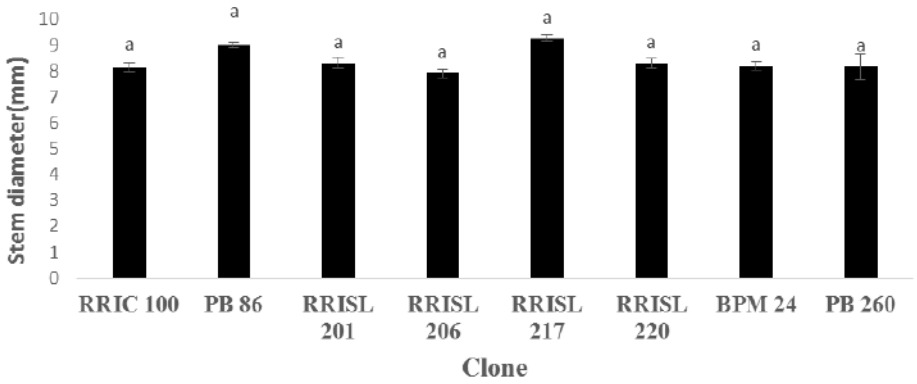


Fig. 7. Effect of clone on diameter of the seedlings after 3 months from transplanting into polybags

Table 10. *Effect of clone on root characteristics of rubber seedlings after three months from transplanting into polybags*

Clone	No of ESR	No of SR	Length of ESR (cm)	Length of SR (cm)	Length of tap root (cm)
RRIC 100	12.0±0.56^{ab}	60.8±2.60^{a}	95.18 ±2.51^{ab}	565.1±23.70^{a}	47.46±3.23^{a}
PB 86	15.0±0.89^{a}	63.2±2.20^{a}	125.5 ±9.46^{a}	615.6±36.05^{a}	39.1±1.88^{a}
RRISL 201	8.2±0.49^{b}	75.0±2.74^{a}	55.26 ±4.61^{b}	833.4±41.64^{a}	42.06±1.51^{a}
RRISL 206	13.6±0.86^{a}	67.0±2.89^{a}	109.36±12.00^{ab}	771.1±52.51^{a}	41.4±2.15^{a}
RRISL 217	11.8±0.47^{ab}	56.8±3.40^{a}	128.12±12.10^{a}	723.1±45.33^{a}	42.54±3.21^{a}
RRISL 220	12.2±0.49^{ab}	59.4±2.70^{a}	113.12±11.24^{ab}	678.4±20.82^{a}	36.22±0.57^{a}
BPM 24	11.8±0.72^{ab}	61.6±1.90^{a}	87.26±5.10^{ab}	646.4±21.80^{a}	39.3±2.35^{a}
PB 260	12.4±0.57^{ab}	51.8±4.30^{a}	124.98±4.79^{a}	726.7±57.60^{a}	36.5±3.18^{a}

ESR: Early Secondary Roots; SR: Secondary Roots

(Means with same letter in a column are not significantly different)

(N M C Nayanakantha, E W Gayani and P Seneviratne)

Clonal propagation

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

Experimental details are given in Annual Review for 2014 and general maintenance of the plants was done (P Seneviratne and G A S Wijesekera).

Effect of bag size on the growth of rubber plants

An experiment was set to see the effect of bag size on growth of rubber seedlings. Three types of poly bags *viz.,* standard size (6"×15"), medium size (5"×15") and small size (3.75"×15") were used to raise seedlings. Germinated seedlings from the clone RRISL 217 were transplanted into polybags arranged in a Randomized Complete Block Design. Results revealed that there was no significant difference in growth characterises of rubber seedlings raised in polybags of different sizes. However, there was a significant difference in root dry weights of rubber seedlings raised in polybags of different sizes (Table 11 & 12).

Table 11. *Effect of polybag size on growth of rubber seedlings after three months from transplanting into polybags*

Treatment	Stem height	Stem diameter
Standard size (6"×15")	77.58 ±2.66^{a}	7.9 ±0.18^{a}
Medium size (5"×15")	72.82 ±2.44^{a}	7.76 ±0.03^{a}
Small size (3.75"×15")	70.26 ±4.11^{a}	7.48 ±0.24^{a}

(Means with same letter in a column are not significantly different)

Table 12. *Effect of polybag size on growth parameters of rubber seedlings after three months from transplanting into polybags*

Treatment	Dry weight of shoot (g/Plant)	Dry weight of tap root (g/Plant)	Dry weight of ESR+SR (g/Plant)	Dry weight of total roots
Standard size (6"×15")	11.75±1.68[a]	2.23±0.23[ab]	1.18±0.11[a]	3.41 ±0.17[a]
Medium size (5"×15")	11.7±1.28[a]	2.57±0.09[a]	0.73±0.15[b]	3.3 ±0.15[a]
Small size (3.75"×15")	9.88±1.04[a]	1.81±0.17[b]	0.73±0.13[b]	2.54 ±0.17[b]

ESR: Early Secondary Roots; SR: Secondary Roots

(Means with same letter in a column are not significantly different)

(N M C Nayanakantha, E W Gayani, P Seneviratne and G A S Wijesekera)

Bud grafting

Rejuvenation of budwood plants - Egaloya Rubber Nursery

An experiment was carried out to assess the rejuvenation capacity of all the successive grafting passages. Seedlings were bud grafted with the budwood of 1-19 generations from three clones *viz.,* RRIC 100, RRIC 102 and RRIC 121. Sprouting % of the scion, length and diameter of the scion, length of the 1st and 2nd leaf whorls were measured (Table 13, 14, 15, 16 & 17).

Table 13. *Sprouting % after two weeks of cut back*

Rejuvenation passages	Sprouting %		
	RRIC 100	RRIC 102	RRIC 121
G_1	89.8	-	-
G_2	100	-	-
G_3	7705	-	-
G_4	87.5	-	-
G_5	77.5	-	-
G_6	66.7	-	-
G_7	47.5	-	-
G_8	66.7	-	67.3
G_9	86.5	66.7	29.4
G_{10}	65	74.5	34.2
G_{11}	68.6	72.4	50
G_{12}	87.2	90.9	55.8
G_{13}	33.3	85.4	70.6
G_{14}	55.5	79.3	67.3
G_{15}	-	89.4	47.9
G_{16}	-	71	58.8
G_{17}	100	-	-
G_{18}	-	-	-
G_{19}	-	65.8	71.7

Table 14. *Mean scion length (cm) after two weeks of cut back*

Rejuvenation passages	Mean scion length (cm)		
	RRIC 100	**RRIC 102**	**RRIC 121**
G_1	4.2	-	-
G_2	2.4	-	-
G_3	4	-	-
G_4	3.4	-	-
G_5	4	-	-
G_6	2.5	-	-
G_7	2.25	-	-
G_8	1	-	2.9
G_9	5.4	2.2	2.0
G_{10}	5.3	3.4	1.7
G_{11}	2.4	2.1	2.3
G_{12}	3.9	4.9	3.1
G_{13}	4.7	7.1	3.4
G_{14}	3.8	2.7	2.5
G_{15}	-	5.3	3.5
G_{16}	-	3.6	4.1
G_{17}	-	-	-
G_{18}	-	-	-
G_{19}	-	1.9	4.3

Table 15. *Mean scion length (cm) after four weeks of cut back*

Rejuvenation passages	Mean scion length (cm)		
	RRIC 100	**RRIC 102**	**RRIC 121**
G_1	17.8	-	-
G_2	18.5	-	-
G_3	17	-	-
G_4	18.2	-	-
G_5	17	-	-
G_6	16.8	-	-
G_7	16.85	-	-
G_8	19	-	18.25
G_9	19	21.6	12.8
G_{10}	19	24.4	17.1
G_{11}	19.8	21.85	14.4
G_{12}	20.15	28	16.5
G_{13}	18	22.6	20.4
G_{14}	18.4	22.7	12.8
G_{15}	-	24.4	16.5
G_{16}	-	20.2	16.4
G_{17}	17.5	-	-
G_{18}	-	-	-
G_{19}	-	19.6	18.7

Table 16. *Angle of the shoot after six weeks of cut back*

Rejuvenation passages	Angle of the shoot		
	RRIC 100	**RRIC 102**	**RRIC 121**
G_1	21.8	-	-
G_2	21.8	-	-
G_3	25.3	-	-
G_4	24.3	-	-
G_5	24.3	-	-
G_6	28.6	-	-
G_7	26.3	-	-
G_8	20	-	33.7
G_9	25.8	50	30.3
G_{10}	27.6	33.7	32.7
G_{11}	21.8	29.3	32.3
G_{12}	27.6	33.4	33
G_{13}	28.7	35	31.8
G_{14}	27.5	26.8	27.2
G_{15}	-	30.8	28.5
G_{16}	-	32.5	29.7
G_{17}	17.5	-	-
G_{18}	-	-	-
G_{19}	-	25.3	29.3

Table 17. *Mean shoot diameter after six weeks of cut back*

Rejuvenation passages	Mean shoot diameter		
	RRIC 100	**RRIC 102**	**RRIC 121**
G_1	5.3	-	-
G_2	5.28	-	-
G_3	5.19	-	-
G_4	5.09	-	-
G_5	5.11	-	-
G_6	4.94	-	-
G_7	5.16	-	-
G_8	5.57	-	5.3
G_9	5.28	5.76	5.4
G_{10}	5.16	5.47	4.8
G_{11}	5.57	5.04	4.77
G_{12}	5.1	6.01	5.02
G_{13}	4.88	5.39	5.46
G_{14}	4.71	5.13	5.05
G_{15}	-	5.56	4.52
G_{16}	-	5.11	5.04
G_{17}	4.12	-	-
G_{18}	-	-	-
G_{19}	-	4.83	5.2

(P Seneviratne and G A S Wijesekera)

Root trainer experiment (RT/2015/Galewatta)

An experiment was set to study the growth and root architecture of rubber seedlings grown in root trainers as compared to polybags in collaboration with Soils and Plant Nutrition Department. Five different potting media were tested as listed below. Half of the plants from each treatment was manured with young budding fertilizer mixture while the other half was manured with Albert's solution at two weeks intervals.

Control - Polybags with top soil (normal potting mixture)
Treatment 1 - Root trainers with topsoil : compost (1:1)
Treatment 2 - Root trainers with coir dust: compost (1:1)
Treatment 3 - Root trainers with topsoil : compost : coir dust (1:1:1)
Treatment 4 - Root trainers with coir dust only

Results revealed that there was an overall reduction in growth of the seedlings irrespective of the type of containers (root trainer or polybag). However, seedlings manured with Albert's solution showed some improved growth characterises as compared to young budding mixture (Table 18, 19, 20 & 21).

Table 18. *Mean diameter of the plants (mm) after three months from transplanting into root trainers or polybags*

	Tr_1	Tr_2	Tr_3	Tr_4	Control
YB Fertilizer mixture	3.92 ± 0.05	4.15 ± 0.06	4.13 ± 0.07	4.31± 0.15	4.06 ± 0.12
Albert's solution	3.87 ± 0.06	4.32 ± 0.07	4.34 ± 0.08	4.5 ± 0.15	4.15 ± 0.13

Table 19. *Mean height of the plants (cm) after three months*

	Tr_1	Tr_2	Tr_3	Tr_4
YB mixture	36.1 ± 0.58	39.1 ± 0.67	37.9 ± 064	39.6 ± 1.04
Albert's solution	36.1 ± 0.55	40.0 ± 0.64	41.1 ± 0.69	39.5 ± 0.92

Table 20. *Mean dry weight of total roots (g) after three months*

	Tr_1	Tr_2	Tr_3	Tr_4	Control
YB mixture	0.85	0.96	1.71	0.96	2.0
Albert's solution	0.99	1.79	0.98	1.57	1.21

Table 21. *Mean dry weight of shoots (g) after three months*

	Tr_1	Tr_2	Tr_3	Tr_4	Control
YB mixture	3.06	3.01	4.0	2.72	3.68
Albert solution	2.5	4.02	2.46	3.76	3.38

(N M C Nayanakantha, P Seneviratne, G A S Wijesekera and E U M de Z Dissanayaka)

Plant restacking experiment at Monaragala

Plants from polybagged nursery established in January 2015 at Monaragala substation were used for the study. More or less same sized plants (about 500) were selected for restacking (R) and non-restacking (NR) treatments. Initially basal diameter of plants was recorded before bud grafting. After bud grafting and cutback of stock plants, about 250 plants were removed to detach the root system from soil and restacked (R) on the same place. Remaining 250 plants kept undisturbed (NR) after bud grafting and cutback. Percentage bud grafting success, scion diameter and height and chlorophyll content (SPAD value) were recorded after fully development of first leaf whorl. Data are present in Table 22.

Table 22. *Growth parameters of stock and scion of restacked (R) and non-restacked (NR) nursery plants at Monaragala substation. Data represent means of 250 plants except for Chlorophyll content where the sample mean is 45*

	Mean stock diameter at Budgrafting (mm)	**% Budgrafting Success**	**Scion diameter (mm)**	**Scion height (cm)**	**Chlorophyll content of scion leaves (SPAD value)**
Restacked plants (R)	2.90 ± 0.075	83.5	6.08 ± 0.073	24.5 ± 0.5	49.06 ± 1.1
Non Restacked plants (NR)	2.85 ± 0.073	84.1	6.82 ± 0.102	31.5 ± 0.7	53.30 ± 1.1

There was no difference in percentage bud grafting success between two treatments (R and NR). However, the scion diameter and height were high in non-restacked plants compared to that in restacked plants. Similarly the chlorophyll content was also high in scion leaves of NR plants (A M W K Seneviratne and L De Zoysa).

Performance of drip irrigation systems for young budding rubber nurseries

A field trial on drip irrigation system was conducted at Moneragala Sub Station to assess the possibility of using drippers for rubber nurseries as a water

saving method under severe drought conditions. Nursery was established in February 2015 and maintained throughout the year. Irrigation was commenced during dry periods from February – September.

Three irrigation systems were installed in the experiment site *viz.,* drip irrigation, sprinkler irrigation and manual watering (as control). A nursery with 2000 plants was established for testing drip and sprinkler systems. Systems were installed in the complete randomized block design (RCBD), with four treatments (Drippers at one day interval D1, Drippers at 2 days interval D2, sprinkler at one day interval and manual watering as control) and each treatment had three replicates. Drip irrigation was provided with pressure compensated on-line dripper at a discharge rate of 2.0 L/hr. Sprinkler irrigation was provided with non-technical sprinklers at 5m radius of water application and placed 5m apart with a discharge rate of 600 l/hr while drippers were operated 10 minutes at a rate of 2 l/hr. Manual watering was done by using watering cans. Number of irrigation days is shown in Table 23. There were 24 rainy days above 4 mm depths during the study period. According to the previous studies and pre-test which were done for drippers, irrigation time was given until soils gets saturated. Sprinklers were operated for 20 minutes with the discharge rate of 600 l/hr.

Table 23. *Irrigation frequencies of different irrigation methods*

Treatment	Irrigation interval (days)	Number of irrigation days
Drippers (D1)	01	60
Drippers (D2)	02	24
Sprinklers (S)	01	60
Manual watering (M)	01	60

Stem diameter and bud grafting success were recorded at monthly intervals throughout the study period and bio mass content was measured once in three months. Root density was taken at the time of uprooting. Samples were oven dried at 85^0C until a constant weight is obtained.

The average stem diameter of irrigated plants from April to August is shown in Figure 8. Seedlings irrigated with sprinkler system gave the highest stem diameter followed by the seedlings irrigated with drip system at one day interval (Fig. 8). Since plants were not exposed to drought stress condition, all seedlings reached to buddable girth within 5 months except the seedlings irrigated with D2 method and hence they were bud grafted later. Bud grafting success was measured after 3 weeks from grafting and also at two leaf whorl stage. Promising results were obtained with drip system at one day interval with regard to budgrafting success (S A Nakandala, P Seneviratne and P D Pathirana).

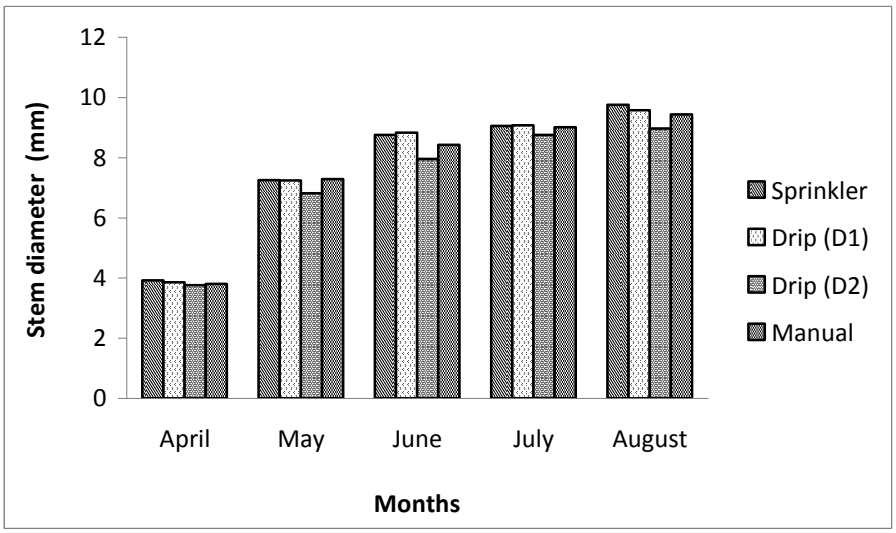


Fig. 8. *Effect of different irrigation systems on growth of rubber seedlings*

Crown budding

Data collection of crow budding experiments were not done during the year under review and also the data collected so far are being analysed (P Seneviratne, R K Samarasekera and M N de Alwis).

Budwood nurseries

BN/2000/DF, BN/2001/Olikanda, BN/2002/Olikanda, BN/2008/Dolahena

Budwood nurseries at Dartonfield, Olikanda and Dolahena were regularly visited. Weeding, manuaring, pollarding and application of fungicide were done. Morphological parameters were recorded at two leaf whorl stage at Dolahena nursery for the clone identification purpose. Authentic budwood were issued to a stakeholder as shown in Table 24.

Table 24. *Budwood issued (m) to estates*

Clone	Budwood issued to Delkeith Estate (m)
RRISL 2003	200
RRISL 2004	200
PB 260	300
Total	700

(P Seneviratne, M K P Perera and R Handapangoda)

Budwood nursery for clone identification purposes (2010/DF)

Pollarding and regular maintenance were done. Morphological parameters were recorded at two leaf whorl stage (P Seneviratne and L de Zoysa).

Moneragala Substation

Management of nurseries, distribution of plants, new planting programmes, upkeep of fields and training programmes were done successfully (A M W K Senevirathna, P Perera and V G D N Gunaseela).

Young budding nursery at Monaragala

About 15 350 good quality young budded plants were obtained from 2015 January nursery and 8909 plants were issued (A M W K Senevirathna, P Seneviratne, P Perera and V G D N Gunaseela).

Budwood nursery

Budwood nurseries with 1603 plants were maintained properly. Details were given in Annual Review for 2013 (A M W K Senevirathna, P Seneviratne, P Perera and V G D N Gunaseela).

Monitoring and certification of rubber plants

Monitoring and certification of rubber plants in Government, RPC's and Private nurseries were done during the year with constraints of transport and human resources. Details are given in Tables 25, 26 & 27.

Table 25. *Details of RPC nurseries established in August 2014, January 2015 and August 2015*

Regional Plantation Company	No. of Estates	No. of Nurseries	No. of plants 2015	Plants certified Y.B.		
				2014 Aug.	2015 Jan.	Total
Balangoda	4	7	18,000	5,000	0	5,000
Elpitiya	2	4	0	14,100	0	14,100
Kegalle	5	9	6,749	23,500	0	23,500
Keleni velly	8	12	104,485	43,200	0	43,200
Kotagala	7	9	0	9,000	0	9,000
Malwatta velly	3	3	0	0	0	0
Namunukula	4	4	0	9,500	0	9,500
Pussellawa	3	3	12,000	14,000	0	14,000
Total	**36**	**51**	**141,234**	**118,300**	**0**	**118,300**

Table 26. *Details of government nurseries established in August 2014, January 2015 and August 2015*

Name of the nursery	Season	No. of plants established
Egaloya	2014 Aug.	446,429
	2015 Jan.	200,000
	2015 Aug.	171,315
Gurugoda	2014 Aug.	212,361
	2015 Jan.	200,000
	2015 Aug.	142,220
Karapincha	2014 Aug.	64,000
	2015 Jan.	200,000
	2015 Aug.	100,000
Meerigama	2014 Aug.	170,000
	2015 Jan.	375,000
	2015 Aug.	175,000
Welikadamulla	2014 Aug.	400,000
	2015 Jan.	400,000
	2015 Aug.	250,000
Middeniya	2014 Aug.	170,000
	2015 Jan.	150,000
	2015 Aug.	166,000
Moneragala	2014 Aug.	373,921
	2015 Jan.	495,000
	2015 Aug.	346,496
Grand total		**5, 207, 742**

Table 27. *Details of private nurseries established in August 2014, January 2015 and August 2015*

Region	Season	No. of plants established	No. of plants certified
Kegalle	2014 Aug.(14)	300,000	23,300
	2015 Jan. (08)	224,000	0
	2015 Aug. (0)	0	0
Rathnapura	2014 Aug.(12)	158,500	77,550
	2015 Jan. (07)	178,000	0
	2015 Aug.(0)	0	0
Kaluthara	2014 Aug.(07)	109,000	3,000
	2015 Jan. (01)	10,000	3,800
	2015 Aug.(0)	0	0
Galle	2014 Aug.(02)	21,500	8,300
	2015 Jan. (01)	5,000	0
	2015 Aug.(0)	0	0

Region	Season	No. of plants established	No. of plants certified
Moneragala	2014 Aug.(02)	20,000	500
	2015 Jan. (0)	0	0
	2015 Aug.(0)	0	0
Total		**1,026,000**	**116,450**

(P Seneviratne, A M W K Senevirathna, M N de Alwis, L Zoysa, R Handapangoda and B V Hasangi Madhushani).

Planting techniques

Selecting plants at the nursery - PT/2001/1 – Nivithigalakele

The details of the experiment are given in the Annual Review for 2001. The soil condition was grouped only arbitararly and the girth and girth increment are given in Table 28. Girth is higher in trees opened later in all three soil conditions. The correlation between the initial and the present girth is given in Table 29. Correlation is low between the initial girth and the present girth under all three soil conditions. The differences in sample size may have contributed to this which was beyond our control. Mean girth of trees opened for tapping in 2008 and 2013 under three soil conditions are given in Fig. 9.

Table 28. *Mean girth of trees opened for tapping in 2008 and 2013 and grown under three different soil conditions (SEM values are given in brackets)*

Soil condition of the planting hole	Opened in 2008		Opened in 2013	
	Girth (cm)	Girth increment (cm)	Girth (cm)	Girth increment (cm)
Bad	63.65± 1.31	0.81 ± 0.13	64.32 ± 1.16	0.60 ± 0.09
Moderate	65.19± 2.02	0.79 ± 0.08	68.38± 1.52	0.53 ± 0.09
Good	63.71± 0.77	0.76 ± 0.24	65.04 ± 1.04	0.61 ± 0.08

Table 29. *Correlation among the present girth and the initial girth of the plants*

	Opened in 2008			Opened in 2013		
	Bad	Moderate	Good	Bad	Moderate	Good
Correlation coefficient (r)	0.29	0.46	0.15	0.25	0.23	0.25
P value	0.06	0.01	0.09	0.04	0.18	0.01
Sample size (n)	44	29	126	71	36	99
STDEV of girth	8.64	10.88	8.68	9.78	9.10	10.34

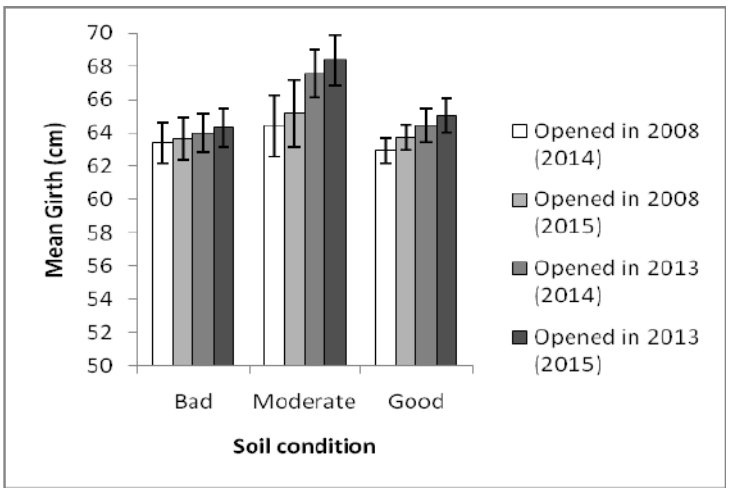


Fig. 9. Mean girth of trees opened for tapping in 2008 and 2013 and grown under three different soil conditions

(P Seneviratne, G A S Wijesekara and L de Zoysa)

Comparison of planting material - PT/Galewatta/2007

Test tapping was commenced (P Seneviratne, M K P Perera and R Handapangoda).

Performances of clones PB 86 and RRIC 100

The details of the experiment are given in the Annual Review for 2013. Monitoring and agro management practices were done throughout the year. Girth values for two clones are given in Table 30.

Table 30. *Mean girth of PB 86 and RRIC 100 clones after two years*

Clone	Girth (cm) at 30cm above ground
PB 86	13. 38±0.49
RRIC 100	14.93±0.49

Study on plant characters and grafting success of rubber in different Agro-climatic zones of Sri Lanka

The details of this experiment were given in the Annual Review for 2014. Growth data were recorded monthly and agro management practices were done during the year. Bud grafting survey was done in all government nurseries and some private and RPC's relevant to the study. Growth measurements were taken monthly and are shown in Tables 31, 32 and 33 (P Senevirathna and R Handapangoda).

Table 31. *Mean growth values of stock nurseries after four months from established*

Egaloya		Moneragala		Ampara	
Diameter (mm)	**Height (cm)**	**Diameter (mm)**	**Height (cm)**	**Diameter (mm)**	**Height (cm)**
7.07±0.24	65.14±8.69	6.10±2.91	44.93±8.69	5.67±0.03	54.67±0.65

Table 32. *Mean growth values for budwood nursery at Egaloya after one year from establishment*

Clone	No. of shoots	Diameter (mm)	No. of leaf whorls	Internodel length in second leaf whorl (cm)	Plant height (cm)
PB 86	3.5±0.47	21.90±0.77	7.65±0.21	11.59±1.57	242.90±12.09
PB 260	5.1±0.59	22.25±0.66	6.58±0.14	17.34±1.24	243.78±10.61
RRIC 100	7.73±0.71	22.33±0.72	5.28±0.15	11.91±0.71	168.96±25.27
RRIC 102	10.6±0.68	20.74±0.66	5.28±0.15	19.09±1.59	182.91±9.42
RRIC 121	7.83±0.65	22.14±0.66	7.35±0.95	13.61±1.06	258.99±9.96
RRISL 203	6.93±0.70	22.17±0.72	6.15±0.15	10.08±10.75	191.18±8.94
RRISL 217	7.45±0.47	19.70±0.55	7.65±0.21	12.10±0.79	240.61±9.79
RRISL 2001	4.25±0.55	21.23±0.63	7.20±0.18	8.21±0.59	215.61±8.90

Table 33. *Mean growth values for budwood nursery in Ampara after one year from establishment*

Clone	No. of shoots	Diameter (mm)	No. of leaf whorls	Internodel length in second leaf whorl (cm)	Plant height (cm)
PB 86	0.96±0.21	18.48±0.64	8.63±0.24	9.9±0.73	231.51±9.21
PB 260	2.29±0.49	16.57±0.70	6.85±0.16	10.77±0.85	189.64±9.84
RRIC 100	9±2.25	15.92±0.74	5±0.16	14.97±2.56	119.17±4.73
RRIC 102	10.44±1.01	19.35±0.47	6.44±0.09	16.01±1.44	224.66±5.94
RRIC 121	4.15±0.47	20.17±0.70	8.35±0.16	13.47±1.96	237.73±9.38
RRISL 203	4.85±0.71	19.08±0.52	7.46±0.17	9.35±1.02	202±8.84
RRISL 217	4.4±0.32	14.1±0.55	7.8±0.21	9.58±0.75	162.85±10.17
RRISL 2001	4±0.46	14.55±0.54	6.89±0.20	7.64±0.66	147.67±7.26

Northern Province planting

Fields established were visited by the Adaptive Research Unit and Plant Science Department (P Seneviratne, N M C Nayanakantha and M N de Alwis).

Kilinochchi

In collaboration with Genetics and Plant Breeding Department and Adaptive Research Unit, an experimental trial was commenced at two locations, Vishwamadu and Akkarayankulam in Kilinochchi. 201 plants (67 from RRISL 203, 67 from RRISL 2001 and 67 from RRIC 121) were planted at Punneneeravi, Vishwamadu at double row spacing of 8' X 8' x 60'. At Skandhapuram in Akkarayankulam, 120 plants from RRISL 2001 were planted at a spacing of 8' X 26' (N M C Nayanakantha, A M W K Senevirathna and M N de Alwis).

Cultural practices during immature phase

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

The experimental layout and the objective are given in the Annual Review for 1992. Table 34 shows, growth and yield parameters of the clones tested under four different densities. Tree girth and bark thickness have decreased with the increase in planting density. Also, a similar decrease was shown in the individual tree yield (g/t/t). The percentage trees in tapping was more or less similar to that of last year values due to the upper cuts on TPD trees. YPH values were not statistically significant among the densities. However, higher YPH was recorded in higher densities due to the higher trees in tapping per hectare overcoming the decrease of g/t/t in higher densities. The overall crop harvested in this year was comparatively low than the previous year due to the higher number of wet and late tapping days.

Table 34. *Effect of planting density on growth and yield parameters of rubber (a) plant girth (cm), bark thickness (mm) at 150cm height and trees in tapping, (b) tree yield (g/t/t) and estimated YPH (kg/ha/year)*

(a)

Density	RRIC 100				RRIC 121			
	Girth (cm)	BT (mm)	% Trees in tapping	Tappable trees/ha	Girth (cm)	BT (mm)	% Trees in tapping	Tappable trees/ha
500	75.02	9.25	60.42	302	89.09	9.15	60.42	302
600	74.15	9.70	63.46	381	80.83	8.80	64.50	387
700	67.02	8.99	61.42	430	79.45	8.55	61.72	432
800	67.35	8.76	64.67	517	75.95	8.02	66.55	532

(b)

Density (tree/ha)	RRIC 100		RRIC 121	
	Yield (g/t/t)	Yield (kg/ha/yr)	Yield (g/t/t)	Yield (kg/ha/yr)
500	23.44	796	34.87	1213
600	22.87	828	30.47	1229
700	20.28	773	26.70	1310
800	17.26	895	25.41	1594

(T U K Silva and V H L Rodrigo)

Planting at low density (PT/1996/Gallewatta & Nivitigalakele)

Data were not recorded during the year under review and data collected so far are being analysed to see the economic feasibility (P Seneviratne and K A G B Amaratunga).

Low density trial at Gallawatta and Nivithigalakele 2012

The experimental details are given in Annual Review for 2012. Monitoring and maintenance were done throughout the year (P Senevirtne and R Handapangoda).

Low density trial at Kandakadu, Pollonnaruwa 2013

The experimental details are given in Annual Review for 2014. Monitoring and maintenance were done throughout the year. 1000 new plants from RRIC 121 were established at spacing of 16' x 16' (P Seneviratne, R Handapangoda and M N de Alwis).

Immature upkeep

Rubber mini clearing (Home garden) concept

Under this programme 491,611 plants were distributed in traditional and non-traditional areas (Table 35). The main objective of this was to expand the rubber cultivation to non-traditional areas while giving the farmers hands on experience on rubber cultivation. NIPM helped in conducting training and awareness programmes.

Table 35. *District wise plant distribution under home garden project*

District	No. of rubber plants distributed	
	Smallholder	**Estates**
Kalutara	124,285	95,095
Colombo	2,210	
Galle	1,375	
Ratnapura	17,655	
Badulla	120,310	22,525
Polonnaruwa	16,380	
Matara	1,500	
Kegalle	3,883	
Moneragala	57,655	9,023
Ampara	17,115	
Trincomalee	2,600	
Total	**364,968**	**126,643**
Grand total	**491,611**	

(P Seneviratne, K A G B Amaratunga, R K Samarasekera, M K P Perera, M N de Alwis, L de Zoysa, P D Pathirana, P K W Karunathilaka and R Handapangoda)

Effect of wind (WN) on growth performance of rubber clones at high elevations (WN/2014/Balangoda)

Experimental details are given in Annual Review for 2014. Site one (01) was having no wind barriers and hence plants were exposed to direct wind while site 2 was having a wind barrier due to presence of naturally grown tree species on the boundary. Results revealed that growth of the plants was poor in site one as compared to site two and that could be attributed to the effect of wind (Fig. 10).

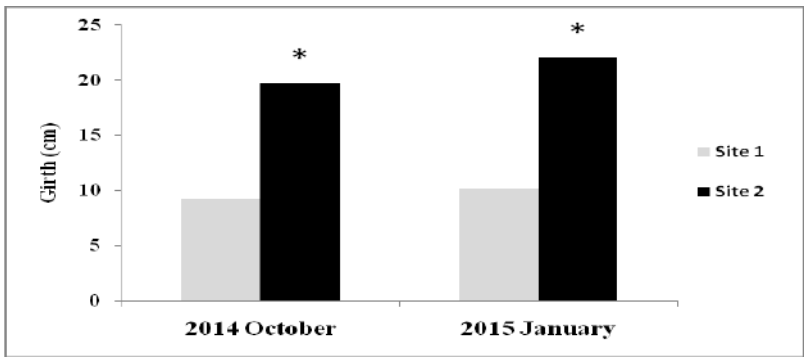


Fig. 10. Effect of wind on girth of rubber plants
(N M C Nayanakantha, W M H E Wijeratne, A M W K Senevirathna and P Seneviratne)

Exploitation

Longer tapping cycle through shorter tapping cuts – Pitiakanda Estate

Details of this experiment are given in the Annual Review for 2010. Yield measurements for the period of January to December 2015 are given in Table 36.

Table 36. *Yield measurements for the period from January to December 2015*

Treatment	No. of trees	No. of tapping days	Average g/t/t	BB %
T_1 - S/4 d3 + 5%E 12/y	45	10	42.0	6
T_2 - S/3 d3 + 2.5%E 12/y	45	10	44.0	8
T_3 - S/2 d3 + 2.5% E 5/y (*BUT up to December 2010)	43	10	45.0	-
T_4 - S/2 d3 + 2.5% E 5/y	43	10	46.5	11

*BUT – Bottom Upward Tapping

Same yield can be obtained by using less bark in T_1 & T_2 when compared with the control T_4.

(P Seneviratne, R K Samarasekera and N C Jayawanthi)

Crop estimation experiment – Sapumalkanda Estate (CE/2012/Sapumalkanda)

Details of this experiment are given in the Annual Review for 2012. Girth, Bark thickness, Bark consumption and Yield measurements were recorded and summary is given in Table 37.

Table 37. *Mean girth, bark thickness, annual bark consumption and yield measurements for the period from January to December 2015*

Girth class (cm)	Girth (cm)	Bark thickness (mm)	Annual bark consumption (cm)	g/t/t
(51-55.9)	55.22	5.62(b)	13.7	51.1(a)
(56-60.9)	64.69	5.87(b)	14.87	56.6(a)
≥(61.0)	73.37	6.47(a)	14.84	48.1(a)

(Letters indicate significant difference at $p \leq 0.05$ according to DMRT. Values followed by the same letter in a column are not significantly different at $p \leq 0.05$)

There is a significant difference in bark thickness in the highest girth class (≥61.0 cm) when compared with the other two girth classes tested (51-55.9cm and 56-60.9 cm) (P Seneviratne, R K Samarasekera and L A R Amaratunga).

Crop estimation experiment - Monaragala (CE/2012/Monaragala)

Details of this experiment are given in the Annul Review for 2012. Girth,

Bark thickness, Annual Bark Consumption and yield measurements were recorded and summaries are given in Tables 38 and 39 for RRIC 121 and RRISL 203 respectively.

Table 38. *Mean girth, bark thickness, annual bark consumption and yield measurements for the period from January to December 2015*

Girth class (cm)	Girth (cm)	Bark thickness (mm)	Annual bark consumption (cm)	g/t/t
T_1 - 45-50.9	57.15	6.36(c)	20.36	25.08(b)
T_2 - 51-55.9	62.32	6.7(c)	19.68	28.97(b)
T_3 - 56-60.9	67.49	6.8(b)	20.02	35.17(b)
T_4 - ≥61	76.51	7.26(a)	22.46	49.71(a)

Table 39. *Mean girth, bark thickness, annual bark consumption and yield measurements for the period from January to December 2015*

Girth class (cm)	Girth (cm)	Bark thickness (mm)	Annual bark consumption (cm)	g/t/t
T_1 - 45-50.9	64.37	6.92(c)	19.24	20.26(b)
T_2 - 51-55.9	58.75	7.17(c)	20.1	20.41(b)
T_3 - 56-60.9	64.77	7.90(b)	20.39	21.11(b)
T_4 - ≥61	71.06	8.93(b)	17.78	33.19(a)

(Letters indicate significant difference at $p \leq 0.05$ according to DMRT. Values followed by the same letter in a column are not significantly different at $p \leq 0.05$)

Irrespective of clones, bark thickness shows a significant difference in the highest two girth classes namely (56-60.9cm and ≥ 61.0 cm) when compared with the lowest girth classes tested (45-50.9cm and 51-55.9 cm). g/t/t shows a significant difference only in the highest girth class when compared with the other girth classes tested (P Seneviratne, K A G B Amaratunga, R K Samarasekera and L A R Amaratunga).

A modified stimulation method for rubber- Pitiakanda

Details of this experiment are given in the Annual Review for 2013. Yield measurements were taken during the year and are summarised in Table 40.

Table 40. *Yield measurements for the period from January to December 2015*

Girth class (cm)	Treatment	No. of trees	Average No of tapping days	g/t/t
	Panel	107	10	35.3(a)
50	Poikanu+Middle+Neththi kanu	109	10	34.2(a)
	Poikanu+ Neththi kanu	93	10	37.9(a)
	Panel	100	9	38.1(a)
55	Poikanu+Middle+Neththi kanu	119	9	31.1(a)
	Poikanu+ Neththi kanu	82	9	44.4(a)
	Panel	104	9	43.3(a)
60	Poikanu+Middle+Neththi kanu	101	9	35.3(a)
	Poikanu+ Neththi kanu	110	9	32.5(a)

(Letters indicate significant difference at $p \leq 0.05$ according to DMRT. Values followed by the same letter in a column are not significantly different at $p \leq 0.05$)

There is no significant difference in g/t/t among the treatments tested (P Seneviratne, A M W K Senevirathna, R K Samarasekera and N C Jayawanthi).

Novel gaseous stimulation system (GST/2014)

Experimental details were given in the Annual Review for 2014. Monthly mean tree yield (GTT) and mean DRC in different stimulation treatments are presented in Figures 11 & 12.

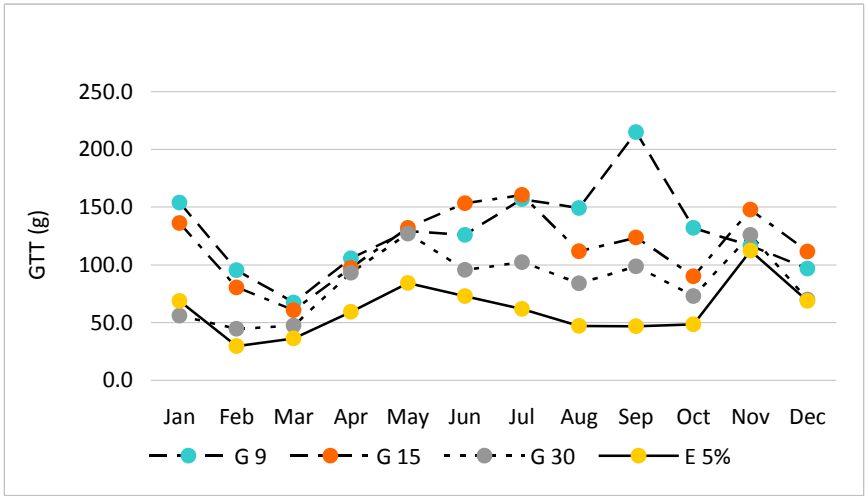


Fig. 11. Monthly mean tree yield (GTT) of treatments: ethylene gassing at 9 day (G 9), 15 day (G 15), 30 day (G 30) intervals and 5% ethephone application monthly (E 5%). Data represent mean of 36 trees

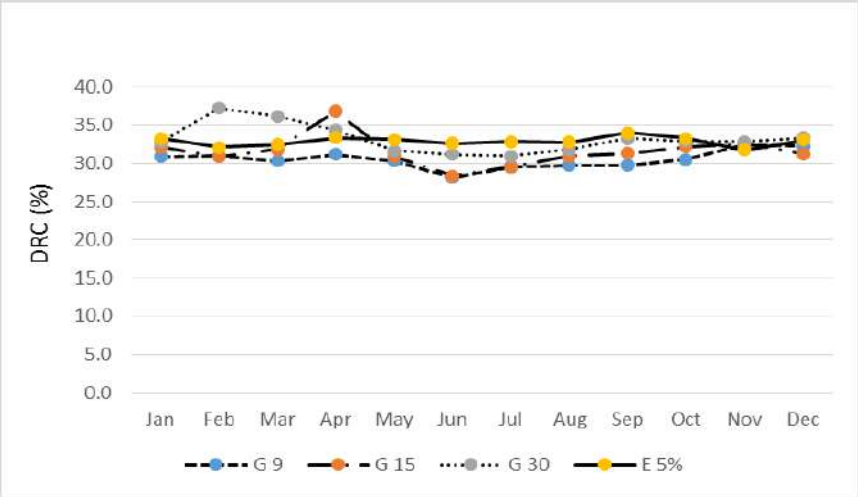


Fig. 12. Monthly mean dry rubber content (% DRC) of treatments: ethylene gassing at 9 day (G 9), 15 day (G 15), 30 day (G 30) intervals and 5% ethephone application monthly (E 5%). Data represent mean of 36 trees. Data revealed that ethylene gassing increase the latex yield over the control (E 5%) with the highest in 9 day interval (G 9) even though the DRC was dropped little with ethylene gassing (A M W K Senevirathna, P Seneviratne and W Karunathilake)

Tapping panel dryness

Survey of TPD trees

Survey in mature rubber fields at Kuruwita substation was started to see the severity of TPD incidence. Data were gathered from all mature fields (P Senevirathna A M W K Senevirathna and P K W Karunathilaka).

Chemical treatments for TPD trees (TPD/TR/2015)

A rubber field from RRIC 121, planted in 1991 and started to harvest in 1997 under S/2 d2 system in the first renewed panel (BI-1, C) was selected from the Dartonfied Estate. TPD affected and rested trees were selected and tapping was resumed for about a week. Subsequently, Ninety TPD affected trees were selected based on the yield and dry cut length (%). Selected TPD trees were divided into three blocks according to the severity of TPD. Considering dry cut length, severity was defined, as 'Severe' (100-76%), 'Medium' (75-50%) and 'Low' (<50). Pre-treatment data (latex volume, g/t/t, %dry cut, DRC) were collected over the period for two weeks. All the trees were rain guarded. TPD affected trees were divided into six groups randomly within each block according to the percentage dryness of the

tapping cut. Each group containing 15 trees was labelled as T_1, T_2, T_3, T_4, T_5 and T_6. Treatments were done according to the Table 41.

Fifteen healthy trees were also treated with *DRC+3* (HD) and another 15 trees were kept as the control (HC) according to Table 41. All the trees were tapped at S/2 d2 downward tapping system.

Table 41. *Treatment plan*

Treatment No.	Treatment
T_1 **(DRC+3)**	DRC+3 (1g/tree, 6 days interval)
T_2 **(AA1)**	Ascorbic Acid 1mM (6 days interval)
T_3 **(AA2)**	Ascorbic Acid 0.5mM (6 days interval)
T_4 **(SNP1)**	Sodium Nitroprusside (100 µM (2 weeks interval)
T_5 **(SNP2)**	Sodium Nitroprusside (50 µM (2 weeks interval)
T_6	Control (TPD)
HD	DRC+3 (1g/tree, 10 days interval)
HC	Control (Healthy)

Results are present in Figures 13 and 14.

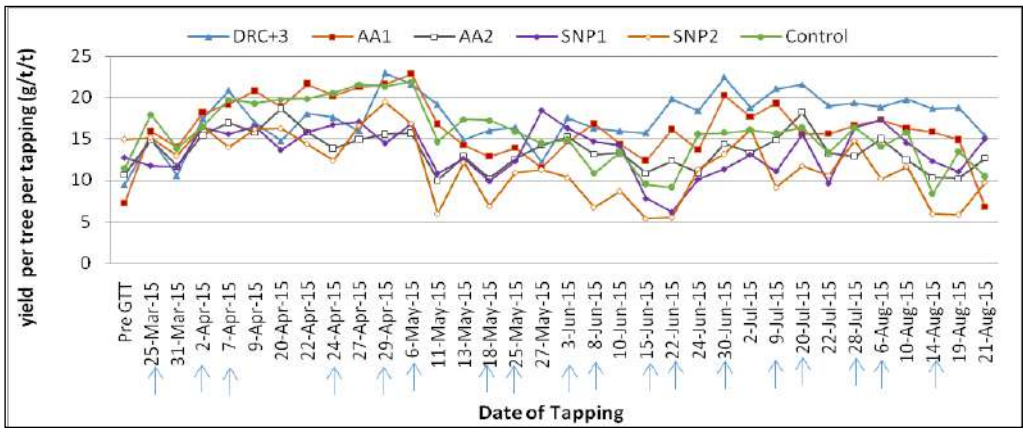


Fig. 13. Comparison of mean yield per tree per tapping (g/t/t) in different treatments with respect to pre-treatment and control data. Dates denoted with arrows were the nearest tapping days followed by chemical applications. DRC+3, AA_1= Ascorbic acid (1mM), AA_2=Ascorbic acid (0.5mM), SNP_1=Sodium nitroprusside (100µM) SNP_2-Sodium nitroprusside (50µM), Control=untreated TPD trees

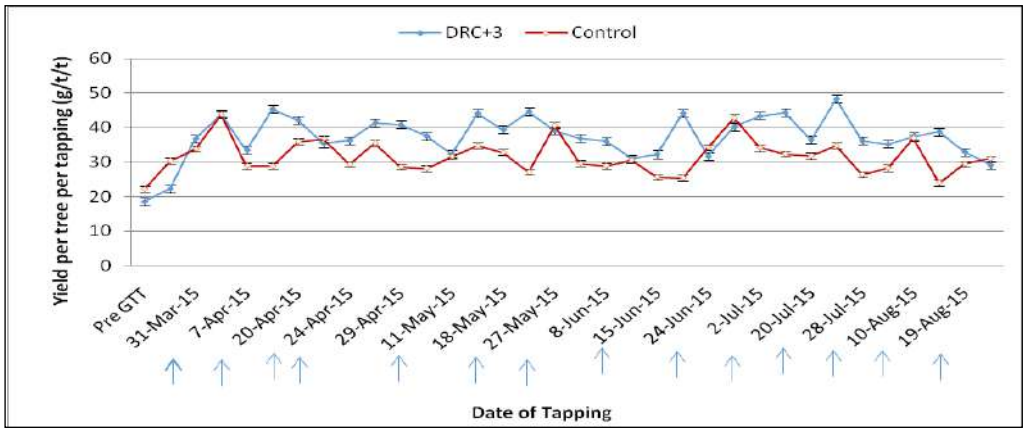


Fig. 14. Comparison of mean yield per tree per tapping (g/t/t) in DRC+3 treatment on healthy trees (HD) with respect to pre-treatment and the control (HC). Dates denoted with arrows were the nearest tapping days followed by chemical applications

There was a trend in increasing the yield per tree per tapping (g/t/t/) in TPD affected trees treated with DRC+3 and, Ascorbic acid (1 mM) (Fig. 13). Similar trend of yield increase in healthy trees treated with DRC+3 was observed (Fig. 14). Higher concentrations of sodium nitroprusside might be preferred as there was a trend in increasing yield of TPD affected trees with 100 µM SNP (A M W K Senevirathna, S N Karunathilaka, W K S W Watawala, N M C Nayanakantha, R K Samarasekara and C Jayawanthi).

Early selection of clones by physiology (PH/2007)

Experimental details were given in the Annual Review for 2007. Girth, annual girth increment and bark thickness measurements taken at the end of the reporting year is given in the Table 42. Harvesting was commenced during 2015 but the test tapping was not done.

Table 42. *Mean girth and bark thickness of different clones measured at 120 cm height*

Clone	No. of trees	Girth at 120 cm (cm)	Bark thickness at 120 cm (cm)
RRISL 2000	11	67.8 ± 3.2	0.75 ± 0.03
RRISL 2001	09	55.9 ± 2.7	0.76 ± 0.03
RRISL 2002	12	60.7 ± 3.3	0.71 ± 0.03
RRISL 2003	14	49.8 ± 2.2	0.61 ± 0.02
RRISL 2004	14	54.3 ± 2.2	0.71 ± 0.02
RRISL 2005	16	65.5 ± 1.7	0.72 ± 0.03

Stem girth at 120 cm was highest and comparable in RRISL 2000 and RRISL 2005 clones compared to other clones. Bark thickness did not differ much among the clones (A M W K Senevirathna and P K W Karunathilake).

Intercropping Agarwood with Rubber (IC/AW/2015)

An intercropping trial of Rubber with Agarwood was established in the Dartonfield Estate of RRISL, Agalawatta in collaboration with Department of Forestry and Environment Science of the University of Sri Jayewardenepura and Sadaharitha Plantations Limited. This long-term research project is aimed at identifying the feasibility of introducing three Agarwood species namely *Gyrinops walla* (GW) *Aquilaria crassna* (AC) and *Aquilaria subintegra* (AS) as perennial intercrops with rubber, as an additional income generation avenue for rubber planters. All Agarwood plants and fertiliser for Agarwood were supplied by Sadaharitha Plantations Ltd.

Both single (3m x 12m) and double (3m x 3m x 18m) row systems of rubber which are used for perennial intercrops were used for the experiment. Three agarwood species referred to above were planted as intercrops with rubber in a single and triple rows, respectively in single and double row systems of rubber, leaving 3m x 3m spacing among agarwood plants and 6m from rubber plants.

Plant height and stem diameter at one foot height taken monthly from both agarwood and rubber were presented in Table 43.

Table 43. *Plant height, stem diameter, height increment and diameter increment during five months period of three agarwood species:* Gyrinops walla *(GW)* Aquilaria crassna *(AC) and* Aquilaria subintegra *(AS) grown as intercrops with rubber under two spacing systems*

Planting system of rubber	Agarwood species	Height at planting (cm)	Diameter at planting (mm)	Height increment (cm)	Diameter increment (mm)
Double row	AC	115.3 ± 1.5	7.1 ± 0.1	28.6 ± 1.5	6.5 ± 0.2
	GW	96.8 ± 1.6	5.2 ± 0.2	8.9 ± 1.9	1.9 ± 0.2
	AS	147.5 ± 1.4	7.6 ± 0.1	26.4 ± 1.6	5.8 ± 0.3
Single row	AC	120.4 ± 3.5	7.4 ± 0.2	28.5 ± 2.5	4.5 ± 0.4
	GW	92.5 ± 1.5	4.7 ± 0.2	8.8 ± 1.1	0.8 ± 0.1
	AS	138.5 ± 7.4	7.8 ± 0.2	22.8 ± 2.2	4.1 ± 0.4

Results revealed that growth rates of two *Aquilaria* species are comparable and higher to that of *Gyrinops walla* indicating that growth

performance of *Gyrinops walla* under full sunlight is inferior to *Aquilaria* species (A M W K Senevirathna, N M C Nayanakantha, A Deshapriya and P K W Karunatillake in collaboration with University of Sri Jayewardhanapura and Sadaharitha Plantations Ltd.).

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

The objective of the experiment and treatment layout were given in the Annual Review for 2013. This study is being continued under two major components, *i.e.* on station experiment at Kuruwita substation and multi location panel data assessments from selected estates. This project was funded by the National Science Foundation, Sri Lanka (RG/2012/AG/06).

On station experiment (BCR/2013/Kuruwita)

On station experiment to assess the overall impact of selected tapping systems representing different bark consumption rates using representative set of clones (BCR/2013/Kuruwita)

Growth parameters, *i.e.* tree girth at 1.5 m height, thickness of bark, length of the tapping cut, shaving thickness of the tapped bark were measured. Yield and yield determinants, *i.e.* daily latex yields in terms of latex volume and metrolac reading (% dry rubber content), census of tapping panel dryness have been taken. Initial flow rates were measured and plugging indices were calculated based on the initial flow rates. Rainfall and the distribution of tapped and wet days were recorded. Phloem turgor pressure and latex sucrose levels were studied. Main treatments were tested as follows;

T1. S/2 d2 with Rainguards (RG), No recovery tappings (NRT)
T2. S/2 d2 with recommended number of RT per month (3 RT)
T3. S/2 d2 with 5 RT per tree per month
T4. S/2 d3+ ET 2.5% with rainguards (Tapping once in three days & NRT)
T5. S/2 d1 - Daily tapping without rainguards

Out of the five tapping systems, T4 which is under stimulation, *i.e*. 2.5% Ethephone was recorded significantly higher latex volume per tree per tapping than the other four systems (Fig.15). Percentage Dry Rubber Content (DRC) was significantly higher in the conventional S/2 d2 tapping system (Fig. 16). The significantly lowest DRC values were recorded in treatments which were subjected to the higher number of recovery tapping (T3) and daily tapping S/2 d1 without rainguards (T5). Yield per tree per tapping was higher in the low frequency

harvesting system (T4) than the other four systems due to the effects of the regular rest and yield stimulation (Fig. 17).

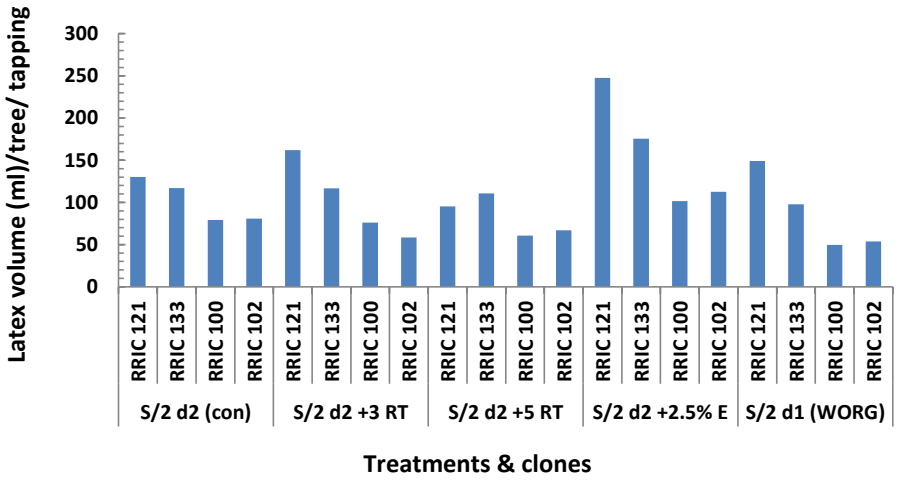


Fig. 15. Mean latex volume (ml) per tree per tapping in five different treatments and four clones

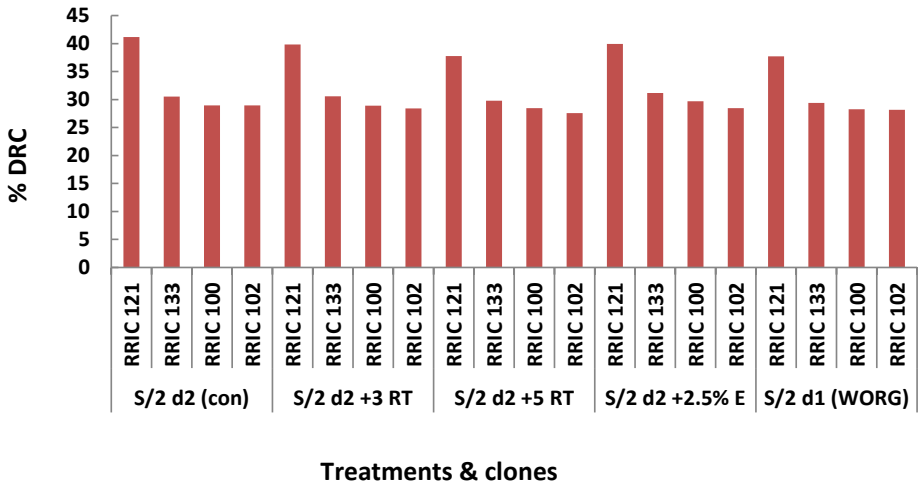


Fig. 16. Percentage Dry Rubber Content in five different tapping systems (treatments) and four clones

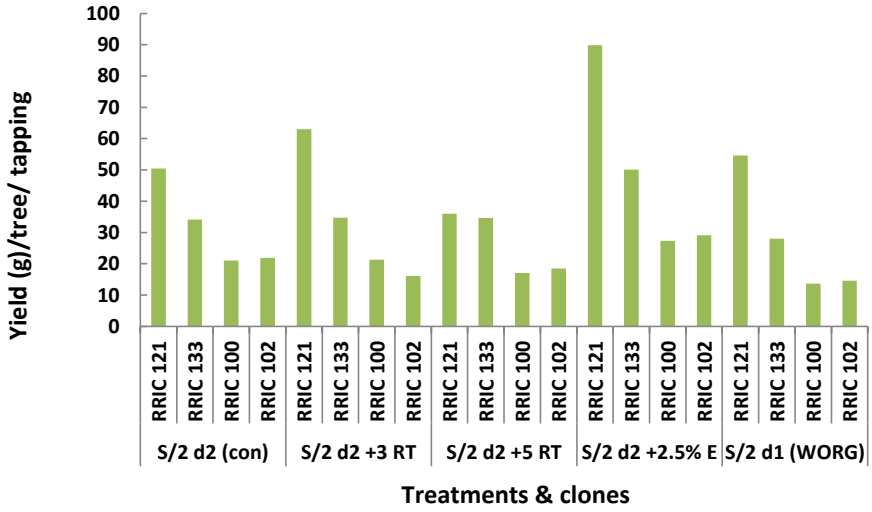


Fig. 17. Yield (g) per tree per tapping in five different tapping systems (treatments) and four clones

Multi location panel data assessments under different tapping systems practiced by the growers

Five sites from Regional Plantation Companies (RPCs), *i.e.* two from Kalutara, one from Ratnapura, two from Kegalle and one from Kurunegala Districts were visited and suitable fields were monitored with the support of the Management of the above estates. The data collected are being summarized and analyzed.This project was funded by the National Science Foundation, Sri Lanka (RG/2012/AG/06). (T U K Silva, A M W K Senevirathna, P Seneviratne H A U Deshappriya and R K Samarasekera).

Intercropping

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

The objective of the experiment and treatment layout are given in the Annual Review for 2002. Growth of rubber with respect to girth and thickness of virgin bark measured at 150 cm height was measured (Table 44 and 45) and those were higher in wider within row systems, *i.e.* T3 and T4. Trees were rainguarded and tapped with half spiral cut on every three days. Daily latex yields were recorded for latex volume and % dry rubber content by using metrolac. Percentage trees in tapping was comparable among treatments (Table 46). Wider within row systems, *i.e.,* T3 and T4 recorded a higher g/t/t values than the other two systems, *i.e.,* T1 and T2 (Table 47). In general, T3 recorded a higher YPH values due to the combination of higher g/t/t

and number of trees in tapping (Table 48 & 49). In general, basal girth and yield per bush of tea were higher in the wider inter row systems, *i.e.* T2 and T4 (Table 48). Tea yields were poor than the previous year due to pruning. Growth and the establishment rates of rambutan and jak were satisfactory and better than that of bud grafted (bg) and seedling (s) durian (Table 49). Flowers were observed on some jak trees in the wider inter row systems of rubber, *i.e.* T2 and T4 and few fruits were harvested.

Table 44. *Mean girth (cm) of rubber in different treatments. Measurements were taken at 150cm height*

Main trts.	Sub treatments				
	Tea	Cinnamon	Durian/ Jak	Rambutan	Sole rubber
T1 (3m×3m)-15m	72.14	68.01	68.55	67.22	72.08
T2 (3m×3m)-18m	72.90	66.96	65.08	64.24	68.02
T3 (3.5m×3.5m)-15m	75.50	73.72	71.88	69.60	72.60
T4 (3.5m×3.5m)-18m	78.08	71.69	75.30	71.98	75.81

Table 45. *Summary of the bark thickness of rubber (mm). Measurements were taken at 150cm height*

Main trts.	Sub treatments				
	Tea	Cinnamon	Durian	Rambutan	Sole rubber
T_1	9.44	9.17	9.41	8.81	8.88
T_2	9.59	9.36	9.28	9.28	9.41
T_3	9.86	9.91	10.18	10.04	10.05
T_4	9.92	9.52	9.14	9.41	9.73

Table 46. *Mean percentage trees in tapping (%TIT) and trees in tapping per hectare (TIT_{ha}) of rubber under different planting systems*

Trt	Tea		Cinnamon		Durian		Rambutan		Sole rubber	
	%TIT	TIT_{ha}	%TIT	TIT_{ha}	%TIT	TIT_{ha}	%TIT	TIT_{ha}	%TIT	TIT_{ha}
T1	78.51	290	76.85	284	87.02	322	81.44	301	76.67	284
T2	81.32	258	86.38	274	89.50	284	94.39	299	87.81	278
T3	92.31	285	78.87	244	80.49	249	90.43	279	91.07	309
T4	88.13	234	84.16	224	87.46	233	88.33	235	89.06	237

Table 47. *Mean yield per tree per tapping (g/t/t) and yield per hectare (YPH) of rubber under different planting systems*

Trt	Tea		Cinnamon		Durian		Rambutan		Sole rubber	
	g/t/t	YPH	g/t/t	YPH	g/t/t	YPH	g/t/t	YPH	g/t/t	YPH
T1	69.05	1803	64.05	1630	59.92	1738	61.49	1673	77.61	1790
T2	66.92	1532	64.48	1589	64.23	1567	59.73	1585	50.48	1277
T3	64.35	1626	95.62	2046	84.19	1889	75.77	1882	83.39	2104
T4	79.58	1646	78.40	1563	88.59	1841	67.67	1406	63.72	1339

Table 48. *Summary of the growth and yield performance of rehabilitated and unrehabilitated Tea under different planting arrangements of rubber*

Main treatments	Tea growth		Tea yield (green fresh leaves)			
	Basal girth (cm)		Tea (unrehab)		Tea (rehab)	
	Tea (unrehab)	Tea (rehab)	g/bush/year	kg/ha/year	g/bush/year	kg/ha/year
T1	22.05	21.36	174	1305	225	1688
T2	22.93	22.02	220	1886	270	2314
T3	21.30	23.42	179	1306	260	1897
T4	22.63	24.06	222	1859	240	2009

Table 49. *Summary of the growth performance of Rambutan, Jak, bud grafted Durian (bg) and Durian seedlings (s) in different planting arrangements of rubber*

Main treatments	Basal girth (cm) at 10 cm height			
	Rambutan	Jak	Durian (bg)	Durian (s)
T1	78.71	60.61	28.90	19.47*
T2	82.16	93.88	53.72	41.90
T3	76.32	60.96	52.64	36.32
T4	75.80	69.08	12.00*	69.10

*Replanting was done in 2007 due to the damage by rabbits

(T U K Silva and H A U Dehsappriya)

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

The objective of this experiment is given in the Annual Review for 2010. Five species, *i.e.* cinnamon, areca, rattan, dracaena and cane palm were established along the fence in year 2010. The plant basal girth and height of different crops are given in Table 50. Cinnamon showed better performance and was harvested second time for this year. However, the mean values for height and diameter of cinnamon were comparatively low than the previous year due to the harvesting of larger stems.

Table 50. *Crops planted along the rubber fence, spacing (m), girth (cm) and their overall plant height (m) at the second year after planting*

Crop	Spacing (m) along the fence	Basal girth (cm)	Plant height (m)
Cinnamon (*Cinnamomum verum*)	0.6 x 0.6 paired rows	6.26	1.73
Rattan (*Calamus rotang*)	2.5	Nm	0.70
Messengiana (*Dracaena messengiana*)	0.9	21.02	1.73
Cane palm (*Dypsis lutescens*)	0.9	12.35	1.32
Arecanut palm (*Areca catechu*)	2.0	33.67	2.86
Main crop	**Spacing (m)**	**Girth at 120 cm**	
Rubber	2.5m x 7.75m	43.08	Not measured

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

The objective of the experiment together with treatment layout is given in the Annual Review for 2011. Out of the four species tested teak recorded a better growth and 100% survival whilst 80% casualties were recorded in other three species due to the dry weather condition prevailed (T U K Silva).

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

Details of the intercrops and the objective are given in the Annual Review for 2011. This field was established as an intercropping demonstration field in the RRISL substation, Moneragala showing every possible intercropping system in a single area.

Growth of rubber in terms of tree girth in different planting systems is given in the Table 51. Plant basal girth and heights of different intercrops with two spatial arrangements of rubber are given in the Table 52. Satisfactory plant height was recorded in each crop at two year after planting (Table 52). Mango, guava and pomegranate showed a rapid growth than rambutan.

Table 51. *Plant girth (cm) of rubber with different systems of intercrops planted under three different rubber spatial arrangements*

Inter cropping system	Rubber spacing (m)	Girth of rubber (cm)
Rubber x Pineapple	Single row system	35.2
Rubber x Banana	2.5m x 7.75m	37.3
Rubber x Pomegranate/Guava	Single row system	18.6
Rubber x Pomegranate/Guava*	2.5m x 12m	13.47
Rubber x Cinnamon	Paired row system	38.25
Rubber x Mango/Rambutan	(3m x 3m) – 18m	37.58

Table 52. *Plant basal girth (cm) and height (m) of different intercrops planted under two different rubber spatial arrangements*

Intercropping system	Year established	Intercrop spacing (m)	Basal girth (cm)	Tree height (m)
Pomegranate	2010		21.45	1.80
Guava			31.20	3.13
Pomegranate		3m x 3m	14.49	1.87
Guava	2012		18.85	2.79
Cinnamon		0.6m x 1.2m	7.98	2.73
Mango	2010	10m	43.05	3.65
Rambutan*		10m	2.20	0.53

*Plants were resupplied (T U K Silva)

Rubber - Rattan intercropping trial - IC/RR/1996 - Kuruwita Sub-station

Data was not collected due to sprawling nature of rattan (P Seneviratne and M K P Perera).

Possibilities of intercropping Cinnamon under Rubber IC/RC/1998 - Kuruwita Sub-station

Data was not collected as the Officer handled this project was transferred to another Department of RRISL.

PLANT PATHOLOGY AND MICROBIOLOGY

T H P S Fernando

DETAILED REVIEW

Staff

Dr (Mrs) T H P S Fernando, Senior Plant Pathologist covered up the duties of the Head of the Plant Pathology and Microbiology Department. Mrs M K R Silva, Research Officer was on duty throughout the year. Experimental Officers, Mrs B I Tennakoon, Mrs E A D D Siriwardene, Mr S C P Wijayaratne, Mr S R D P C Peiris and Mr E A D N Nishantha continued to work in the department. Mr S R D P C Peiris covered up all the duties and responsibilities of the Audio Visual and IT Unit. Miss A N Wijewardena and Miss W M S P Wijekoon assumed duties as Technical Officers of the department with effect from 22nd April 2015. Mrs K A D Y Madushani Lanka, Management Assistant was on duty throughout the year and Miss H K I Madushani worked as a Temporary Research Assistant under the NRC Grant 11-39.

Retirement:

Mr E B Fernando, Experimental Officer retired from the services of the Plant Pathology & Microbiology Dept., Rubber Research Institute with effect from17th April 2015. He joined the institution in the year 1976 and served for 39 years. His dedication towards the upliftment of the rubber research was appreciable. And also as a senior officer he always attempted to guide the junior colleagues in a professional background. We wish him and his family a healthy and a peaceful future.

Research grants record

Source and grant No	Duration	Title of the project	Allocation	Status	Output
International Foundation for Science, Sweden [IFS – Stockholm] **IFS D/5127-1**	April 2012 - April 2015	Development of Integrated management Strategies of White Root Disease of Rubber (*Hevea brasiliensis*)	8600 USD	Completed (Final report in preparation)	04 publications
National Research Council **NRC 11-39**	April 2012 - October 2015	Studies on white root disease of rubber to develop improved management strategies	Rs.4,165,000	Completed [Final report in preparation]	01 Mphil – 05 publications

Research grants record					
Source and Grant No	**Duration**	**Title of the project**	**Allocation**	**Status**	**Output**
National Science Foundation [NSF]	Dec. 2015	Support for Research Equipment	Rs.825,000	In progress	Received Gradient PCR machine

Research students

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

Name	Duration	University	Project title
DMC Wickramarachchi	January 2015 – June 2015	University of Wayamba	Morphological and molecular characterization of native *Trichoderma* isolates against *Rigidoporus microporus* the causative agent of white root disease of *Hevea brasiliensis*
PKNN Sandamali	April 2015 – August 2015	University of Uva Wellassa	Antagonistic effect of some native *Trichoderma* isolates on economically important pathogens of rubber
MMK Peiris	April – December 2015	University of Sri Jayawardenapura	Cultural, reproductive and genetic variability of *Corynespora cassiicola* from different host plants
PW Balasooriya	July – December 2015	University of Sri Jayawardenapura	Estimation of Soil microbe population from traditional & non traditional rubber growing lands in Sri Lanka
DYL Wijesinghe	December 2015 – todate	University of Sri Jayawardenapura	Variability study of *Corynespora cassiicola* from traditional and non-traditional rubber growing areas
PMSM Premajayantha	October 2015 – Feb 2016	Aquinas University College	Optimization of diffèrent media for *Trichoderma* spp

Committes attended

Officers	Subject	Organization
THPS Fernando MKR Silva	Scientific Commette Meeting	Rubber Research Institute of Sri Lanka
THPS Fernando	National Plant Protection Commette	CARP
	Pesticide Technical's Advisory Commette	Department of Agriculture
	Pesticide Sub-Committe	Department of Agriculture

Training programmes/Seminars attended

Officers	Training programme	Duration
THPS Fernando, EADN Nishantha	Workshop on Bio security Implementation of South American Leaf Blight of Rubber in the Asia-Pacific Region	12-16 January 2015
EADD Siriwardene SCP Wijayaratne SRDPC Peiris EADN Nishantha	2015 Training Course on Important Tropical Crops Pest Control for Developing Countries	10 - 29 September 2015
THPS Fernando	IRRDB Annual International Conference held in Vietnam	31 Oct – 04 Nov. 2015

Training programmes conducted

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

Experimental/Advisory visits

Purpose	No of visits
Experimental	240
Advisory	59
Other	87
Total	386

LABORATORY AND FIELD INVESTIGATIONS

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

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

Out of different materials established as excluders of mammalian pests, galvanized square mesh of two different brand names, PVC-coated galvanized square mesh, poultry mesh and one type of PVC mesh were further evaluated for the effectiveness and durability. The trial which was established to evaluate the efficiency of luminous sticker stripes was also monitored (M K R Silva, T H P S Fernando and B I Tennakoon).

Tree injection against white root disease – I Vogan estate

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

Table 1. *Recovery rate of the WRD infected plants treated with tebuconazole using tree injectors*

Tree No.	*Rating for the disease severity	
	Prior to treatment	After the treatment
1	2	0
2	1	0
3	2	0
4	1	0
5	1	0
6	003	1
7	1	0
8	2	2
9	3	1
10	3	Dead
11	1	2
12	2	2
13	1	2
14	3	Dead
15	1	1
16	3	1
17	3	Dead

*o – no infection at the collar region 1 – Rhizomorphs seen at the collar region
2 – Collar rot partial 3 – Collar both sides dead

Comparison of the effectiveness of different commercial products of tebuconazole and hexaconazole – Raigam Estate

Eight commercial products of the systemic fungicides were tested for the efficacy of controlling the white root disease. The percentage recovery rate is given in the Table 2 (T H P S Fernando, E B Fernando, S C P Wijayaratne and S R D P C Peiris).

Table 2. *Testing of different commercial products of the systemic fungicides against white root disease*

Type of the chemical	Percentage recovery after chemical treatments	
	After the 1st application	After the 2nd application
Eraser	28	70
Breaker	70	85
Hexadash	60	70
Hayzole	65	75
Hexa	45	60
Orius	45	60
Contaf	50	75
Folicur	70	90
Control	5	0

Rehabilitation of WRD clearings with infected* Mucuna bractiata *– cover crop

Experiments to rehabilitate disease clearings at Dartonfield Estate and Egaloya nursery are in progress. Rehabilitation was done using manual methods using sulphur sprinkling (T H P S Fernando, E B Fernando and S C P Wijayaratne).

Alternative chemicals for the management of the bark cracking disorder

Trials established in Pussalla Estate, Woodend Estate and Sorana Estate are being monitored for the recovery. Assessments were on the bark rot level at the collar region, foliar symptoms and formation of latex pads (T H P S Fernando, E A D N Nishantha and S R D P C Peiris).

Management of secondary leaf fall disease of rubber

Experiments were continued to test the application of chemicals to control Secondary leaf fall diseases caused mainly by *Oidium heveae*. Soluble sulphur and sulphur dusting were performed. Five rounds of chemical spraying were completed at the selected sites in Pussella and Mirishena Estates. The disease condition was mild during the year and hence the evaluation of the effectiveness could not be done (T H P S Fernando, M K R Silva, E B Fernando, S C P Wijayaratne and S R D P C Peiris).

Screening of fungicides against abnormal leaf fall disease

In the trial carried out at Galewatta to assess three fungicides, Brunolium Planetarium, Ridomyl (Mancozeb+Metalaxyl) and Mancozeb against the *Phytophthora* bark rot disease, it was found that, Ridomyl at the concentration of 5g/l was more effective in both preventive and curative actions. The trial was carried out in a ten year old clearing of RRISL 203 and the disease conditions were provided by artificially inoculating the trees with a spore suspension of *Phytophthora.* The trial will be repeated for the consistency of the results (M K R Silva, T H P S Fernando and B I Tennakoon).

Chemical control of cockchafer grub attack

Alternative chemicals identified for cockchafer grub attack, Imidocloprid, Diazinone, Fipronil, Penthoate, Thiamethoxam were tested in view of identifying effective alternative insecticides for Chlorpyrifos. Concentrations of chemicals were tested at Gulugahakanda, Pussella, Padukka and Raigam Estates (Fig. 1a, b, c, d) (T H P S Fernando and E A D N Nishantha).

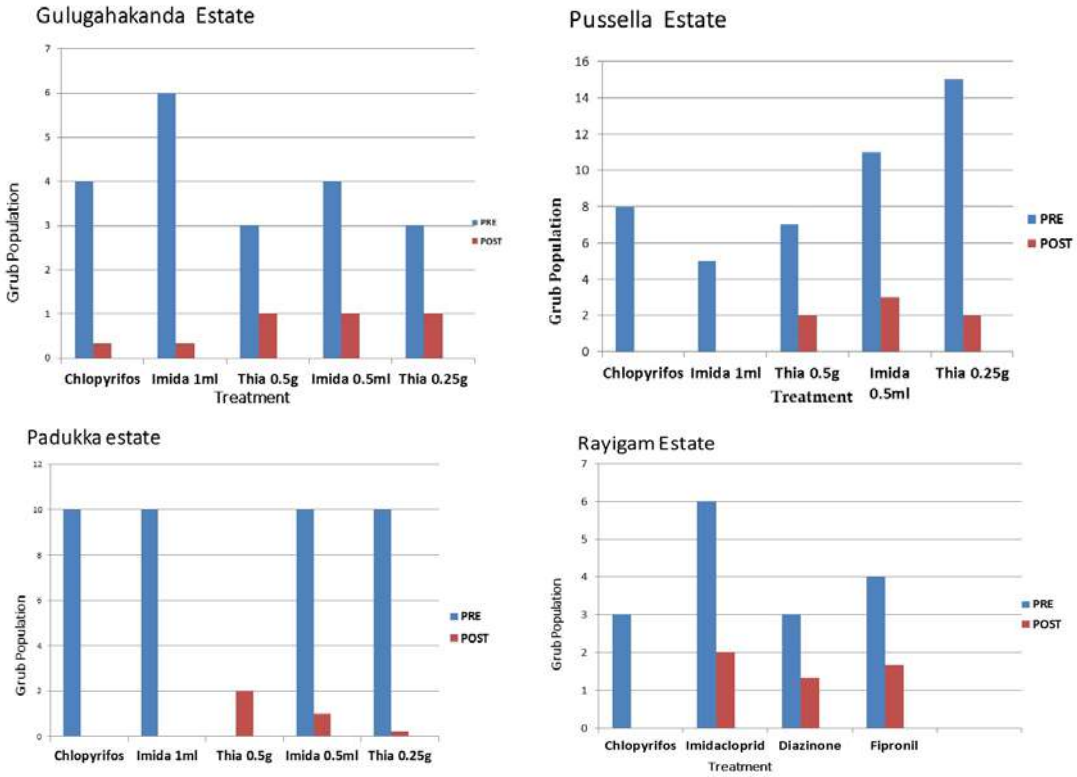


Fig. 1. Grub counts of the infested sites before and after treatment

Chemical control of the brown root disease

Observations were taken in the trial established to screen the effectiveness of the two systemic fungicides, tebuconazole and hexaconazole on the control of the brown root disease under field conditions. This experiment is carried out in a four year old clearing at Galagedara. The initial infectious level was assessed and a rank was given for each tree prior to the application of the fungicides. The treatments used were tebuconazole (Folicur 250 EW) in 1% concentration, hexaconazole (Hayzole 5% EC) in 1% concentration and hexaconazole (Hayzole 5% EC) in 2% concentration (M K R Silva, T H P S Fernando, R L C Wijesundera and B I Tennakoon).

Biology of pests (23/P/02)

Variability of Rigidoporus microporus isolates from different rubber growing agro-climatic areas

Effect of different media, temperature, pH levels and light intensity were tested against the growth of *R. microporus* under *in vitro* conditions. The growth of *R. microporus* was maximum in pH range between 7-8 and temperature range of 25-30 ^{0}C. The exposure of the fungus to continuous dark condition resulted in the maximum mycelium growth of *R. microporus* compared to continuous light condition. Among the different media tested Malt Extract Agar was the best.

All isolates under investigation, except the isolate R6 produced comparatively lower Pectin lipase (PL) and Polygalacturonase (PG). The enzyme production of PL and PG was significantly higher in the R6 isolate. All isolates showed lower activities of cellobiase, higher β- glucosidase and laccase enzyme activity. Molecular weight of PL and PG in the isolate R6 showed 30.2 ± 2.0 kDa and 42.8 ± 0.8 kDa respectively. Molecular weights of laccase ranged from 57.2 kDa to 69 kDa for all isolates in their 1st peak.

The twelve isolates tested grouped into two clusters. R2, R8 and R11 were more virulent. Isolate R6 & R10 isolates were less virulent. All the isolates stopped their growth from 50ppm and above concentrations of tebuconazole. All the isolates showed tolerance to Hexaconazole. In RAPD and ISSR analysis, dendrogram showed a number of sub clusters indicating the high genetic variation among the investigated isolates. These results indicated that there is no clear correlation existing between *R. microporus* isolates and their geographical origin (T H P S Fernando, E A D D Siriwardene, S C P Wijayaratne and I Madushani, This project is partially funded by IFS, Stockholm; D/5127-1-2012).

Variability of* R. microporus *from different hosts in Sri Lanka

The Morphological, cultural, pathological and genetical variability of the present population of *Rigidoporus* spp. from Sri Lanka was investigated. Malt extract agar (MEA) was the best medium for the growth of the fungus. The optimum

temperature range was 25-30 ^{0}C. Growth initiated at 10-15 ^{0}C by all isolates except for one isolate (R9- *Alstonia macrophylla*) and none of the isolates grew at 40 ^{0}C which was detrimental to the pathogen. The optimum pH ranged between 7-8 while none of the isolates grew on pH 3. Except the isolate R8 (*Salix babylonica*), all isolates showed higher growth rates under continuous dark conditions. This study reveals the possibility of controlling the pathogen in land preparation, through the concomitant management of temperature, pH, and light condition in unfavorable way to pathogen. Pathogenicity also varied among the isolates and all the isolates tested were pathogenic to *H. brasiliensis* (Fig. 2). Therefore, the development of selection criteria for intercrops and cover crops is also important to reduce the disease incidence in rubber plantations (T H P S Fernando, R L C Wijesundera, E A D D Siriwardene and I Madushani. This project is partially funded by NRC 11-39).

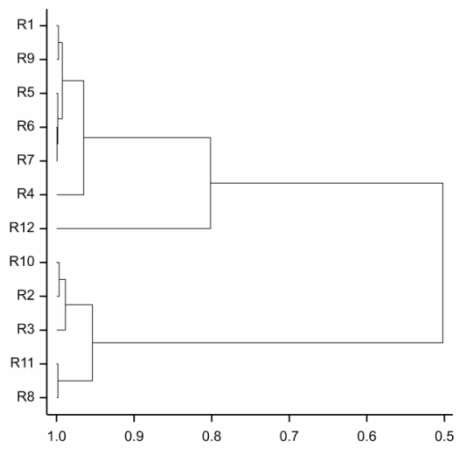


Fig. 2. Dendogram showing the clusters *of Rigidoporus microporus* isolates based on the pathogenicity

Genetic variation of *Rigidoporus microporus* isolates from *Hevea brasiliensis*

The morphological and genetic variation among 12 isolates of *R. microporus* were determined using morphological characters such as growth rate, colony characters, effect of pH and molecular marker (RAPD-PCR). Isolates were collected from eleven rubber growing regions of Sri Lanka. The molecular analysis was conducted using 15 random primers. Only six primers (OPM 5, OPB17, OPL 8, OPN 14, OPN 13, and OPL 10) showed reproducibility and produced 80 bands with an average of 13.33 bands per primer (Fig. 3) (T H P S Fernando, Isuru Kumari, E A D D Siriwardene and I Madushani. This project is partially funded by IFS).

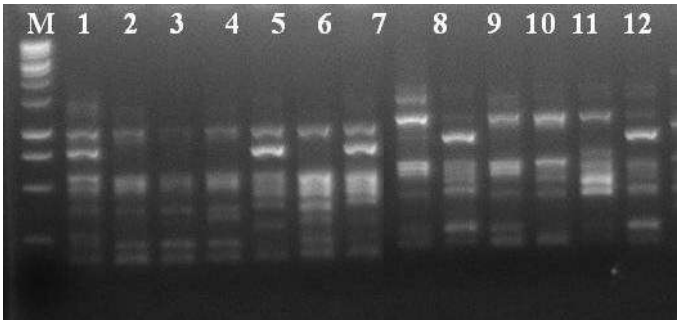


Fig. 3. RAPD profile for primer OPB 17 *R. microporus* isolates

Genetic variability of the pathogen population

The genetic variability of *Rigidoporus microporus* was investigated by ISSR and random primers. Significant variations (Fig. 4) were observed in the genetic diversity among the pathogen population (T H P S Fernando, R L C Wijesundera, E A D D Siriwardene and I Madushani. This project is partially funded by NRC 11-39).

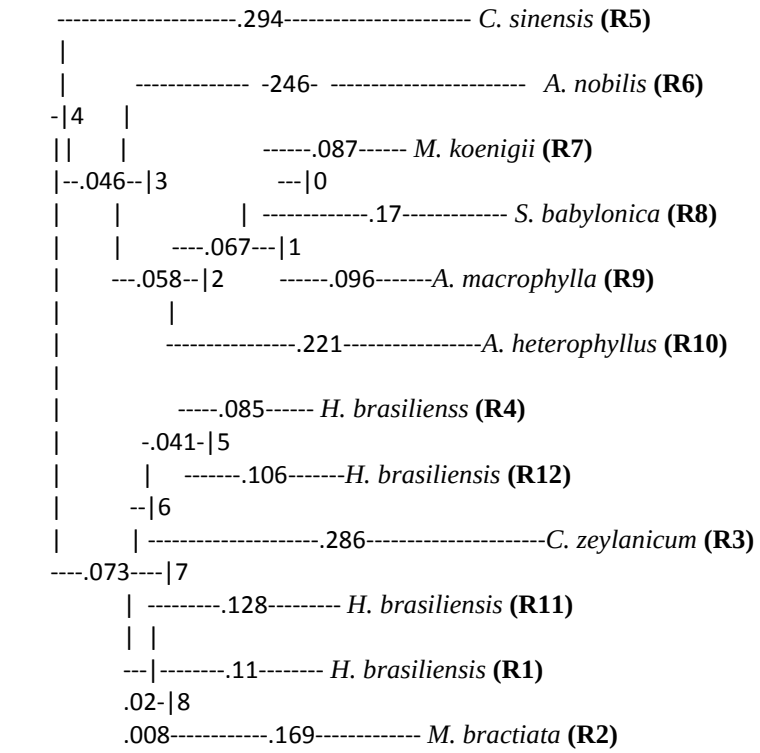


Fig. 4. Dendrogram of twelve isolates constructed using RAPDistance program V 1.04: method Neighbour joining tree

Cultural, reproductive and genetic variability of *Corynespora cassiicola* from different host plants

C. cassiicola has a wide host range. The morphology and reproductive characteristics such as colony appearance, growth rate, mycelia width, conidia concentrations obtained showed a significant variability except in conidial dimensions among rubber and alternative host isolates (Table 3). But the rubber isolates were difficult to distinguish using cultural characteristics. Therefore, cultural variability could not be used to differentiate isolates of *C. cassiicola* from different host origin (Fig. 5). The dendogram constructed showed that the genetic variability is high among rubber and alternative host isolates. The clusters showed a correlation between RAPD profiles and their host origins. This confirms the host specialization among the isolates under investigation. According to the results obtained, there is a strong morphological and genetic variability among the two populations of rubber and alternative host isolates (Table 4 and Fig. 6). Further studies will be carried out with a larger sampling size (T H P S Fernando, E A D N Nishantha and M M K Peiris).

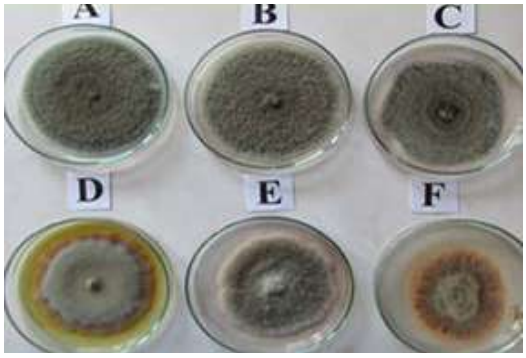


Fig 5. Upper and lower surface view of *C. cassiicola* isolates from different hosts

Table 3. *Collection of fungal isolates from different host plants*

Label	Isolate	Accession name	Origin of accession
A	RRISL 202	K 01	Kuruwita
B	RRISL 110	K 04	Kuruwita
C	RRISL 201	NK 04	Stock culture collection of Department of
D	Eggplant	GL 09	Plant Pathology and Microbiology,
E	Papaya	WG 16	Rubber Research Institute, Sri Lanka
F	Tomato	MT 29	

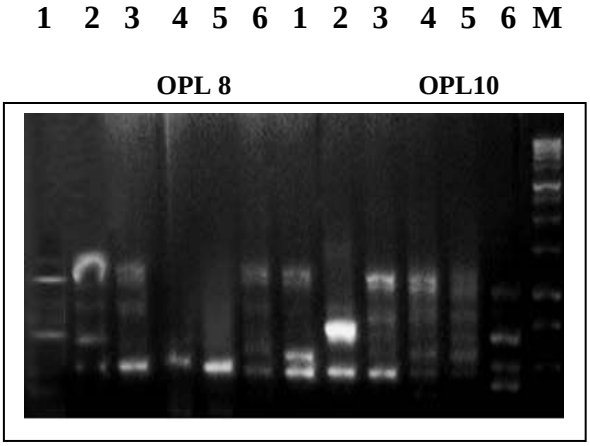


Fig 6. Amplification profile for primers OPL 8, OPL 10
M: 1kb DNA ladder (Promega, USA), 1: A, 2: B, 3: C, 4: D, 5: E, 6: F

Table 4. *Variability in conidia dimensions of* C. cassiicola *isolates from different hosts*

Isolate	Conidia length/µm	Mean conidial length/µm	Conidia width/µm	Mean conidial width/µm
A	50.0 - 245.0	120.0 ± 8.07	5.00 - 10.00	6.888 ± 0.286
B	55 - 140.0	90.11 ± 3.82	5.00 - 7.50	5.988 ± 0.178
C	50.5 - 147.5	86.49 ± 3.84	5.00 - 7.50	5.650 ± 0.146
D	17.5 - 165	93.71 ± 6.40	5.00 - 10.00	6.613 ± 0.297
E	27.5 - 157.5	86.45 ± 5.93	5.00 - 10.00	6.875 ± 0.272
F	35 - 150	77.69 ± 4.24	5.00 - 7.50	6.144 ± 0.187

***Biology of* Phellinus noxius**

Collection of isolates of *Phellinus noxius:* the pathogen causing brown root rot was continued from rubber plants of various rubber-growing regions in the country. This was done from rubber as well as from other possible alternative hosts. The reported incidences of Brown Root Disease during the year were from Deniyaya, Neluwa, Kegalle, Warakapola, Dehiowita, Moneragala and Galewatta. Moreover, the disease was reported from Mango *(Mangifera indica)* and Sandalwood *(Santalum album)* from Moneragala and Balangoda areas respectively (Table 5). Similar to the

last year, it was observed that the disease occurrence is high in certain agro-ecological regions of the country.

Studies on the morphological characteristics of the pathogen cultures were carried out. The nature of the margin, fluffiness and the density of the cultures of different isolates were tested in the petri plate. Moreover, the development of coloration with time by different isolates was tested. The growth rates of the isolates in different media *i.e.* Malt Extract Agar, Potato Dextrose Agar, Lima Bean Agar and Czapec Dox Agar was investigated. The growth variation of 14 isolates on Malt Extract Agar is shown in the Figure 7.

Table 5. *Reported incidences of Brown Root disease during the year*

Approx. Location	Agro-ecological zone	Number of incidences
Badalkumbura	IM2b	06
Rambukkana		02
Galagedara	IL1a	02
Ruwanwella (Wadakada, Gabbala)		02
Bulathkohupitiya	WM1a	01
Mawathagama		01
Deraniyagala		01
Madulla, Moneragala		01
Agalawatta		01
Matugma		01
Galapitamada		01
Parambe		01
Molagoda		01

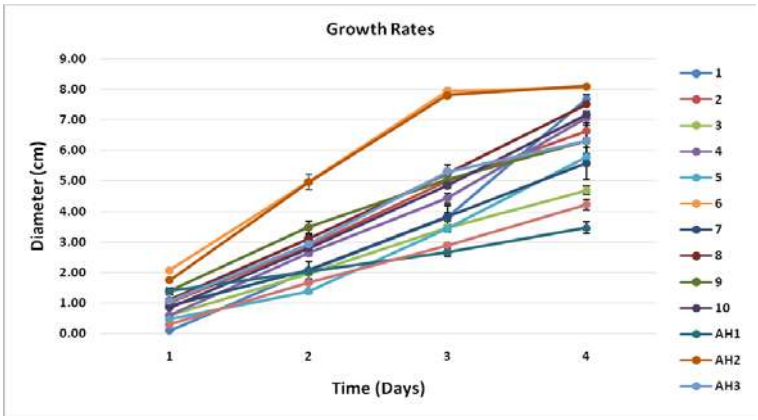


Fig. 7. The growth variation of 13 isolates of *Phellinus noxius* on Malt Extract Agar

Field trials established at Moneragala and Dartonfield to investigate the influence of agro-climatic conditions on the spread of the disease were maintained (M K R Silva, T H P S Fernando, R L C Wijesundera and B I Tennakoon).

***Biology of* Ustulina deusta**

Collection of disease specimens from different locations of the country and isolation of the pathogen was continued in order to evaluate the variability of the Sri Lankan population of *Ustulina deusta:* the pathogen causing *Ustulina* root rot and *Ustulina* stem rot (M K R Silva, T H P S Fernando and B I Tennakoon).

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

***Screening of the clones against* Powdery mildew**

Screening of the clones against Powdery mildew was initiated for the year 2015 but could not proceed due to transport problems (T H P S Fernando, E B Fernando, B I Tennakoon and S C P Wijayaratne).

Screening of the clones against Bark rot

At the clonal screening trial carried out at Kuruwita, it was observed that there is a varying reaction of different clones on the artificial inoculation of the standard spore suspension of the pathogen. The field screening will be repeated in upcoming years for the consistency of the results (M K R Silva, T H P S Fernando, B I Tennakoon and E B Fernando).

Screening of clones against Corynespora leaf fall disease (CLFD)

Screening of the clones against CLFD was undertaken for the year 2015. The average disease severity index was given to different clones (Table 6).The screening programme could not get completed due to the lack of transport facilities (T H P S Fernando, E A D N Nishantha and E A D D Siriwardena).

Table 6. *Survey on Corynespora leaf fall disease – 2015*

Clone	ADSI *	Clone	ADSI *
RRIC 121	0	RRISL 202	2.36
RRIC 102	0	RRISL 208	1.4
RRIC 130	0	RRISL 220	0
RRISL 203	0	RRISL221	0
PB 260	0	RRISL222	0
RRIC 133	1.0	RRISL 202	2.2
RRISL 201	1.26	RRISL 200	3.5
RRISL 205	0	RRISL 2000	0
RRISL206	0	RRISL 2002	0
RRISL210	0	RRISL 2004	0

Clone	ADSI *	Clone	ADSI *
RRISL211	0	RRISL 2005	0
RRISL215	0	RRISL 2006	0
RRISL216	0	GPS 1	0
RRISL217	0.8	PB 255	1.0
RRISL219	0	PR 255	0
RRISL2001	0	PR 305	0
RRISL2003	0	RRII 105	1.0
RRISL 218	1.4	PB 235	0
RRISL 204	0	BPM 24	0

*ADSI- Average Disease Severity Index
ADSI; 0-free from the disease; 0.01-1.0, slight infections; 1.01-2.0, moderate infections; 2.01-3.0, severe infections

Maintenance of nurseries for screening purposes – Ratnapura district

Bud wood nursery established in substation – Kuruwita was generally maintained (T H P S Fernando, M K R Silva and E A D N Nishantha).

Establishment of a nursery for screening purposes - Moneragala district

Nursery was generally maintained and will be used for screening purposes in the future (T H P S Fernando, M K R Silva, E B Fernando and S C P Wijayaratne).

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

***Studies on White Root Disease with special reference to* Mucuna bractiata**

A survey is in progress to detect the cover crop *Mucuna* infected with *Rigidoporus microporus.* The incidence of WRD on *Mucuna* was revealed as given in Table 7. The survey is in progress (T H P S Fernando, S C P Wijayaratne and E B Fernando).

The WRD survey – Establishment of the disease distribution

The survey could not be continued during the year 2015 successfully due to the transport problems. The reports for the completed estates are being prepared (T H P S Fernando, E B Fernando and S C P Wijayaratne - Project is partially funded by NRC 11-39).

***Report of new hosts for* Rigidoporus microporus**

Steps have been taken to expand the host range of *Rigidoporus microporus*, the causative agent of white root disease. *Salix* spp. was reported as an alternative host as a world's first repot (T H P S Fernando, R L C Wijesundera, E A D D Siriwardene and I Madushani. This project is partially funded by NRC 11-39).

Table 7. *Results of WRD survey with reference to Mucuna, cover crop*

Estate	Presence/Absence of disease on the cover crop, Mucuna
Udabage	√
Udapola	X
Eladuwa	X
Delkith	√
Raigam	√
Padukka	√
Payagala	X
Dartonfield	X
Arappolakanda	√
Kuruwita	X

Biological control of *Hevea* diseases (23/P/05)

A liquid medium for biological control agents

A medium is being tested for the growth of the identified native bio-control agents with rubber serum. Further investigations are carried out at the Department of Biochemistry and Physiology (T H P S Fernando, K V V S Kudaligama and E A D D Siriwardene. This project is partially funded by IFS, Stockholm. D/5127-1).

A solid medium for biological control agents

Compost has been identified as a suitable medium for the introduction of *Trichoderma inocula* in to the soil. The studies revealed that the medium should be slightly modified to enhance the establishment and also it was noted that the composition of compost from different agents are not consistent. Hence, this influenced the propagation of the micro-organism (T H P S Fernando and E A D D Siriwardene, This project is partially funded by IFS, Stockholm. D/5127-1).

Effect of sulphur application on the soil PH and on the soil microbe populations

Trials were carried out to test the application of sulphur on the variability of P^H and also on the beneficial soil microbe populations. Two experimental sites were selected in Nivthigalakele and Dartonfield estates. Planting holes were made as recommended and two sulphur application methods (application on to the surface and to mix with the soil at the time of refilling) were employed. Observations were made at monthly intervals (T H P S Fernando and E A D D Siriwardene: This project is partially funded by the IFS, Stockholm, D/5127-1).

Identification of antagonistic plants to control WRD

Data collection of the field experiment which was established to test the antagonistic action of the selected plant species over *Rigidoporus microporus* was

further carried out at two locations, Kuruwita and Galewatta. This trial was established to test the reduced chance of a rubber plant to get the disease when the antagonistic plant is in the surrounding (M K R Silva and B I Tennakoon).

Miscellaneous (PP– 06)

Agronomic approaches to minimize the inoculum potential and to improve tree vigour: Multiclonal clearings

The clones of the two clearings are monitored for the average disease severity index Corynespora leaf fall disease. The disease severity showed a slight increase with the inhibition of tapping (T H P S Fernando and E A D D Siriwardene).

Development of early detection methods for white root disease of rubber

The experiment was undertaken using different mulch materials at Vogan Estate to test the applicability. Mucuna litter was used as the mulching material and the experiment is in progress. The results are to be taken every three months period. The project is partially funded by NRC 11-39 (T H P S Fernando, R L C Wijesundera and E A D D Siriwardena).

Decorative handicrafts from partially decomposed rubber leaves

More environmental friendly method using rubber serum is being tested for skeletanization of rubber leaves. Optimization of the medium for efficacy is in progress. Skeletanization was successful at a percentage of around 75% after two weeks of incubation. The skeletanization was further enhanced by the incubation after boiling the leaves in water. The experiment is progressing (T H P S Fernando, K V V S Kudaligama, E A D D Siriwardena and Madushani Lanka).

Defense mechanism against WRD

Field trials which were established at Kuruwita to evaluate the reaction of economically important plant species; coconut, arecanut, oil palm, banana and pineapple against *Rigidoporus microporus* were artificially inoculated with the fungus and the disease reaction was periodically observed (M K R Silva and B I Tennakoon)**.**

Studies on beneficial soil micro flora

Estimation of soil microbial populations from traditional and non – traditional rubber growing lands. To understand the soil microbial distribution in traditional and non – traditional rubber lands, samples were collected as given in Table 8. Soil samples were collected from three depths and the pH was also measured (Fig 8). The microbial populations (Fungi & bacteria) were estimated and the effect of the cover crop was also studied. Identification of antagonistic fungi among the isolated populations was done. Dual culture test was done against *Rigidoporus*

microporus and twelve isolates were found effective (Fig. 9) (T H P S Fernando, E A D D Siriwardene and P W Balasooriya).

Table 8. *Collection of soil samples from different rubber growing areas*

District	Zone	Cover crop/Land type	Soil type
Kalutara	Wet	*Mucuna*	RYP
Kalutara	Wet	*Pueraria*	RYP
Kalutara	Wet	Bare rubber	RYP
Monaragala	Intermediate	*Mucuna*	IBL/RBL
Monaragala	Intermediate	*Pueraria*	IBL/RBL
Monaragala	Intermediate	Bare rubber	IBL/RBL
Ampara	Dry	Bare rubber	
Ampara	Dry	Non rubber	
Vavuniya	Dry	Bare rubber	RBE
Vavuniya	Dry	Non rubber	RBE

RYP - Red yellow podzolic soils RBE - Red Brown Earths
RBL-Reddish Brown Latasolic IBL – Immature Brown Loam

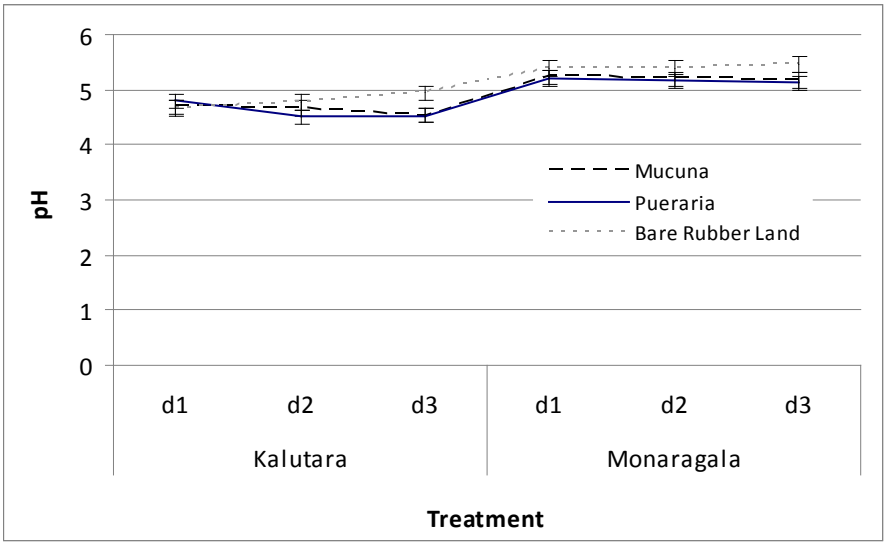


Fig. 8. Variation of soil pH according to the depth of sample collection

Table 9. *Microbial populations isolated from the soils of rubber growing districts in Sri Lanka*

District	Treatment or land	Depth	Bacteria ($x10^5 CFUg^{-1}$)	Fungi ($x10^3 CFUg^{-1}$)	Bacteria Fungi
Kalutara	Pueraria	d1	100.67	200.00	50.34
		d2	90.33	163.33	55.31
		d3	68.00	130.00	52.31
	Mucuna	d1	78.00	136.67	57.07
		d2	73.00	110.00	66.36
		d3	67.33	103.33	65.16
	Bare rubber	d1	40.33	70.00	57.61
		d2	42.00	93.33	45.00
		d3	33.67	76.67	43.92
Monaragala	Pueraria	d1	22.43	80.00	28.04
		d2	22.06	63.3.3	34.83
		d3	20.00	40.00	50.00
	Mucuna	d1	19.67	66.67	29.50
		d2	18.03	43.33	41.61
		d3	16.33	33.33	48.99
	Bare rubber	d1	12.73	10.00	127.30
		d2	11.80	26.27	44.92
		d3	10.37	10.00	103.70
Ampara	Bare rubber	d1	28.07	14.00	200.50
		d2	24.36	8.33	292.44
		d3	21.63	7.33	295.09
	Bareland	d1	24.23	11.67	207.63
	(NR)	d2	22.70	10.33	219.75
		d3	23.90	7.33	326.06
Vavuniya	Bare rubber	d1	18.60	9.33	199.36
		d2	15.70	8.00	196.25
		d3	9.90	6.00	165.00
	Bareland (NR)	d1	18.13	10.67	169.92
	Bareland	d2	16.03	5.33	300.75
	(NR)	d3	8.33	3.67	226.98

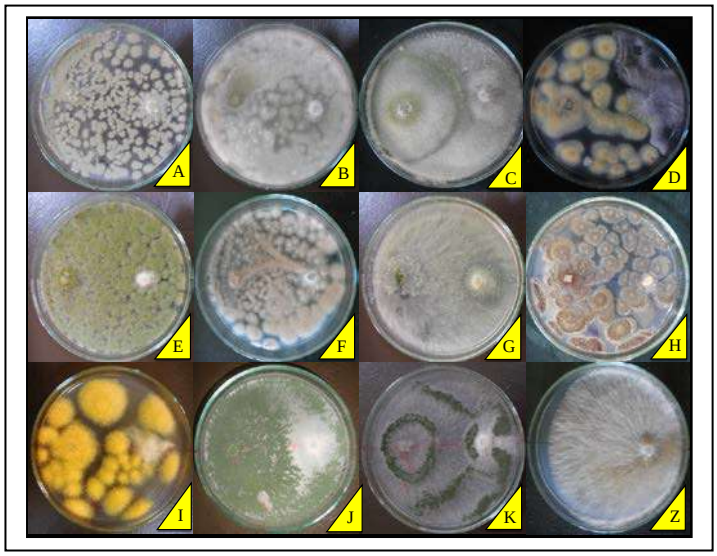


Fig 9. Antagonistic fungal isolates against *R. microporus*

A - Isolate	(*Penicillium* sp)	G - Isolate	(*Trichoderma*sp)
B - Isolate	(*Penicillium* sp)	H - Isolate	(*Aspergillus*sp)
C - Isolate	(*Trichoderma* sp)	I - Isolate	(*Aspergillus*sp)
D - Isolate	(Unknown sp)	J - Isolate	(*Trichoderma*sp)
E - Isolate	(*Aspergillus*sp)	K - Isolate	(*Trichoderma*sp)
F - Isolate	(Unknown sp)	Z - Control	(*R. microporus*)

Advisory visits (PP - 07)

The staff of the department made 59 advisory visits mainly to handle complicated disease problems. Majority of these visits were for the estate sector while the others were directed by the Extension staff (T H P S Fernando, M K R Silva, E B Fernando, B I Tennakoon, E A D D Siriwardene, S C P Wijayaratne and E A D N Nishantha).

Training Programmes (PP - 08)

The staff of the department served as the resource personnel in training Estate Managers, Assistant Superintendents and Field Officers. Students from Universities and Technical Colleges were also trained on departmental activities. Mr Priyantha Peiris covered all audio visual aspects with regard to the training programmes organized by the institution (T H P S Fernando, M K R Silva, E B Fernando, B I Tennakoon, E A D D Siriwardene, S C P Wijayaratne, S R D P C Peiris and E A D N Nishantha).

SOILS AND PLANT NUTRITION

R P Hettiarachchi

DETAILED REVIEW

Staff

Mrs R P Hettiarachchi, Senior Soils Chemist continued her postgraduate studies while on duty throughout the year. Experimental Officers, Mrs C K Maheepala, Mr U Mitrasena, Miss V U Edirimanna, Miss A Thevarapperuma, Mr T Gunathileke, Mr J A S Chandrasiri, Technical Officer Mrs K E de Silva, Mr G C Malawaraarachchi and the English Stenographer Mrs L Rupasinghe were on duty throughout the year. Mrs K M M E K Kulatunga and Mrs R H N S Alwis assumed duties as Technical Officer on April 22, 2015. Mr T B Dissanayake, Experimental Officer was transferred to the Genetics and Plant Breeding Department with effect from the 7th March and Mr S N Silva, Experimental Officer, retired from duty with effect from 9th August 2015.

Mrs R P Hettiarachchi continued her research project on "Biofilmed biofertilizer for improved plant growth and soil health of rubber nurseries and plantations" leading to a PhD degree at the Postgraduate Institute of Agriculture, University of Peradeniya, Sri Lanka under the supervision of Dr R S Dharmakeerthi, Prof. G Seneviratna and Prof. A N Jayakody.

Seminars/Conferences/Meetings/Work-shops attended

Officer	Subject	Organization
RP Hettiarachchi	Scientific Committee Meetings	RRISL
	Executive Committee Meetings, Soil Science Society of Sri Lanka	Soil Science Society of Sri Lanka
	Finalization of IAS Risk Assessment Protocol and Preparation of National list of Fauna and Flora	State Ministry of Environment
	Seminar for the License holders on implementation of new Licensing Procedure of the New Atomic Energy Act	Atomic Energy Regulatory Council
	Revision of Standards for Inorganic Solid Fertilizers	Ministry of Agriculture
	Symposium on Toxicological Aspects of Glyphosate	Crop Life of Sri Lanka
	Mid Term Technical Secession	Soil Science Society of Sri Lanka

Seminars/Conferences/Meetings/Work-shops addressed

Officer	Subject	Organization
R P Hettiarachchi	Determination of Desirable Properties of Bacteria, Fungi and their Biofilm Associated with Rubber Rhizosphere	Annual Congress Postgraduate Institute of Agriculture

Training programmes conducted

Client	No. of programmes
Smallholders	5
University students	8
NIPM, Agriculture diploma *etc.*	5

Advisory visits

Client	No. of visits
Plantations	03
Smallholdings	02

LABORATORY AND FIELD INVESTIGATIONS

Soil fertility management

Mass production of Mucuna bracteata *plants*

Objective of this was to provide *Mucuna* plants to smallholders and also to estate sector. Nurseries were established in RRISL substations in Nivithigalakele and Kuruwita and at Payagala Estates and 1200 polybagged *Mucuna* plants were issued (Table 1) (R P Hettiarachchi, U Mitrasena and A Thewarapperuma).

Table 1. *Details of issuing Mucuna plants at different nurseries*

Name of the nursery	Number of plants
Payagala	490
Kuruwita	335
Nivitigalakele Substation	375
Total	1200

Biofilm biofertilizers for rubber

Soil is an excellent niche of microorganisms, *i.e.* protozoa, fungi, bacteria and viruses. Some soil bacteria that are able to colonize surrounding the plant roots is called rhizobacteria, and play a significant role in maintaining the dynamic of soil

fertility and plant growth These bacteria support fixation of atmospheric nitrogen, solubilization of phosphatic minerals and secretion of stimulating hormones, like auxin such as Indole 3 Acetic Acid (IAA). Solubilization of insoluble inorganic aluminum and iron phosphate compounds is an important strategy for increasing availability of phosphorus in the soil. Some soil bacterial isolates have an ability to solubilize inorganic low soluble phosphates.

Quantitative estimation of phosphorus solubilization

In liquid medium with $CaHPO_4$, out of 30 bacterial isolates, 22 were capable of solubilizing phosphorus higher than 100 ppm (Table 2) and were clustered in two different regions (Fig. 1). The isolates which were able to solubilize phosphorus less than 100 ppm were clustered separate to others (Fig. 1). Bacterial isolates those have an ability to solubilize phosphorus more than 100 ppm of the medium with $CaHPO_4$ were further evaluated for their phosphorus solubilization of the medium with HERP and ERP. For the medium with HERP, the strains coded as B3, B5, B6, B7, B9, B17, B23 and B25 increased the soluble phosphorus content more than 20 ppm at the end of the incubation period (mean value = 33.55 ppm). In the medium containing ERP, 5 strains coded as B5, B6, B17, B23 and B25 out of 22 strains increased the soluble phosphorus content more than 20 ppm at the end of the incubation period (mean value = 34.1 ppm). In general, strains B5, B6, B17, B23 and B25 exhibited higher solubilizing capability for the three spairingly soluble inorganic phosphates in liquid medium than the other strains and it was evidenced by the clustering pattern of the dendrogram based on phosphorus solubilization in the medium with $CaHPO_4$ (Fig. 1).

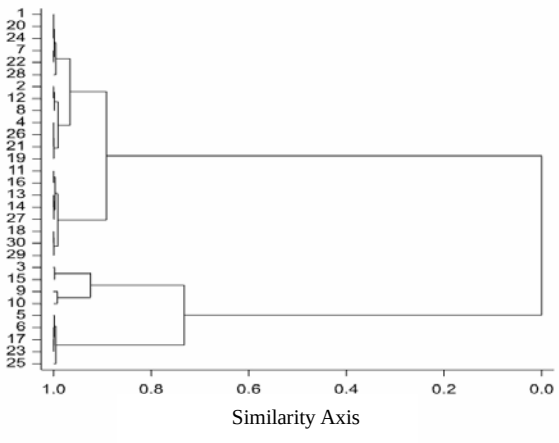


Fig.1. Dendrogram for solubilization of phosphorus by different bacterial strains in liquid medium with $CaHPO_4$

Table 2. *Mean soluble P contents by different bacterial isolates*

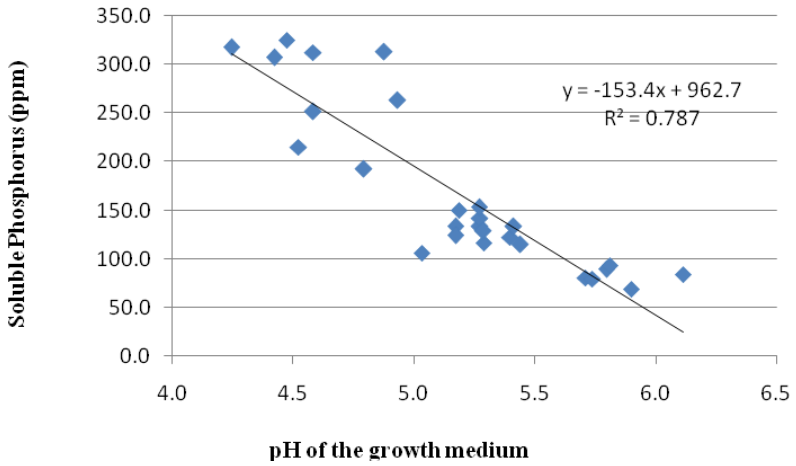
Isolate No.	Mean soluble P with $CaHPO_4$/ppm
1B	123 ± 10.8
2B	150 ± 7.5
3B	263 ± 15.6
4B	133 ± 8.1
5B	307.6 ± 11.2
6B	317.6 ± 2.5
7B	116 ± 7.0
8B	142 ± 22.9
9B	192 ± 9.0
10B	215 ± 7.0
11B	89 ± 10.3
12B	153 ± 7.6
13B	80 ± 10.2
14B	79 ± 4.7
16B	93 ± 4.2
17B	313 ± 5.9
18B	69 ± 4.6
19B	128 ± 11.7
20B	122 ± 14.2
21B	133 ± 9.1
22B	114 ± 0.6
23B	312 ± 2.1
24B	124 ± 11.4
25B	325 ± 10.5
26B	133 ± 4.2
27B	84 ± 7.2
28B	106 ± 7.1
29B	74 ± 14.0
30B	70 ± 5.0

Phosphorus solubilization and growth medium acidity (pH)

The majority of bacterial strains acidified liquid medium containing three insoluble inorganic phosphates. The solubilization of $CaHPO_4$ in the liquid medium by different strains was accompanied by a drop in pH (4.2 to 6.1) from an initial pH of 6.8-7.0 after the incubation period. There was an inverse correlation between the pH of the medium and the released of P content in the supernatant of the culture medium containing $CaHPO_4$ and HERP as a sole source (Fig. 2a and 2b). No correlation was

found between pH and the amount of P released in the culture medium containing ERP (Fig. 3).

(a)



(b)

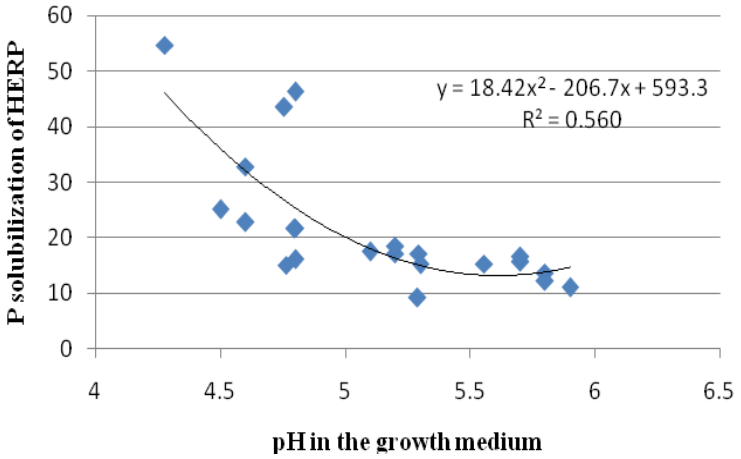


Fig. 2a. & b. Relationship between pH and solubilized phosphorus by bacterial strains in liquid medium with $CaHPO_4$ (a) and HERP (b)

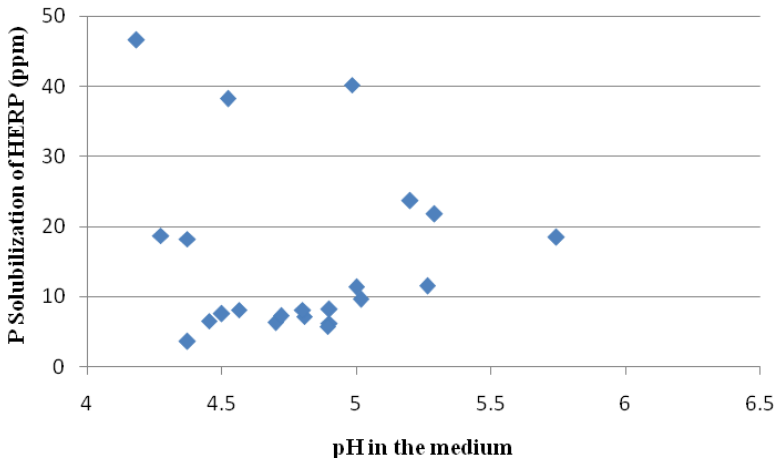


Fig. 3. Relationship between pH and solubilized phosphorus by bacterial strains in liquid medium with ERP

Quantitative estimation of phosphorus solubilization with biofilm

Out of 30 bacterial isolates, 14 bacterial isolates had an ability to colonize on fungal mycelia and formed biofilm community structure (Fig. 4). The rest did not form biofilm.

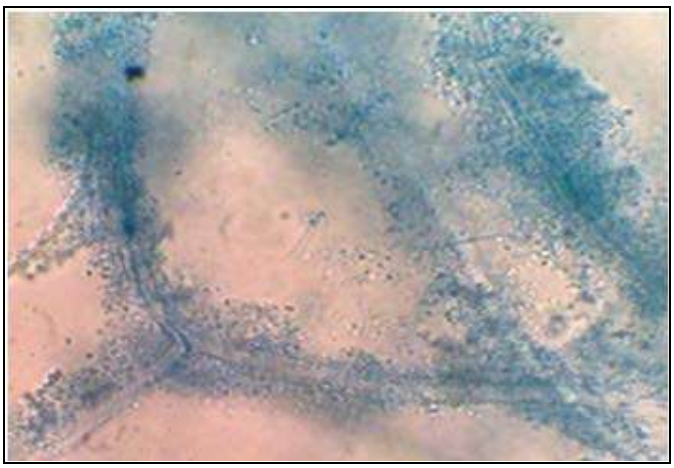


Fig. 4. A microscopic view of fungal filaments attached by bacteria for the formation of fugal bacterial biofilm Magnification: 2,000 x

In order to evaluate the effectiveness of phosphorus solubilization in biofilm, comparison was made to compare bacterial broth containing soluble P (variable 1) with fungi alone (variable 2) and their biofilm culture (variable 3) (Table 3). This contrast effect was significant at the probability level $p< 0.0001$.

Table 3. *Sparingly soluble phosphorus sources solubilized by different microbial treatments after 07 days of incubation*

Treatment	$CaHPO_4$ solubilized (ppm)
Bacteria only (B25)	325.3^c
Fungi only (F2)	6660^b
Biofilm (B25F2)	9600^a

Indole acetic acid production (IAA) of isolates

Out of 30 bacterial isolates 22 isolates were capable of solubilizing $CaHPO_4$ higher than 100 ppm, 9 isolates were screened based on indole acetic acids (IAA) production ability. Those isolates were coded as B2, B3, B4, B6, B7, B12, B19, B23 and B25. There were significant differences ($P<0.0001$) among the nine isolates on the production of IAA which ranged from 0.3 to 4.8 µg/ml, with mean value of 3.0122 ± 1.26. Same pattern was observed on the production of IAA among the biofilm community structures and it ranged from 0.7 to 7.9 mg/ml, with the mean value of 4.9348 ± 1.98. Furthermore, a significant difference (($P<0.0001$) in the production of IAA was recorded in the presence of particular biofilm community structures (B2F2, B3F2, B6F2, B23F2, B25F2) compared to their bacteria alone counterpart (Fig. 5).

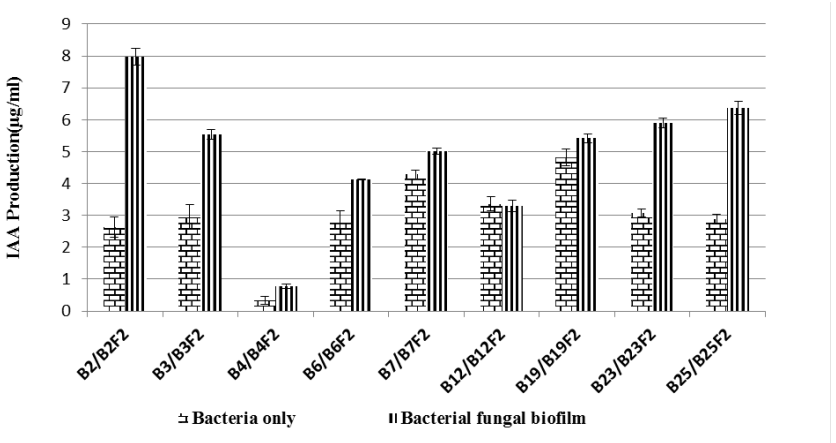


Fig. 5. Indole acetic acid productions in the medium containing different bacteria and their biofilm community structures

Nitrogenase activity of different isolates and their biofilms

Nitrogenase activity was observed with 3 bacterial isolates which were coded as B3, B19 and B25 out of total 30 bacterial isolates and it was ranged from 3 to 8 μmol C_2H_4/hr. Moreover some bacterial isolates that exhibited either no or low nitogenase activity, showed significantly ($p<0.0001$) higher nitrogenase activity with their biofilm community structure (Table 4).

Table 4. *Comparison of nitrogenase activity (μmol C_2H_4/hr) between bacteria and their biofilm community*

Code of bacteria and their biofilm	Difference of nitrogenase activity (μmol C_2H_4/hr) between bacteria and their biofilm
B6 and B6F2	90.65[a]
B23and B23F2	82.84[a]
B25and B25F2	40.74[b]
B12and B12F2	8.67[c]

This project was carried out in collaboration with the Institute of Fundamental Studies, Hantana, Kandy (R P Hettiarachchi, R S Dharmakeerthi, E De Silva, T Gunathilake and A Thewarapperuma).

Quantitative response of inorganic fertilizers to young budding nursery plants with biofilm biofertilizers at field conditions

Three experiments were started at Dartonfield estate, Millawa estate and RDD nursery at Egaloya using different inorganic fertilizer applications and Biofilm biofertilizers to evaluate the effectiveness on nursery plants. The RRISL recommended N P K Mg young budding fertilizer mixture was applied at 0, 50% and 100% of the currently recommended level with and without the application of developed BFBF (B25F2) (Table 5). Treatments were arranged in a randomized block design with 50 single plants as one replicate.

The treatments having 100%F+BFBF, 50%F+BFBF and 100%F gave slightly higher diameter and height values during the experimental period of five months and the effectiveness was apparent at the latter part of the experiment (Fig. 6 & 7).

Table 5. *Treatment combinations of the experiment*

Treatment	Design
T1	S + C + H + P+ 0%F
T2	S + C + H + P + 50%F
T3	S + C + H + P + 100%F
T4	S + C + H + P + BFBF (B25F2) + 0%F
T5	S + C + H + P + BFBF (B25F2) + 50%F
T6	S + C + H + P + BFBF (B25F2) + 100%F

S = Soil C = Compost H = HERP P = Rubber seedling plant
BFBF = biofilmed biofertilizer 0%F = No inorganic fertilizer
50%F = 50% of the recommended dose of fertilizer for nursery plants
100%F = Full amount of the recommended dose of fertilizer for nursery plants

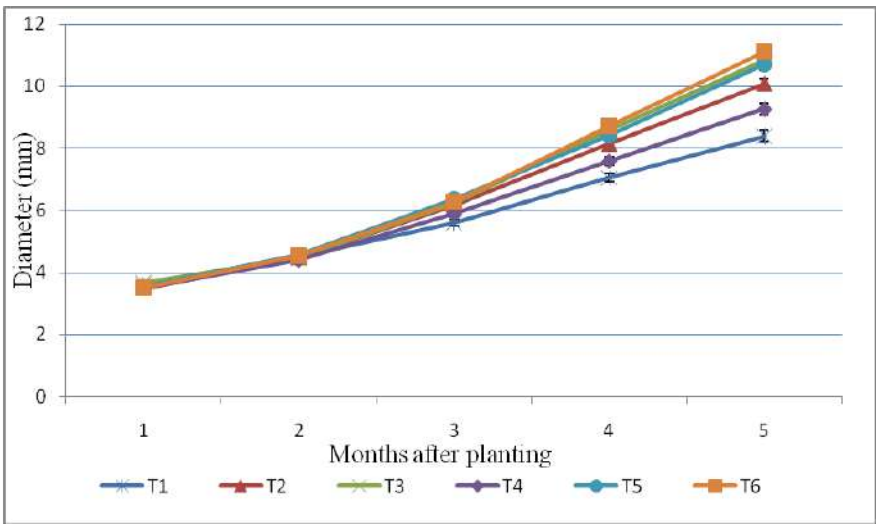


Fig. [A.N.1]6. Effect of different fertilizer treatments on diameter of rubber seedlings

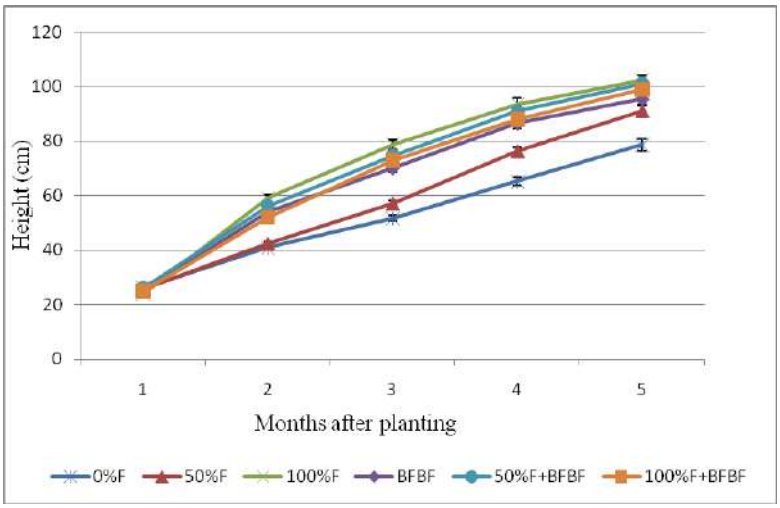


Fig. 7. Effect of different fertilizer treatments on height of rubber seedlings

This study showed that combine use of chemical fertilizer with BFBF (50%F+BFBF and 100%F+BFBF) treatments improved plant growth parameters *i.e.* leaf area, leaf and total dry weights of seedling nursery plants at field conditions. 100%F+BFBF treatment gave the highest values and 50%F+BFBF gave the second highest values for all growth parameters. Moreover, all these assessments with 50%F+BFBF and 100%F+BFBF treatments are higher than the recommended fertilizer treatment (100%F) (Table 6). Improved growth parameters with reduced rates of chemical fertilizer were also recorded with tea plantations in Sri Lanka.

Table 6. *Leaf dry weight (g), total dry weight (g) and leaf area (cm^2) of plants grown with different combinations of chemical fertilizers and biofilmed biofertilizers*

Treatments	**Leaf dry weight (g)**	**Total dry weight (g)[A.N.2]**	**Leaf area (cm^2)**
0% F	3.92^{c}	18.55^{d}	1243.9^{b}

50% F	6.74[abc]	31.0b[c]	1782.4[ab]
100% F	8.79[ab]	35.38[ab]	2317.2[a]
BFBF	6.15[bc]	28.04[c]	1647.2[ab]
50%F + BFBF	8.83[ab]	37.19[ab]	2400[a]
100%F+ BFBF	9.6[a]	41.30[a]	2492[a]

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

Nutrient contents of N, P, K and Mg of leaf samples did not show significant differences among 100%F, 100%F+BFBF and 50%F+BFBF treatments and were generally within the accepted levels (Table 7).

Table 7. *Effect of different combination of fertilizer applications on leaf nutrient contents of young budding seedling plants*

Treatments	**Leaf nutrients contents (%)**			
	N	**P**	**K**	**Mg**
0%F	2.468[a]	0.254[a]	0.768[b]	0.127[ab]
50%F	2.898[a]	0.240[a]	0.896[a]	0.084[b]
100%F	3.172[a]	0.258[a]	0.918[a]	0.148[a]
BFBF	3.084[a]	0.274[a]	0.744[b]	0.104[ab]
50%F+BFBF	3.162[a]	0.246[a]	0.912[a]	0.141[a]
100%F+BFBF	3.262[a]	0.240[a]	0.894[a]	0.105[ab]

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

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

This experiment was conducted at Millawa estate to study the effectiveness of BFBF (B25F2) with inorganic fertilizers on soil fertility, and their influence on mineral composition of rubber leaves and growth. One year old RRISL 203 plants was used. Pre-treatment soil analysis of the experimental site indicated the mean values for the pH- 4.7; CEC- 2.02 (cmol+/kg); organic carbon 0.69% ,bulk density -1.4g/cm^3, total nitrogen 0.076%, available phosphorus 8-10ppm, potassium 125 ppm and magnesium 250ppm. Treatments tested were as follows, T1-Recommended Fertilizer application (RF), T2 -100% RF +BFBF,T3-50% RF + BFBF and T4 -75% RF +BFBF. N P K Mg fertilizers and freshly prepared BFBF was diluted 10 times and was applied 200ml/plant at three months intervals throughout the experimental period. The design of this experiment was a randomized block with five replicates. Each replicate had 25 effective trees.

Immature field plants did not show any significant difference among different

fertilizer treatments within one year of experimental period for plant growth parameters, diameter/height (Fig. 8). Concentration of major nutrients N, P and Mg in leaf samples were generally within the acceptable level. Also BFBF treatments gave much higher leaf P and K values compared to 100%F treatment (Table 8).

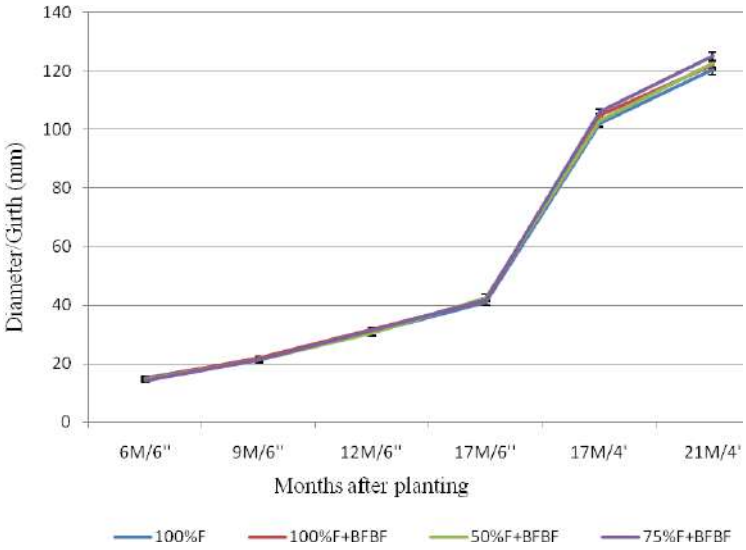


Fig. 8. Effect of different combinations of fertilizer and BFBF on plant diameter (up to 17th month) and girth (from 17th month onwards) of immature rubber plants

Table 8. *Effect of different combinations of fertilizer application on leaf nutrient contents of rubber plants of 2nd year*

Treatments	**Leaf nutrient content (%)**			
	N	**P**	**K**	**Mg**
100%F	2.428^{a}	0.218^{a}	0.540^{a}	0.241^{a}
100%F+BFBF	2.438^{a}	0.224^{a}	0.568^{a}	0.251^{a}
50%F+BFBF	2.270^{a}	0.224^{a}	0.574^{a}	0.177^{a}
75%F+BFBF	2.425^{a}	0.240^{a}	0.578^{a}	0.207^{a}

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

There were no significant difference among different treatments for soil pH,

bulk density, OC and CEC. However BFBF treatments gave slightly higher pH, organic carbon and CEC values and reduced bulk density up to some extent (Table 9).

Table 9. *Effect of different fertilizer application treatments on some soil fertility parameter in the top 0-15cm soil layer*

Treatments	pH	Bulk density (g/cm^3)	OC%	CEC (cmol+/kg)
100%F	4.77[a]	1.404[a]	0.72[a]	2.05[a]
100%F+BFBF	4.87[a]	1.41[a]	0.83[a]	2.40[a]
50%F+BFBF	5.04[a]	1.33[a]	0.92[a]	1.89[a]
75%F+BFBF	4.9[a]	1.35[a]	0.95[a]	2.3[a]

Means with same letters in a column are not significantly different at $p< 0.05$ [A.N.3]

Study of the weed management in immature rubber using a new weedicide

This experiment was continued to compare the effectiveness of weedicides, Gluphosinate ammonium (GA) and Glyphosate (GLY) with soil active pre emergency weedicide Diuron (DIU) to control weeds in immature rubber fields. It was observed that combine use of weedicides, Gluphosinate ammonium and Glyphosate with Diuron control the weed growth in area compared to Gluphosinate ammonium and Glyphosate alone applications. It was also observed that 50% regeneration appeared at 14weeks after application of Gluphosinate ammonium only treatment and that period was extended upto 25th week with the combine use of Gluphosinate ammonium with Diuron (Fig. 9) (R P Hettiarachchi, A Thevarapperuma and T Gunatilleke).

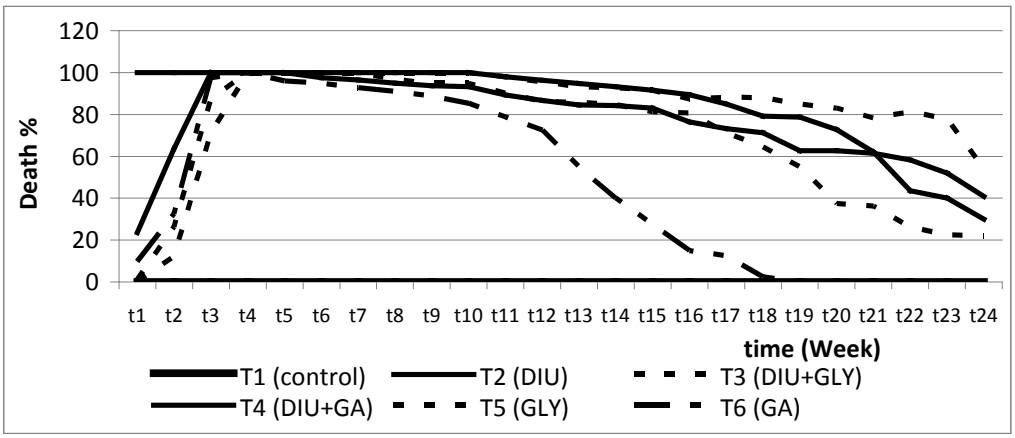


Fig. 9. Effect of different weedicides and their combinations on weed death (%) around the base of immature plants

Plant nutrition and fertilizer use

Micronutrient requirement of different rubber growing soils

Combine use of macronutrient and micronutrient fertilizers to improve growth of rubber plants

This experiment was done in 2014 at Dartonfield estate and was repeated in RDD nurseries to confirm the best micronutrient level for nursery plants. Based on the results, new experiment was established at Dartonfield, Millawa estate and RDD nurseries to evaluate the effectiveness of macronutrient and micronutrient fertilizers and biofertilizer to improve soil fertility and plant growth of *Hevea* seedlings under field conditions.

The treatment combinations are given in the Table 10 and were arranged in a completely randomized block design with 80 replicates. Growth assessments, diameter and height were measured throughout the experimental period are presented in Figures 10 & 11.

Table 10. *Treatment combinations of the experiment*

Treatments	Combination
T1	Recommended fertilizer + BFBF + MN + C
T2	Recommended fertilizer + BFBF + C
T3	Recommended fertilizer + MN + C
T4	Recommended fertilizer + C
T5	½ Recommended fertilizer + BFBF + MN + C
T6	½ Recommended fertilizer + BFBF + C

T7 ½ Recommended fertilizer + MN + C

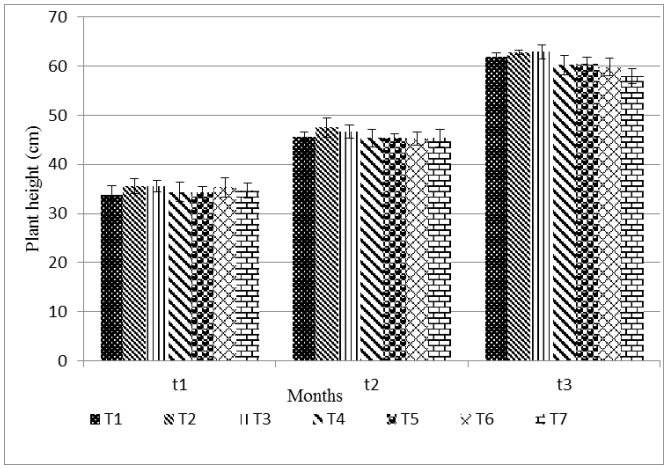


Fig. 10. Effect of different combinations of fertilizer application on plant height of nursery plants

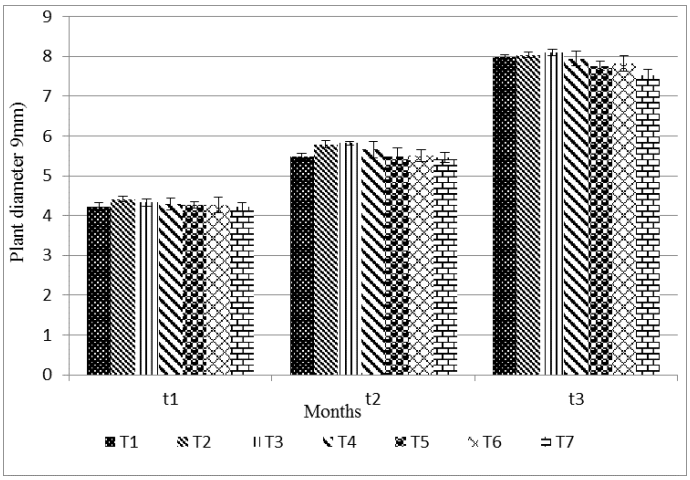


Fig. 11. Effect of different combinations of fertilizer application on plant diameter of nursery plants

It could be observed that there were no significant difference among treatments. Also, half recommended fertilizer with micronutrient and biofertilizer gave comparable growth assessments to recommended fertilizer treatment (R P Hettiarachchi, T Gunathilake, A Thewarapperuma and K E de Silva).

***Nutrient requirement of* Hevea *grown in the low country Intermediate* Zone**

The experimental details were given in the Annual review for 2011. These Experiments were started to investigate the best fertilizer mixture and was not continued due to the lack of fertilizers in correct time (R P Hettiarachchi, S N Silva and C K Maheepala).

Slow release fertilizer application

Fertilizer use efficiency can be increased by minimizing losses due to leaching, surface runoff, ammonia volatilization and denitrification. Under ideal soil fertility management, nutrients are supplied through fertilizers at times and in amounts to meet the need of the plants. To achieve this objective, there have been efforts in the last several decades to develop fertilizer products which release nutrients at controlled rates and concentration to allow plants to maintain maximum growth but minimize losses. The use of slow release fertilizers are reported to have several advantages over conventional fertilizers. Prevention of environmental hazards and wastage due to excessive leaching losses of nutrients, improved assessment of economic benefits expected from reduced specific toxicity as a result of synchronizing nutrient supply with nutrient demand, reduced labour costs associated with repeated applications are some of them.

Four field experiments were started at Dartonfield, Millawa and Panawatta estates and RDD nurseries to evaluate the effectiveness of slow release fertilizers for nursery plants. The treatment combinations are given in the Table 11 and were arranged in a completely randomized block design with 100 replicates. Plant diameter and height were measured throughout the experimental period are presented in Figure 12 and 13. It was found that there was no significant difference among different treatments and slow release fertilizer application treatments gave slightly higher plant diameter values than the normal fertilizer recommendation. Plants of all treatments reached buddable girth of above 6 mm in diameter at three months planting (R P Hettiarachchi and J A S Chandrasiri).

Table 11. *Treatment combinations of the experiment*

Treatment	Combination
T1	Normal fertilizer recommendation
T2	Slow release fertilizer application (Balance 5g+10g)
T3	Slow release fertilizer application (Balance 10g+10g)
T4	Slow release fertilizer application (N high 5g+10g)
T5	Slow release fertilizer application (N high 10g+10g)

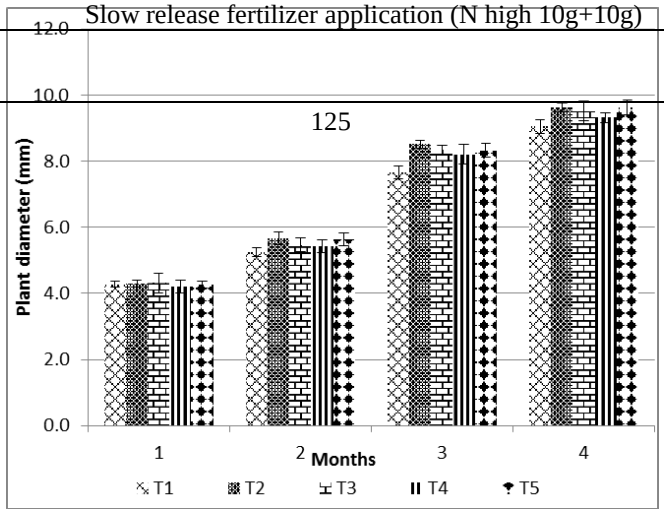


Fig. 12. Effect of different forms of fertilizer on plant diameter of nursery plants

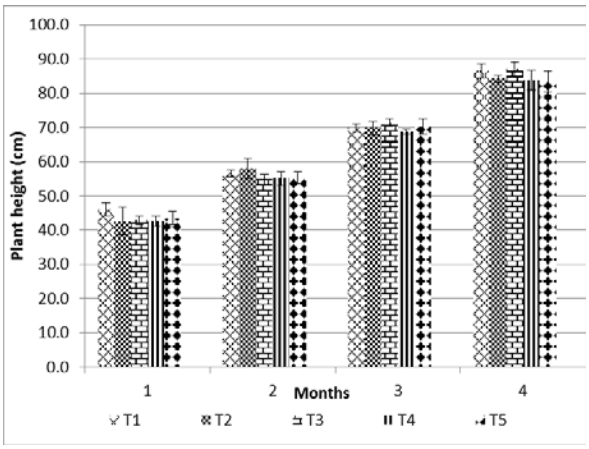


Fig. 13. Effect of different forms of fertilizer application on plant height of nursery plants

Soil moisture stress management

Investigation on soil moisture stress management in nontraditional areas

Planting rubber in non-traditional areas (Uva, Northern and Eastern Provinces) with Good Agricultural Practices (GAPs) (NRC Grant 11-125)

Experiments conducted at Dammeria B, Passara and Bibile estates, Bibile to investigate the effect of different GAPs in maintaining good performance of young rubber plants under stressful conditions were completed at the end of 2014 (Dr D M A P Dissanayaka, Head, Advisory Services Department was the principal investigator of

this project. Dr Wasana Wijesooriya and Dr R S Dharmakeerthi were co-investigators. Experimental Officers U Mitrasena, A Thewarapperuma and T Gunathilake of the Soils and Plant Nutrition Department carried out the activities reported under experiments).

Demonstration plots for Soil moisture stress management in Moneragala Sub Station

This demonstration plot was divided into sub plots in order to generate information on growth response to different fertilizer mixtures (R/U/ 15:15:7+Mg and R/SA/ 9:12:4:2) under different soil moisture stress management situations and was not continued due to the lack of fertilizers in correct time (R P Hettiarachchi, S N Silva and U Mitrasena).

Rehabilitation of degraded lands

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

This experiment was started in Panawatta and Ekerella estates. At first pre-treatment soil analysis was done to measure the fertility levels of the experimental sites. Data were assessed in experimental sites are given in Table 12. The available P, exchangeable K, Mg and Ca levels as well as the total nitrogen, cation exchange capacity and also the total carbon contents of those soils are intermediate in nature (R P Hettiarachchi, U Mitrasena, V Edirimannne, T Gunathilake and G C Malawararachchi).

Table 12. *Pretreatment analytical values of soil samples Panawatta and Ekerelle estates*

Assessment	Measurement	Optimum range
pH	4.2 - 4.9	4.0 - 6.0
Organic carbon (%)	1.0 -1.3	2 – 3
Total N (%)	0.10 - 0.15	0.11 - 0.25
K (ppm)	62	100 – 150
Ca (ppm)	70	
Mg (ppm)	22	30 – 50
Available P (ppm)	15	11 – 30
Cation exchange capacity (cmol+/kg)	3 - 3.5	15
Microbial biomass carbon (ppm)	225 - 275	

Services

Site-specific fertilizer recommendation by soil and foliar survey programme

Under this programme 2215 hectares of mature rubber fields were surveyed and 30 fertilizer recommendations were given for the next three years. Details of the survey are given in Table 13 (R P Hettiarachchi, A Thewarapperuma and all the staff of the department).

Table 13. *Detail repot of the site specific fertilizer recommendation programme in 2015*

Estate	Extent surveyed (ha)	Estate	Extent surveyed (ha)
Penrith	272	Pussella	219
Hillstreem	51	Diddenipotha	130
Halwatura	97	Eladuwa	168
Citrus	13	Miyanawita	66
Elston	340	Attanagalla	74
Pallegoda	188	Mahaoya	33
Opatha	190	Dodangaslanda	37
Madeniya	20	Wilpita	137
Higgoda	140	Kuruwita	70
Andapana	78	Millawitiya	41
Walpita	14	Kalupahana	125
Durampitiya	155	Edurupola	197
Miriswatta	76	Weoya	161
Sandenland	55	Kiriporuwa	214
Salawa	18	Lomant	173

Land selection and suitability for rubber cultivation

Under the routine land selection programme 300 hectares of land were surveyed for the suitability of cultivation rubber (R P Hettiarachchi and all the staff of the department).

Analytical services

The Department analyzed approximately 1000 samples (7,500 parameters) including more than 70 fertilizer samples for rubber growers to assure application of good quality fertilizers to their rubber lands (R P Hettiarachchi and all the staff of the department).

BIOCHEMISTRY AND PHYSIOLOGY

K V V S Kudaligama

DETAILED REVIEW

Staff

Mrs K V V S Kudaligama, Senior Biochemist, covered the duties of the Head of Biochemistry and Physiology department throughout the year whilst managing the research and development work of the department. Technical Officer, Mr R P S Randunu and Management Assistant, Mrs H A M E Hettiarachchi were on duty throughout the year. Experimental Officer, Mr M K P Perera was transferred to the Department of Biochemistry and Physiology with effect from 27.04.2015. Mrs P D T L Madushani assumed duties as a Technical Officer with effect from 24.04.2015. Mr R G N Lakshman has been working as a Research Assistant on contract basis under the research project (RG/2011/AG/10) funded by the National Science Foundation through out the year.

Achievements

Dr (Mrs) K V V S Kudaligama has won the GRC Postgraduate award 2015 awarded by the Sri Lanka Association for the Advancement of Science.

Research students

Student name	University	Research topic
AKBP Ariyasinghe	University of Ruhuna	Analysis of some physical properties and biochemical components of rubber (*Hevea brasiliensis*) wood of RRIC 100 and PB 86 genotypes grown in Dartonfield estate, Kalutara
TDC Hasanthi	University of Ruhuna	Variation of some physical properties and biochemical components of rubber (*Hevea brasiliensis*) wood of RRIC 121 genotype with age
PS Sandaruwan	Wayamba University of Sri Lanka	Effect of rain guard on some latex physiological parameters of RRIC 121 genotype of *Hevea brasiliensis* grown in Low country wet zone during re-foliation period

Student name	University	Research topic
UN Udayakumari	Uva Wellassa University	Development of a suitable low cost liquid medium for bio fungicides
LKI Madushani	Uva Wellassa University	Developing a calibration curve to quantify chlorophyll content in *Hevea brasiliensis*
DS Hewamanage	University of Ruhuna	Effect of different types of stimulant on latex and raw rubber properties of *Hevea brasiliensis* harvested with S/4 d3 system
TMCSRSK Thennakoon	University of Peradeniya	Variation of latex yield of RRISL 203 rubber clone *Hevea brasiliensis Mull.Arg* with S/2 d1 2d/7 tapping system using ethephon
GMNS Ganthuna	Aquinas University Collage	Investigation of raw rubber properties in new *Hevea* progenies at Kuruwita RRISL Substation

Seminars/Conferences/Workshops/Exhibitions attended

Officer/s	Subject/Theme	Organization
KVVS Kudaligama	International Forestry and Environment Symposium	University of Sri Jayawardhenepura
	Scientific Committee Meetings	RRISL
	Progress Review Meetings	MPI
	IRRDB Fellowship – 2015	RRIV
	Annual General Meeting	SLAAS

Training programmes conducted

Officer/s	Subject/Theme	
KVVS Kudaligama	Low intensity harvesting	Plantation Management Diploma Course, Aquinas University Collage
	Use of stimulant in low intensity harvesting	Induction Course for Planter Trainees, NIPM
	Low intensity harvesting	HNDT (Agri) – Gampaha
	Low intensity harvesting	Rubber Extension Officers, NIPM
	Dry rubber content determination	

Field visits

Advisory - 02 visits
Experimental - 235 visits
Miscellaneous - 07 visits

Sample testing
% Dry rubber content of latex - 20 samples
Commercial Ethephon mixtures - 18 samples

LABORATORY AND FIELD INVESTIGATIONS

Biochemical assessment in latex to develop stimulation base harvesting systems (BCP/01)

Low frequency tapping with liquid stimulation

BCP/01/a

Commercial scale experiment on S/2 d4 system started in 2010 in Kuruwita substation with RRIC 100 genotype was terminated at the beginning of 2015 due to completion of tapping on BI-11 panel of trees. Performance of the tapping system during five year period are given below.

Yearly variation of yield per tree per year (YPT) was alike in both harvesting systems with an average of 4.32kg for five year testing period. Average annual yield received by S/2 d4 system varied between 96% - 103% of the yield given by the traditional S/2 d2 system (Fig. 1).

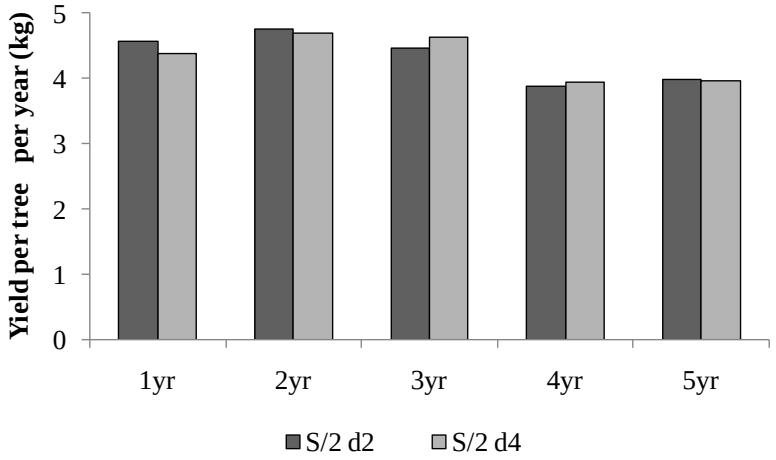


Fig. 1. Average amount of rubber harvested per tree per year in S/2 d2 and S/2 d4 harvesting systems

Yield per hectare per year (YPH) of S/2d2 and S/2d4 harvesting systems were also comparable with averages of 1,729kg and 1,728kg respectively. Average tapping days observed in S/2 d2 and S/2 d4 systems were 154 and 82, respectively. Loss of

tapping days due to rain in S/2 d2 system was 14% and it was reduced to 9% in tapping blocks harvested with S/2 d4 system.

Dry rubber content of latex (DRC) of S/2 d4 system showed no significant difference from that of S/2 d2 system. Over the five year period DRC did not fall below 35% in both harvesting systems (Fig. 2).

Bark consumption per tapping was slightly higher in LFH system than in S/2 d2 system. Nevertheless, overall bark usage was less in S/2 d4 system. Therefore, in S/2 d4 system expected years of harvesting in base panels showed 75% increase over that of S/2 d2 (Table 1).

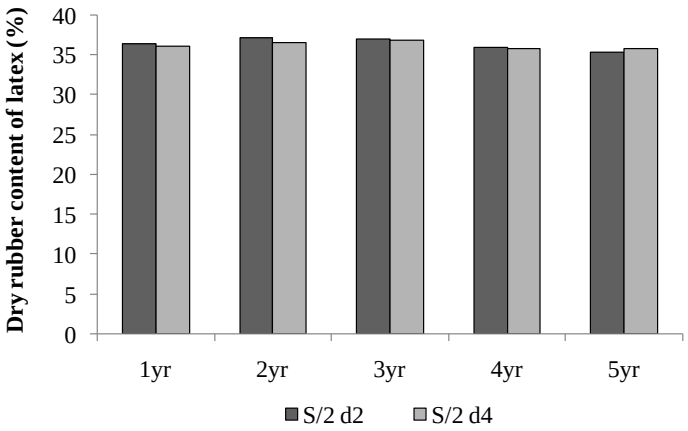


Fig. 2. Dry rubber content of latex of S/2 d2 and S/2 d4 harvesting systems

Table 1. *Bark consumption in S/2 d2 and S/2 d4 harvesting systems*

Harvesting system	Linear bark consumption		Virgin & renewed panel harvesting	
	Annual (cm/yr)	per tapping (cm)	Expected years	% increase over d2 harvesting
S/2 d2	20.79	0.135	23	-
S/2 d4	11.90	0.144	40	75

Trees affected with tapping panel dryness (TPD) were 8.7% and 8.9% in S/2 d2 and S/2 d4 harvesting systems, respectively. Initial plasticity (Po), plasticity retention index (PRI), Mooney viscosity (V_R), ash%, nitrogrn% and Lovibond colour of S/2 d4 system did not show any significant variation with S/2 d2 system (Table 2).

Table 2. *Variation in raw rubber properties of unfractioned unbleached (UFUB) crepe produced under S/2 d2 and S/2 d4 systems*

Harvesting system	Po (Wallace units)	PRI	V_R (ML 1+4 @100ºC)	Lovibond colour	Ash (%w/w)	Nitrogen (% w/w)
S/2 d2	38[a]	74[a]	78[a]	2.0[a]	0.18[a]	0.46[a]
S/2 d4	39[a]	75[a]	80[a]	1.8[a]	0.16[a]	0.43[a]

Means with the same letter are not significantly different (p=0.05)

Average intake per harvester (IPH) was 8.15kg in S/2 d2 system whilst it was 15.19kg in S/2 d4 system. Observed average scrap rubber amount was 6.6% in S/2 d2 system whilst it was 8.4% in S/2 d4 LFH system. Increased IPH has resulted in 29.65% increase in daily wage of a harvester due to extra amount of rubber harvested over the norm. Adoption of S/2 d4 system has reduced the cost of production (COP) by LKR 19.40 and increased the net profit per hectare of rubber land by LKR 38,520/= when compared to the traditional S/2 d2 harvesting system.

A new experimental block was selected in a mature field with RRIC 121 genotype from Kuruwita RRISL Sub station to further testing of S/2 d4 system in commercial scale. Performance of this block was continuously monitored along with that of S/2 d2.

Dry rubber content of latex harvested under both tapping systems were comparable. Yield per tree per year (YPT) observed in S/2 d2 and S/2 d4 systems were more or less similar. There was a 13% loss in tapping days from the expected level in S/2 d2. However, this was reduced to 12% in S/2 d4 (Table 3). Average daily income of a harvester tapping with S/2 d4 system was Rs.966/= whilst that was Rs.730/= in S/2 d2 harvesters.

Table 3. *Performance of commercial scale S/2 d4 low frequency system with ethephon stimulation*

Clone	Tapping system	Actual tapping days	DRC (%)	GTT (g)	IPH (kg)	YPT (kg)	YPH (kg)
RRIC 121	S/2 d2	156	37.05	28.06	8.4	4.4	1751
	S/2 d4	79	37.25	54.17	16.3	4.3	1712

Testing of the weekend harvesting system with two consecutive tappings per week was continued in commercial level with application of 2% ethephon at every two weeks interval. Yield levels in terms of yield per tree (YPT) and per hectare per year (YPH) of S/2 d1 2d/7 was 8% higher than that of S/2 d2 system (Table 4). When

compared to S/2 d2 system, loss of tapping days from the expected level was 1.8% lower in S/2 d1 2d7 system.

Table 4. *Performance of commercial scale S/2 d1 2d/7 low intensity system with ethephon stimulation*

Clone	Tapping system	Actual tapping days	DRC (%)	GTT (g)	IPH (kg)	YPT (kg)	YPH (kg)
RRIC 121	S/2 d2	156	37.05	28.06	8.4	4.4	1751
	S/2 d1 2d/7	92	37.15	51.48	15.4	4.7	1894

(V H L Rodrigo, K V V S Kudaligama, R P S Randunu, M K P Perera and P D T L Madushani)

Low intensity tapping system with liquid stimulation
BCP/01/b

Commercial scale testing of S/4 d3 system started in 2010 was continued at Kuruwita Substation with application of 2.5% water based and oil based commercial ethephon mixtures with application of yield stimulant at 15 days intervals. Dry rubber content of latex in low intensity system was comparable with S/2 d2 system. YPH of the field applied with water based ehtephon was 166kg below the average of S/2 d2 system. However, YPH of oil based ehtephon was 106kg higher than the S/2 d2 field (Table 5).

Table 5. *Performance of commercial scale S/4 d3 low intensity system with ethephon stimulation*

Clone	Tapping system	Type of stimulant	Actual tapping days	DRC (%)	GTT (g)	IPH (kg)	YPT (kg)	YPH (kg)
RRIC 121	S/2d2	-	156	37.05	28.06	8.4	4.4	1751
	S/4 d3	Water based	106	36.93	37.39	11.2	4.0	1585
	S/4 d3	Oil based	106	37.31	43.79	13.1	4.6	1857

(V H L Rodrigo, K V V S Kudaligama, R P S Randunu, M K P Perera and P D T L Madushani)

Genotypic and spatial variation in tree physiology
(BCP/02)

Wood quality: Physical and biochemical aspects in* Hevea *genotypes

BCP/02/c

Wood samples from RRIC 100 and PB 86 genotypes were collected from 25 year old trees in Dartonfield estate and analysed for the biochemical composition and wood physiology.

On avergage RRIC 102 and RRIC 100 genotypes had 76.4% moisture content in green wood of trees older than 25 years. However, moisture content in rubber wood of RRIC 121 genotype was about 10% lowere than that of RRIC 102 and RRIC 100 genotypes. Highest moisture content, 82.03% was observed in wood of PB 86 genotype (Table 6). Total extractive content of RRIC 100 was considerably high and amount in RRIC 121 was low. RRIC 102 and Pb 86 had more or less similar amount of extraxtable components in wood. In general ligning content in RRIC 102 and RRIC 121 was about 19% whilst it was about 15% in RRIC 100 and PB 86 genotypes. α-cellulose % in RRIC 102 genotype was considerably high whilst other three genotypes had more or less similar amount of α-cellulose content (Table 6).

Table 6. *Average physical properties and biochemical components of green wood of different Hevea genotypes*

	Genotype			
	RRIC 102	**RRIC 121**	**RRIC 100**	**PB 86**
Physical properties				
Moisture content (%)	76.14	66.56	76.67	82.03
Specific gravity	0.65	0.67	-	-
Density (kg m^{-3})	593.82	639.95	-	-
Biochemical constituents				
Total extractives (%)	14.18	13.48	16.15	14.93
Holocellulose (%)	93.94	92.69	90.86	91.22
α-cellulose (%)	63.63	59.14	58.35	58.44
Lignin (%)	19.05	19.54	15.76	15.56
Hemicellulose (%)	30.31	33.52	32.50	32.78

(K V V S Kudaligama and R P S Randunu)

Geo-spatial analysis of biochemical and physiological factors for modeling the optimized latex yield of rubber

(BCP/02/b)

Aim of this project was to develop an information system on optimum latex yield by mapping chlorophyll content, canopy structure and health of canopy of plantations using advanced GIS techniques.

Estimation of leaf chlorophyll content, collection of yield data were done in Gallewatta, Kuruwita and Padiyathalawa. Analysis of data was continued using areal maps of the selected sites during wintering and high yielding periods. Effect of different low intensity harvesting systems on leaf canopy structure was also taken in to account (K V V S Kudaligama, R P S Randunu in collaboration with the Dept. of Plant Pathology and Microbiology and the University of Sri Jayawardhenepura).

Productivity improvement through biochemical and physiological aspects (BCP/03)

Identification of plant physiological and biochemical factors to optimize the productivity

(BCP/03/a)

Plant physiological performance, growth and environmental factors of plants of RRIC 121, RRISL 203 and RISL 2001 were measured in experimental field established in Vauniya in 2013.

Positive association of relative water content with soil moisture content was observed in all three genotypes tested. However, RRIC 121 genotype showed the least sensitivity in relative water content to soil moisture content (Fig. 3).

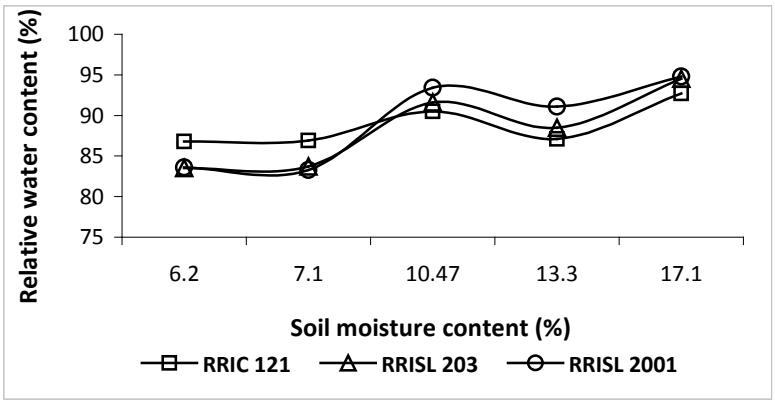


Fig. 3. Variation of relative water content with soil moisture content in three different *Hevea* genotypes

Positive association was observed in stomatal conductance with the soil moisture content in all genotypes tested. However, RRIC 121 genotype showed least variation in stomatal conductance with soil moisture content whilst RRISL203 showed the highest variation (Fig. 4). Number of leaves per plant of all three genotypes were more or less similar and increased with age.

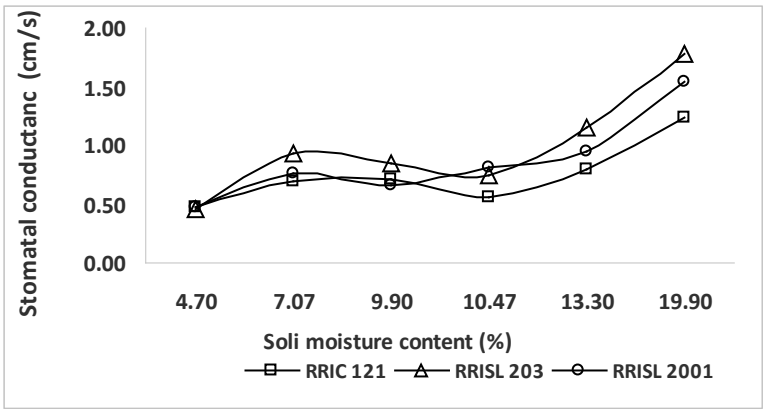


Fig. 4. Variation of stomatal conductance of three *Hevea* genotypes planted in 2013 under different soil moisture conditions

All three *Hevea* genotypes have shown very low growth rate in peak dry period. RRISL 2001 has shown the highest growth rate whilst RRISL 203 has shown the lowest growth rate (Fig. 5).

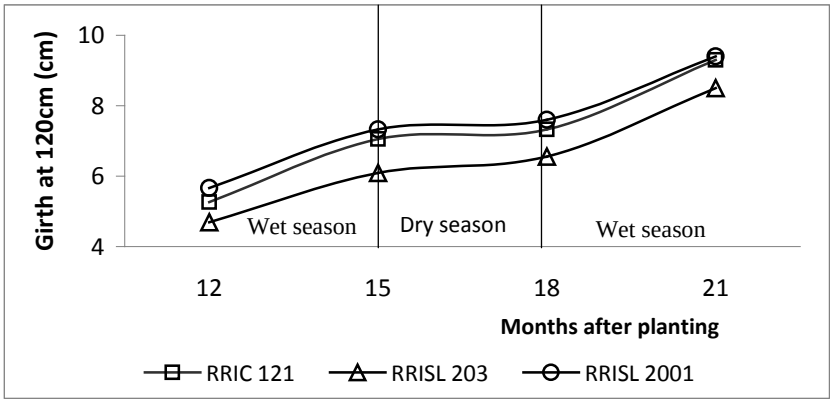


Fig. 5. Variation of girth pattern with age in three different *Hevea* genotypes planted in 2013

Height increment of plants has shown a similar pattern in all genotypes. Relatively low girth increment was observed during 3 to 6 and 15 to 18 months after planting that represented the peak dry period in the area (Fig. 6).

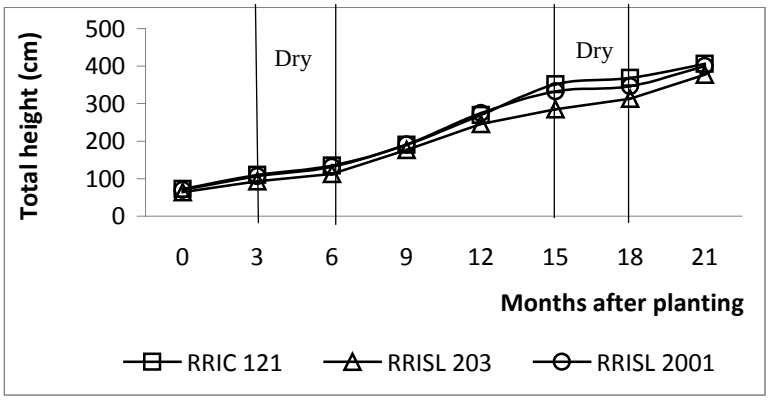


Fig. 6. Variation of total height with age in three different *Hevea* genotypes planted in 2013

(V H L Rodrigo, K V V S Kudaligama, R P S Randunu, M K P Perera, P D T L Madushani and A A A Nadeshani)

Identification of biochemical and physiological factors of latex to optimize the productivity (BCP/03/b)

Experiments were started to investigate effect of different types of commercial ethephon mixtures on latex physiological factors. Rubber field with RRIC 121 genotype replanted in 2002 was selected from Kuruwita Substation of RRISL. Different types of readymade ethephon mixtures; semisolid water based (Ethephon plus), semisolid oil based (Mortex) and liquid (ET 500) given by the suppliers were used in the experiment. Appropriate concentrations of Ethephon plus and ET 500 were made by diluting the commercial mixture with water where needed. However, in the case of oil based mixture, available concentration close to the desired level was used as dilutions could not be done. Yield performances of these mixtures at the end of 2015 on different harvesting systems are given in the Table 7.

With the application of same dosage in S/4 d3 system, oil based mixture gave higher yield when compared to semisolid waster based mixture. Daily intake of a harvester in S/2 d4 harvesting system with 3.3% ethephon (monthly application) was 25.45 kg whilst 6.46kg lesser yield was observed with reduced dosage (2.5% at monthly intervals) of Motex (Table 7). However, with the same dosages liquid ethephon formulation showed lesser performance in S/2 d1 2d/7 system and did not vary much with the type of stimulant applied (Table 7). It seems that type of stimulant

did not matter much when the application frequency of stimulant is high (K V V S Kudaligama, R P S Randunu, M K P Perera, P D T L Madushani and A A A Nadeshani).

Table 7. *Average yields observed with different types of commercial ethephon mixtures in different harvesting systems*

Tapping system	Stimulant	Stimulation frequency	Average DRC (%)	Average GTT (g)	Average IPH (kg)	Average YPT (kg)	Average YPH (kg/ha/yr)
S/2 d2	-	No stimulation	36.69	35.09	10.53	5.47	2188
S/4 d3	Ethephon	2.5% every 15 days	39.64	65.05	19.52	6.90	2760
	Mortex	2.5% every 15 days	38.72	76.96	23.09	8.16	3264
	ET 500	2.5% every 15 days	39.64	62.35	18.71	6.61	2644
S/2 d4	Ethephon	3.3% monthly	38.57	74.00	25.45	5.85	2340
	Mortex	2.5% monthly	38.90	63.32	18.99	5.00	2000
	ET 500	3.3% monthly	38.95	58.90	17.67	4.65	1860
S/2 d1 2d/7	Ethephon	2.0% every 2 weeks	37.34	77.55	23.26	7.13	2852
	Mortex	2.5% every 2 weeks	36.84	72.03	21.61	6.63	2652
	ET 500	2.0% every 2 weeks	36.57	81.88	24.56	7.53	3012

Addressing the needs of rubber (*Hevea brasiliensis*) grown in dryer regions of Sri Lanka through the assessments on physiological parameters and the quality of raw rubber produced

(BCP/04)

National Science Foundation funded project to address the needs of rubber grown in dryer regions of Sri Lanka through the assessments on physiological parameters and the quality of raw rubber produced was completed at the end of year. Project was conducted in two main objectives. First to investigate feasibility of introduction of LFH to smallholders in Eastern Province and secondly to investigate performance of rubber plants in the Dry Zone.

Biochemical and physiological assessments in latex under stress conditions (BCP/04/a)

Due to the tapping rest given during peak dry period in Padiyathalawa, observed number of tapping days were lower than that in Polgahawela. Average dry rubber content observed in all three tapping systems were more or less similar. Lowest yield performance was observed in S/2 d3 system. However, yield under S/2 d4 system was 18.42% higher than that of S/2 d2 system (Table 8).

Table 8. *Performance of different low intensity harvesting systems practiced in rubber smallholdings in Padiyathalawa*

Clone	Tapping system	Actual tapping days	DRC (%)	GTT (g)	IPH (kg)	YPT (kg)	YPH (kg)
RRIC 121	S/2 d2	124	37.17	21.05	6.26	2.63	1052.74
	S/2 d3	83	37.03	28.64	8.59	2.38	950.70
	S/2 d4	62	37.99	45.16	14.23	3.11	1246.66

Despite of the harvesting system, sucrose content was highest in S/2 d2 system. When considered the two seasons sucrose utilization for rubber synthesis was lower in dry period. Generally thiol content was higher during the wet period and this may be favourable for rubber regeneration. When considered the both seasons highest inorganic phosphorous content in S/2 d3 system revealed that laticifers needs higher metabolic activity and trees are under considerable stress in rubber production (Table 9).

Table 9. *Latex physiology of different low intensity harvesting systems practiced in rubber smallholdings in Padiyathalawa*

Clone	Tapping system	Sucrose (mM)		Thiol (Mm)		Inorganic Phosphorous (mM)	
		Wet	Dry	Wet	Dry	Wet	Dry
RRIC 121	S/2 d2	17.89	18.39	0.79	0.50	38.99	42.83
	S/2 d3	9.55	18.36	0.70	0.55	84.82	129.25
	S/2 d4	6.78	17.00	0.83	0.51	51.88	44.96

Dry rubber content of latex was considerably higher in S/2 d2 and S/4 d3 systems. Yield per hectare per year of S/2 d3 and S/2 d4 system was comparable with traditional S/2 d2 system. However it was 13.39% low in S/4 d3 system practiced (Table 10).

Table 10. *Performance of different low intensity harvesting systems practiced in Polgahawela Substation*

Clone	Tapping system	Actual tapping days	DRC (%)	GTT (g)	IPH (kg)	YPT (kg)	YPH (kg)
RRIC 121	S/2 d2	133	39.06	35.49	10.55	4.72	1888.26
	S/2 d3	89	37.67	52.53	15.74	4.68	1870.27
	S/2 d4	71	37.29	66.24	19.87	4.70	1881.44
	S/4 d3	89	39.68	45.93	13.73	4.09	1635.37

In all four tapping systems tested sucrose content tended to decrease during wintering period of trees. Except in S/2 d4 system decrease in thiol content was observed in other tree harvesting systems during wintering. Inorganic phosphorous content did not showed any distinct pattern in variation among the harvesting systems tested (Table 11) (V H L Rodrigo, K V V S Kudaligama and R P S Randunu).

Table 11. *Latex physiology of different low intensity harvesting systems practiced in Polgahawela Substation*

Clone	Tapping system	Sucrose (mM)		Thiol (mM)		Inorganic Phosphorous (mM)	
		High yielding	Wintering	High yielding	Wintering	High yielding	Wintering
RRIC 121	S/2 d2	11.33	9.05	0.61	0.55	33.14	44.77
	S/2 d3	8.89	5.45	0.60	0.51	35.17	37.76
	S/2 d4	6.31	2.29	0.63	0.66	58.59	39.04
	S/4 d3	8.58	2.30	0.57	0.35	37.53	33.25

Biochemical and physiological assessments in rubber plants under stress conditions (BCP/04/b)

Experiment was conducted in Vauniya South comes under DL 1b agro-ecological zone. Immature rubber fields planted with RRIC 121 genotype in 2010, 2011, 2012, 2013 were monitored for their performance with age.

Generally, variation of girth and height increment over the period monitored was more or less similar. Average girth and height increment during five year period were about 7.05 cm/yr. and 181.75 cm/yr., respectively. However, highest girth and height increment (9.9cm/yr. and 271 cm/yr., respectively) were observed in the 3rd to 4th year after planting (Table 12).

Chlorophyll content of leaves have been increased with age of plants up to 3rd year and there after no significant increase was observed (Fig. 7).

Table 12. *Growth performance of RRIC 121 rubber plants in Vauniya South*

Parameter	1st year	2nd year	3rd year	4th year	5th year
Girth @ 120cm height (cm)	5.3	12.2	17.8	27.7	33.5
Total height (cm)	270	434	595	866	997

Fig. 7. Variation of leaf chlorophyll content in rubber plant at Vauniya

When soil depth and distance from plant increased, root density has decreased. Root density in inter row space is greater than that within row. Inter rows space soil density has shown higher values than rows values. Greater volume of roots were dense at 0-15cm depth of soil (Table 13).

Table 13. *Variation of root density (mg/cm^3) vertical distance from plant and soil depth within rows and inter rows in 5 years old rubber plants of RRIC 121 genotype in Vauniya*

Soil depth (cm)	Within rows (distance from plant)			Inter rows (distance from plant)		
	30 cm	60 cm	90 cm	30 cm	60 cm	90 cm
0-15	2.01	1.59	1.01	2.64	1.86	1.53
15-30	0.97	0.96	0.96	1.16	0.73	0.51
30-45	0.40	0.24	0.17	1.05	0.70	0.42

In general, environmental temperature and light intensity have shown higher values in relative humidity and soil moisture content have shown lower values in dry season than in wet season. However, environmental temperature and light intensity

were comparatively low and relative humidity and soil moisture content were higher in rubber field during both dry season and wet season (Fig. 8) (V H L Rodrigo, K V V S Kudaligama and R P S Randunu).

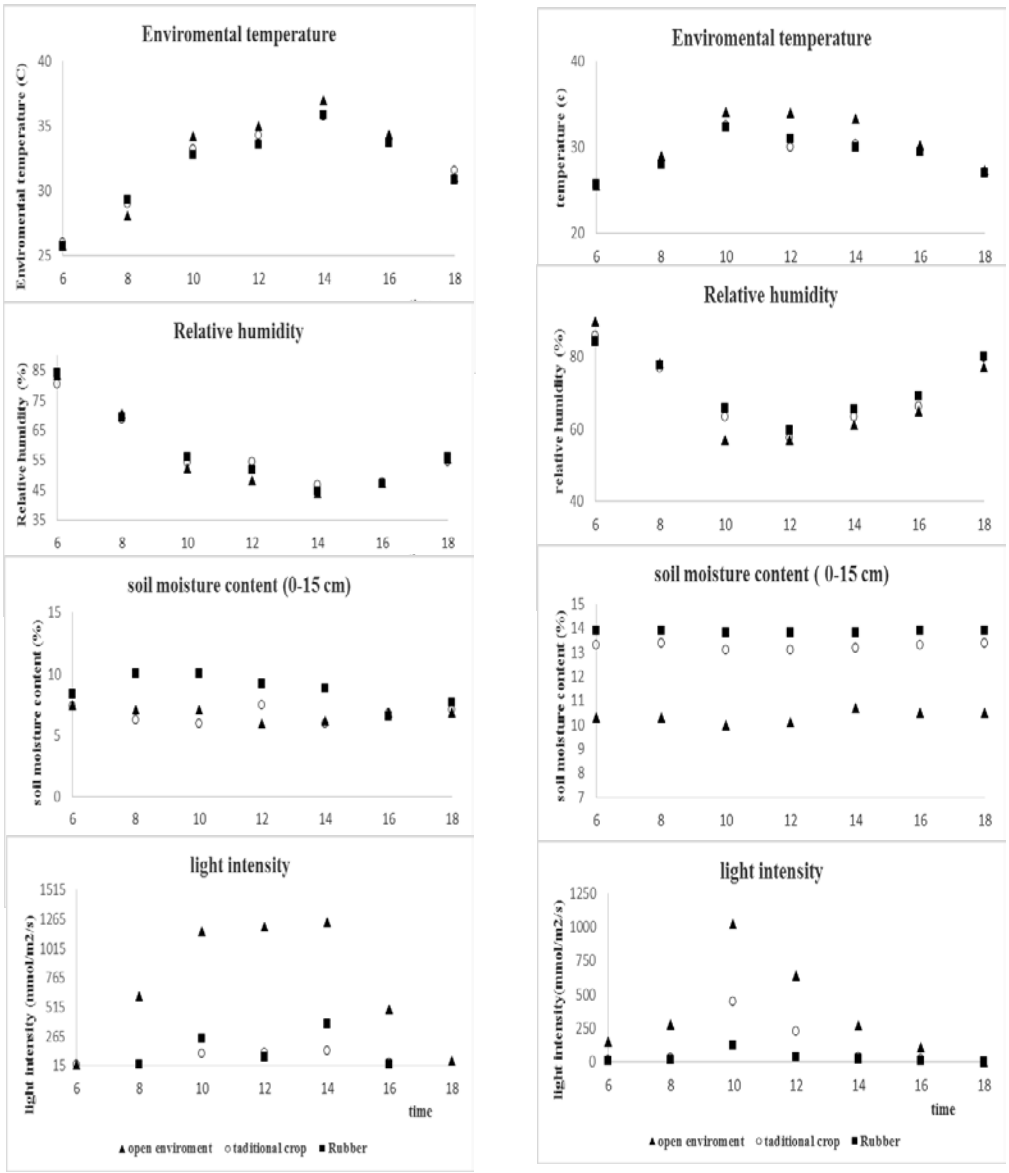


Fig. 8. Variation of micro environmental conditions under different cropping systems during wet and dry seasons in Vauniya

Effect of climate change on biochemical and physiological status of rubber (BCP/05)

Identification of effects on biochemical & physiological factors in adverse climatic conditions and stress conditions (BCP/05/a)

This experiment was started in view of assessing the biochemical and physiological changes of rubber plants with climatic changes. Experimental site was established in 2013 in Vauniya with three popular rubber genotypes *i.e*. RRIC 121, RRISL 203 and RRISL 2001 was monitored during the year together with environmental factors. In 2015 three new sites were also established in Vauniya, Kandakaduwa, Dartonfield and Pasyala with five different genotypes *i.e*. RRIC 121, RRIC 100, RRISL 203, RRISL 2001 and PB 260.

RRIC 121 genotype has shown the highest epicuticular wax content whilst RRISL 203 genotype showed the lowest value during both seasons. In general leaf epicuticular wax content is comparatively higher during the dry season in all three genotypes (Fig. 9).

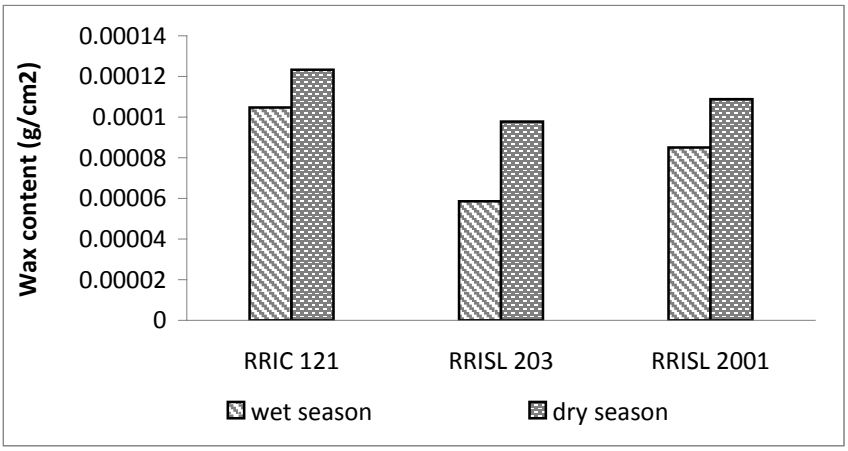


Fig. 9. Variation of epicuticular wax content during wet and dry seasons in three different *Hevea* genotypes planted in 2013 in Vauniya

Despite of the genotype, highest chlorophyll content has shown in wet season in both years. Variation of leaf chlorophyll content from wet to dry season was higher in RRISL 203 and least variation was observed in RRIC 121 genotype (Fig. 10) (K V V S Kudaligama, R P S Randunu, M K P Perera, P D T L Madushani and A A A Nadeshani).

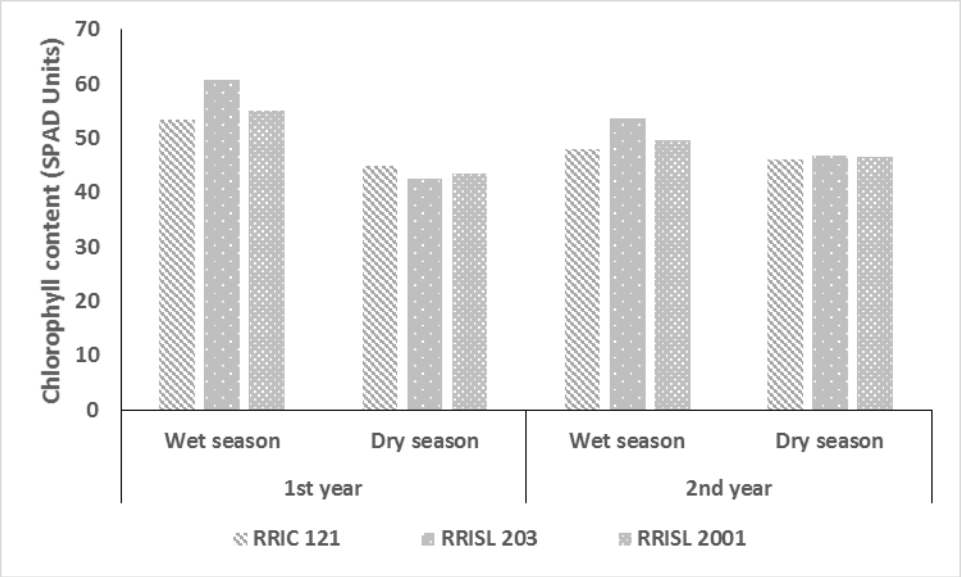


Fig. 10. Variation of chlorophyll content in 1st and 2nd year during both wet and dry period in three different *Hevea* genotypes planted in 2013.

Microbioligical biochemistry (BCP/06)

A short term project was initiated to identify low cost media for development of biofungicide. Possibility of developing a low cost medium for biofungicide with natural rubber serum and molasses were investigated. Natural rubber serum was rich with N, P, K and Mg and C:N ratio was not optimum for growing bio agents. Therefore, possibility of increasing the C content was done with molasses and combination of rubber serum and molasses in 3:2 ratio was best for the growth and sporulation of *Trichoderma* (K V V S Kudaligama in collaboration with the Dept. of Plant Pathology and Microbiology).

ADVISORY SERVICES

A Dissanayake

DETAILED REVIEW

Staff

The Head of the Department, two Regional Advisory Officers (RAOo), twenty one Rubber Extension Officers (REOo) and the Assistant Training Officer were on duty throughout the year. Mr A H Kularathna Regional Advisory Officer (Colombo) assumed duties as the Acting Deputy Director Administration of RRISL with effect from 26.06.2015. Mr Sanjeewa Gunaratne was transferred from Ratnapura region to Kalutara region as RAO and assigned to cover up duties of the posts of RAOo, in Colombo/Gampaha and Galle, Matara regions as well. Mr R A D Ranawaka was assigned to cover up duties of the post of Regional Advisory Officer in Ratnapura region. Mr Nimal Gunaratna, DREO and Mr W Siriwardana, Rubber Extension Officer retired from the services of ASD in March and August 2015 respectively. Mr A R Kulathunga and Mr T L Ramanayake joined the ASD as REOo in January and March 2015 respectively.

Conferences/Meetings/Seminars/Workshops attended

Officer/s	Subject/s	Organization/s
Anura Dissanayake	Smallholder plantations entrepreneurship development prgramme – Progress Review Meeting	IFAD Project Reviewing Team
	Development of a sustainable model for Smallholder plantations entrepreneurship development prgramme	IFAD project (Monaragala) and District Secretariat (Monaragala)
Anura Dissanayake PKKS Gunaratna RAD Ranawake	Scientific Committee Meetings	Rubber Research Institute of Sri Lanka

PROGRESS OF PROJECTS AND SERVICES

Extension and advisory programmes were carried out under four thrust areas, to improve the adoption rates of recommended technologies to enhance the productivity of the rubber smallholder sector, in the year 2015.

Thrust area 01: Transfer of technologies to deliver specific recommendations developed by the RRISL on all agronomic and processing aspects

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

To demonstrate the value of adopting RRISL recommendations to increase the land use efficiency of rubber smallholdings, the extension strategy focused on farmer participatory development of selected rubber holdings as "Model rubber holdings" was continued successfully and 249 rubber holdings were up graded (Table 1).

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

Target for the year 2015	Region	No. of developed holdings	
		Mature	Immature
Establishment of **250** "Model rubber holdings"	Colombo	05	05
	Kegalle	50	50
	Kalutara	20	20
	Ratnapura	34	35
	Galle	15	15
	Total	**124**	**125**
			249

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

Advisory and extension support services were provided to maintain 64 "Model rubber processing centres" to demonstrate the importance of the adoption of recommended practices to improve the quality of RSS to obtain maximum economic returns (Table 2).

Table 2. *Participatory development of rubber processing centers*

Target for the year 2015	Region	No. of model centers maintained	Total capacity (kg)
Establishment of 50 "Model RSS Centers"	Colombo	03	1,250
	Kegalle	22	4,070
	Kalutara	15	10,175
	Ratnapura	11	4,785
	Galle	13	4,335
	Total	**64**	**24,615**

Project 3 (ASD/01/C) Promotion of usage of rainguards

To popularize the rainguards technology as a short term strategy to increase the productivity of rubber smallholders, 64 rainguard demonstrations were established under supervision of Rubber Extension Officers (Table 3).

Table 3. *Details of rainguard demonstration holdings*

Target (2015)	**Region**	**Achievements**	
		No. of demonstrations established	**Extent of the rubber land (ha)**
Establishment of 56 demonstrations	Colombo	10	19.80
	Kegalle	22	18.20
	Kalutara	09	10.47
	Ratnapura	12	32.75
	Galle	11	21.90
	Total	**64**	**103.12**

Project 4 (ASD/01/D) Promotion of soil conservation practices for soil fertility improvement

This project was not implemented during the year 2015.

Project 5 (ASD/01/E) Construction, rehabilitation and modification of new and substandard rubber processing centers

Advisory and extension services were provided for construction of 33 new RSS production centres and rehabilitation of 21 substandard processing centres, to maintain them as cost effective units according to the requests of owners (Table 4).

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

Region	**No. of RSS production centers**	
	New centers	**Rehabilitated centers**
Colombo	02	02
Kegalle	12	05
Kalutara	01	03
Ratnapura	14	06
Galle	04	05
Total	**33**	**21**

Project 6 (ASD/01/F) Promotion of area specific intercropping and mixed cropping systems

To introduce and popularize area specific intercropping systems as a strategy to increase the income during immature period of rubber smallholdings, 28 intercropping demonstration units were established (Table 5).

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

Target (2015)	Region	No. of demonstrations	Extent (ha)
100 units	Colombo	03	8.00
	Kegalle	06	4.10
	Kalutara	06	3.00
	Ratnapura	07	3.43
	Galle	06	3.00
	Total	**28**	**21.53**

Project 7 ASD/01/G Promotion of fertilizer application for mature rubber as a short term strategy for productivity improvement

This project was not continued due to supply chain problems of inputs required by the rubber smallholder sector.

Project 8 Rehabilitation of substandard immature and mature rubber holdings (ASD/01/H)

Advisory and extension support services were provided to rehabilitate 245 immature and 233 mature substandard rubber holdings respectively (Table 6).

Table 6. *Rehabilitation of substandard rubber holdings*

Target (2015)	Achievements		
	Region	No of immature holdings rehabilitated	No. of mature rubber holdings rehabilitated
Rehabilitation of 440 substandard rubber holdings	Colombo	10	10
	Kegalle	96	88
	Kalutara	40	40
	Ratnapura	69	66
	Galle	30	29
	Total	**245**	**233**

Project 9 Participatory development of "Forward march" model rubber villages (ASD/01/I)

Technology transfer activities in relation to the "Forward march" rubber model village established in Botale village in the Warakapola REO range were

successfully attended with the active participation of 40 rubber smallholders. The project is in progress.

Project 10 (ASD/01/J) Projects related advisory visits in traditional rubber growing areas

Three thousand four hundred and fourteen pre-planned projects related advisory visits were conducted by Rubber Extension Officers to solve technology adoption problems in the rubber smallholder sector (Table 7).

Table 7. *Details of projects related advisory visits made in traditional rubber growing areas*

Region	Type of advisory visits							Total
	Model farm development	Rehabilitation of substandard rubber holdings	Introduction of Intercropping Systems	Introduction of rainguard technology	Maintenance of Model RSS centers	Construction of new RSS centers	Rehabilitation of substandard RSS centers	
Colombo	107	118	37	49	21	23	20	**375**
Kalutara	296	432	36	27	77	16	11	**895**
Kegalle	315	443	15	66	57	40	11	**947**
Ratnapura	229	354	21	39	17	25	13	**698**
Galle	143	235	28	35	33	14	11	**499**
Total	**1090**	**1582**	**137**	**216**	**205**	**118**	**66**	**3414**

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

Project - 11 (ASD/2/A) Individual advisory visits on requests of stakeholders in traditional rubber growing areas

One thousand six hundred and five advisory visits were made by REOo to solve technology adoption problems of rubber smallholders in relation to all agronomic and processing aspects. A separate report was prepared by REOo on each visit and forwarded to the Head office for follow up actions (Table 8).

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

Region	No. of visits conducted by REOo
Colombo	114
Kegalle	654
Kalutara	167
Ratnapura	389
Galle	281
Total	**1605**

Project 12 (ASD/02/B) Individual advisory visits in non traditional rubber growing areas

This project was not conducted due to lack of field staff in non-traditional rubber growing areas.

Project 13 (ASD/02C) "Vihidum Sathkara" centrally planned special group advisory and extension programmes for rubber smallholders in traditional rubber growing areas

To meet the growing demand for advisory services from rubber smallholders to solve their technology adoption problems 19 "Vihidum Sathkara" group advisory programmes were conducted for the benefit of 931 rubber smallholders in traditional rubber growing areas (Table 9) and 2301 in non-traditional area (Table 10).

Table 9. *Details of "Vihidum Sathkara" centrally planned special group advisory and extension programmes conducted for rubber smallholders in traditional rubber growing areas*

Region	No. of programmes conducted by REOo	No. of mature holdings inspected	No. of immature holdings inspected
Colombo	1	19	31
Kegalle	9	274	271
Kalutara	2	46	44
Ratnapura	6	102	94
Galle	1	25	25
Total	**19**	**466**	**465**

931

Table 10. *Details of "Vihidum Sathkara" centrally planned special group advisory and extension programmes conducted for rubber smallholders in non-traditional rubber growing areas*

Locations	DS Division	No. of immature holdings inspected	No. of mature holdings inspected
Ella	Badalkumbura	74	32
Madukotanarawa	Badalkumbura	93	15
Thalawegama	Badalkumbura	27	76
Hulandawa South	Moneragala	118	0
Karametiya	Medagama	118	1
Pangura	Madulla	109	18
Nugeyaya	Wellawaya	24	0
Sellaba	Wellawaya	25	0
Magodayaya	Buttala	56	0
Tanwatta	Moneragala	57	10
Nelliyedda	Madulla	20	3
Polgahapitiya	Medagama	66	0
Pallewela	Siyambalanduwa	107	0
Keenagoda	Medagama	110	3
Yudaganawa	Buttala	83	0
Attalamulla	Badalkumbura	85	22
Meegodayaya	Badalkumbura	78	7
Naranawatta	Badalkumbura	79	12
Deliwa	Madulla	91	8
Polagahagama	Madulla	115	0
Siyambalagune	Wellawaya	87	9
Kehelattawala	Bibila	87	0
Thampalawela	Madulla	103	0
Pusselawa	Badalkumbura	105	0
Lunugala Colany	Badalkumbura	88	6
Medagama	Badalkumbura	74	0
	Total	**2079**	**222**
		2301	

Project 14 (ASD/02/D) "Vihidum Sathkara" centrally planned special group advisory and extension programmes for medium scale rubber estate owners in traditional rubber growing areas

Twenty three "Vihidum Sathkara" centrally planned special group advisory and extension programmes were planned and conducted to increase the productivity of 72 medium scale Rubber estates in traditional rubber growing areas (Table 11).

Table 11. *Details of "Vihidum Sathkara" centrally planned special group advisory and extension programmes conducted for improvement of medium scale rubber estates*

Region	No. of programmes conducted	No. of medium scale estates benefitted
Colombo	1	4
Kegalle	7	28
Kalutara	4	11
Ratnapura	8	20
Galle	3	9
Total	**23**	**72**

Thrust area 3: Human resource development of all stakeholders of the rubber smallholder sector

Project 15 (ASD/03/A) Awareness raising programmes in traditional rubber growing areas

Forty four programmes were conducted to educate 1054 rubber growers, replanted their lands in 2013 and 2014 on general aspects of rubber cultivation and immature up keep (Table 12).

Table 12. *Details of Awareness Raising Programmes conducted in traditional rubber growing areas*

Region	No. of programmes conducted by REOo	No. of rubber farmers benefitted
Colombo	4	122
Kegalle	15	418
Kalutara	8	168
Ratnapura	11	240
Galle	6	106
Total	**44**	**1054**

Project 16 (ASD/03/B) Awareness raising programmes in non traditional rubber growing areas

A team of REOo led by Head/ASD, conducted 87 awareness programmes on general aspect of rubber cultivation and processing for the benefit of 2567 rubber growers in Ampara, Baticaloa (Tables 13) and Monaragala districts (Tables 14 and 15). All these programmes were funded by the National Research Council (NRC) and Smallholder Plantation Entrepreneurship Development Programme (SPEnDP).

Table 13. *Details of awareness programmes conducted in Ampara and Baticaloa districts*

Month	DS division	Location	No. of participants
September	Chenkaladi	Mongalagama	79
July	Mahaoya	Nuwaragalatenna	81
July	Mahaoya	Warapitiya	61
Total			**221**

Table 14. *Centralized Awareness Programmes conducted in Monaragala district*

Month	Villages	DS division	No of participants
March	Alupotha, Gedawila Meegahayaya, Kalagahakiula, Naranwatta	Badalkumbura	160
April	Thambana Magandaoya Therappahuwa Guruhela Kumbukkana Nugeyaya	Medagama Madulla Badalkumbura Siyambalanduwa Moneragala Wellawaya	178
June	Yudaganawa Obbegoda, Hindikiula Thalawegama Radaliyedda Medagama	Buttala Madulla Moneragala Bibile Medagama	198
July	Hulandawa North Tenagalalanda, Radaliyedda, Udumulla, Kollodeniya	Moneragala Bibile Madulla	83
August	Lunugala Colany Moratuwagama, Katutharalagama Karandagama, Kalugahagalge	Badalkumbura	103
September	Badalkumbura, Meegahameda, Batugammana, Suduwatharagama	Badalkumara Moneragala	130
October	Yathurawa Velanhinna, Nakkala Udagangoda	Badalkumbura Moneragala	146
	Total		**998**

Table 15. *Awareness and training programmes conducted under "Vihidum Sathkara" Programme in Moneragala district*

Month	Villages	DS division	No of participants
March	Ella, Madukotanarawa Thalawegama	Badalkumbura	233
April	Hulandawa South Karametiya Pangura	Moneragala Medagama Madulla	214
June	Nugeyaya, Sellaba Magodayaya Tanwatta Nelliyedda Polgahapitiya	Wellawaya Buttala Moneragala Madulla Medagama	205
July	Pallewela, Keenagoda Yudaganawa	Siyambalanduwa Medagama Buttala	186
August	Attalamulla, Alamana Muthukeliyaya Watteyaya, Helatantula Meegodayaya Wegaratenna, Naranawatta Bogahapelessa, Wasipana	Badalkumbura	101
August	Deliwa, Namaloya Ruwalwela, Polagahagama	Madulla	116
September	Siyambalagune Anapallama, Gaapitagama Goonaganara, Konketiya Kehelattawala Kanawegalla, Mallenawa Kotagana, Egodakotagana Thampalawela, Katupelella	Wellawaya Buttala Bibila Madulla	184
October	Pussellawa Maiyakkawatta Lunugala Colany	Badalkumbura	109
	Total		**1348**

Project 17 (ASD/03/C) Training programmes for effective management of rubber estates owned by medium level rubber growers

This project was not conducted during the year 2015.

Project 18 (ASD/03/D) Mobile tapper training schools

As a solution to the tapper shortage in rubber growing areas, 18 mobile training programmes were conducted and 317 new harvesting assistants were introduced to the rubber industry (Table 16).

Table 16. *Details of Mobile Tapper Training Schools conducted in traditional rubber growing areas*

Region	No. of training programmes	No. of new harvesting assistants introduced
Kegalle	07	105
Kalutara	05	95
Ratnapura	03	59
Galle	03	58
Total	**18**	**317**

Project 19 (ASD/3/E) Skill development of rubber tappers

To upgrade the knowledge and skill levels of semi-skilled harvesting assistants, 55 skill development training programmes were conducted to improve the quality of tapping of 734 selected harvesting assistants (Table 17).

Table 17. *Details of skill development programmes conducted for semi-skilled rubber tappers*

Region	No. of programmes	No. of semi skilled tappers trained
Colombo	05	89
Kegalle	18	282
Kalutara	12	112
Ratnapura	13	178
Galle	07	73
Total	**55**	**734**

Project 20 (ASD/3/F) Quality improvement of RSS

To improve the product quality of RSS produced by rubber smallholders, 25 one day training programmes were conducted for the benefit of 371 selected RSS producers (Table 18).

Table 18. *Details of training programmes conducted for quality improvement of RSS*

Region	No. of training programmes	No. of RSS producers benefitted
Colombo	04	71
Kegalle	09	136
Kalutara	03	33
Ratnapura	07	113
Galle	02	18
Total	**25**	**371**

Project 21 (ASD/03/G) Training programmes on identification, control and eradication of white root disease

Forty six farmer training programmes were conducted to educate 690 rubber growers on identification, control and preventive measures of white root disease (Table 19).

Table 19. *Details of Training programmes conducted on identification, control and prevention of white root disease*

Region	No. of training programmes conducted by REOo	No. of farmers benefitted
Colombo	02	37
Kegalle	18	270
Kalutara	07	108
Ratnapura	14	191
Galle	05	84
Total	**46**	**690**

Project 22 (ASD/03/H) "Nipunatha Saviya" special training programmes to avoid/prevent in-discriminatory exploitation of rubber trees by smallholders

Eighteen full day workshops were conducted to educate selected rubber smallholders and their harvesting assistants totaling 659 on importance of adhering to RRI tapping recommendations to avoid in-discriminatory exploitation of rubber trees (Tables 20).

Table 20. *Details of Nipunatha Saviya" special programmes conducted*

Region	No. of training programmes	No. of owners and tapers benefitted
Colombo	01	38
Kegalle	07	226
Kalutara	04	186
Ratnapura	03	154
Galle	02	55
Total	**17**	**659**

Project 23 (ASD/03/J)"Erambumata Athwalak" training for village youth on land preparation, contour lining and planting

Five village youths were trained to help rubber permit holders in land preparation and soil conservation activities.

Thrust area 04: Research on extension and socio economic aspects of the rubber smallholder sector for effective planning of extension programmes

Data collection was carried out in relation to all field training and advisory programmes and used for GIS based mapping for effective planning of extension programmes.

The research study funded by the National Research Council (NRC) on the feasibility of expending rubber cultivation into non-traditional areas was conducted successfully. Eight on farm trials set up in Uva, Eastern, North-Central and Northern provinces were maintained. Farmers were educated on agronomic practices for immature upkeep. Girth data collected after 3 years and statistical analysis are in progress. Leaf samples were collected and analysis of nutrients were carried out by soils and plants nutrients department. The experimental trials are in progress.

Other special services provided by the ASD

Rubber Extension Officers identified area specific and institutional needs of rubber smallholders in relation to their field management practices. Accordingly, advisory and extension activities were focused to address following issues and problems.

1. Un-economical latex harvesting practices of rubber smallholders through correction of tapping panel markings.
2. Introduction and demonstrations of technically improved new tapping knives
3. Technology transfer activities on contour lining for holing and soil conservation practices for new rubber cultivators.
4. ASD staff members served as resource persons in training programmes organized by the Thurusaviya Fund and the Rubber Development Department

RUBBER TECHNOLOGY AND DEVELOPMENT

Dilhara Edirisinghe

DETAILED REVIEW

Staff

Dr (Mrs) D G Edirisinghe, Acting Head of the Department was promoted to Head of the Department with effect from 2nd July, 2012 and she was on duty throughout the year. Mrs G D D Senevirathne, Senior Research Officer reading for PhD degree was on study leave until 31st August and thereafter she was on no pay leave upto 31st December at the Queensland University of Technology, Australia. Mr W D M Sampath, Research Officer was on duty throughout the year.

Mrs M K Mahanama, Mrs S I Yapa, Mrs P C Wettasinghe, Mr S L G Ranjith, Mr P L Perera and Mrs Priyanthi Perera, Experimental Officers were on duty throughout the year. Mr D G M J Abeywardena, Technical Officer was on duty throughout the year. Mr K I D P Perera, Graduate Trainee resigned from the Institute on 23.01.2015. Miss Gayathri Bhagyawedha and Mr K I D P Perera were recruited to the Post of Technical Officer on 22.04.2015 and 27.05.2015, respectively. Miss S M D Shashee Rekha De Alwis Wijerathne, Management Assistant was also on duty throughout the year.

Research students

MSc students

- Mr J C Jayawarna, MSc (Polymer Science & Technology) student from the University of Sri Jayawardenepura completed his research project on "Reclaiming of natural rubber latex product waste by a mechanochemical process for production of solid tyre treads" under the supervision of Dr (Mrs) D G Edirisinghe.

- Mrs C N De Silva, MSc (Polymer Science & Technology) student from the University of Sri Jayawardenepura completed her research project on "Evaluation of suitability of rubber wood pyrogenic carbon as a filler in natural rubber based tyre tread compounds" under the supervision of Dr (Mrs) D G Edirisinghe.

- Miss Kalani Edirisinghe, MSc (Polymer Science & Technology) student from the University of Sri Jayawardenepura completed her research project on "Urea a potential preservative for natural rubber latex" under the supervision of Dr (Mrs) D G Edirisinghe.

- Mr Indika Perera, MSc (Polymer Science & Technology) student from the University of Sri Jayawardenepura conducted his research project on "Modification of nitrile latex compound waste for oil seal applications" under the supervision of Dr (Mrs) D G Edirisinghe.

- Miss Kosalani Dhanapala, MSc (Polymer Science & Technology) student from the University of Sri Jayawardenepura conducted her research project on "Surface treatment of palmyra fibre for replacement of carbon black in natural rubber and styrene-butadiene rubber based tyre treads" under the supervision of Dr (Mrs) D G Edirisinghe.

BSc students

- Miss Melani Mahanama, a BSc (Palm & Latex Technology) undergraduate student from the Uva Wellassa University of Sri Lanka completed her research project on "Effect of aloe vera on properties of latex based products" under the supervision of Dr (Mrs) D G Edirisinghe.

- Miss Ovini Jayewardene, a BSc undergraduate student from the University of Sri Jayewardenepura completed her research project on "Evaluation of properties of cast films prepared with citronella oil" under the supervision of Dr (Mrs) D G Edirisinghe.

- Miss T Kirushanthi, a BSc undergraduate student from the Uva Wellassa University of Sri Lanka completed her research project on "Investigation on suitability of banana fiber as a filler material in natural rubber latex based household gloves" under the supervision of Dr (Mrs) D G Edirisinghe.

- Mr W M S L Dissanayake, a BSc (Chemical Science & Technology – Special) undergraduate student from the Sabaragamuwa University of Sri Lanka conducted his research project on "Effect of silane coupling agent on properties of natural rubber (NR)/low density polyethylene (LDPE)/waste low density polyethylene (rLDPE) blends filled with rice husk" under the supervision of Mr W D M Sampath.

- Miss C K Ranasooriya, a BSc undergraduate student from the University of Sri Jayewardenepura completed her research project on "Effect of a titanate coupling agent on properties of natural rubber/low density polyethylene/waste low density polyethylene blends" under the supervision of Mr W D M Sampath.

- Mr I P U I Gunathilake, a BSc (Sports Science) undergraduate student from the Sabaragamuwa University of Sri Lanka completed his research project on "Development of a pressure absorbing paving material for prevention of injuries" under the supervision of Mr W D M Sampath.

- Miss N B H M Bandara, a BSc undergraduate student from the Sabaragamuwa University of Sri Lanka completed her research project on "Effect of maleic anhydride on properties of natural rubber/low density polyethylene/waste low density polyethylene blends" under the supervision of Mr W D M Sampath.

Seminars/Training/Conferences/Workshops/Meetings attended

Officer/s	Subject/Theme	Organization
DG Edirisinghe WDM Sampath	41st, 42nd, 43rd and 44th Scientific Committee Meetings	Rubber Research Institute of Sri Lanka
DG Edirisinghe	Progress Review Meetings	Ministry of Plantation Industries
DG Edirisinghe	Meeting with Rubber Development Officers of RDD (Kegalle district), in regard to training smallholders on rubber products manufacture	National Institute of Plantation Management & Rubber Development Department
WDM Sampath	Workshop on "Organizational behaviour and administrative personality" conducted by Mr Gamage	Rubber Research Institute of Sri Lanka
DG Edirisinghe WDM Sampath	Technical Session and Annual General Meeting	Plastics & Rubber Institute of Sri Lanka
DG Edirisinghe	Workshop on "Work life balance of scientists"	National Science & Technology Commission
DG Edirisinghe WDM Sampath	MERCon 2015	Engineering Research Unit, University of Moratuwa
DG Edirisinghe WDM Sampath	Workshop on "Project Management" conducted by Prof. Uditha Jayasinghe	Rubber Research Institute of Sri Lanka

Officer/s	Subject/Theme	Organization
DG Edirisinghe	Meeting on evaluation and recommendation of applications received in regard to the financial scheme implemented to assist companies manufacturing/exporting rubber products, in obtaining quality certifications and testing	Export Development Board
DG Edirisinghe WDM Sampath	2nd Biennial International Symposium on Polymer Science and Technology	University of Sri Jayawardenepura

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

Officer/s	Subject/Theme	Beneficiary/Client
DG Edirisinghe	Latex technology	MSc students (Polymer Science and Technology) - University of Sri Jayawardenepura
DG Edirisinghe	Latex compounding principles and dipped products manufacture	Students of the DPRI Course in Rubber technology - PRISL
WDM Sampath	Synthetic rubbers	Students of the Certificate Course in Rubber Technology - PRISL
MK Mahanama	Latex compounding ingredients Latex processing techniques	Students of the Certificate Course in Rubber Technology - PRISL
Priyanthi Perera	Structure – property relationship of polymers	Students of the Certificate Course in Rubber Technology - PRISL
Staff of the department	Two workshops on “Rubber based products manufacture”	Officers of National Design Centre, Katubedda
DG Edirisinghe	Composition of natural rubber latex and stability	Induction Course for Planter Trainees – NIPM
WDM Sampath	Value addition to raw rubber	Induction Course for Planter Trainees – NIPM
DG Edirisinghe	Introduction to natural rubber latex characteristics	National Diploma in Plantation Extension Management-NIPM
DG Edirisinghe	NR latex, composition and its characteristics	National Diploma in Plantation Management-Rubber Agronomy & Processing – NIPM
DG Edirisinghe	Natural rubber latex characteristics	Professional Programme in Rubber Manufacture & Factory Practices – NIPM
Staff of the department	Field training programme on “Rubber product manufacture”	Undergraduate students of Palm & Latex Technology and Value Addition – Uva Wellassa University

Officer/s	Subject/Theme	Beneficiary/Client
DG Edirisinghe	Urea, a potential preservative for natural rubber latex	Scientific Committee Meeting – Rubber Plantation Companies
WDM Sampath	Rubber products manufacture as a cottage industry	Technology Update – Research & Technical staff of RRISL
MK Mahanama	Use of "Power Mat" as a weed control device	Technology Update – Research & Technical staff of RRISL
MK Mahanama	Evaluation of inventions in Galle, Badulla, Jaffna, Trincomalee, Kurunegala and Ratnapura	Sri Lanka Inventors' Commission
WDM Sampath	Effect of a titanate coupling agent on chemical and ageing properties of calcium carbonate filled natural rubber and low density polyethylene composites	IIUPST 2015 – University of Sri Jayewardenepura
WDM Sampath	Improvement of physico-mechanical properties of calcium carbonate filled natural rubber and low density polyethylene blends with titanate coupling agent	MERCon 2015 – University of Moratuwa
WDM Sampath	The effect of coupling agent and mixing methods on properties of natural rubber and low density polyethylene blends	International Research Sessions – University of Peradeniya
Staff of the department	Five "Krushi FM" live radio programs on "Rubber based products manufacture"	Agriculture Department & Rubber Development Department
MK Mahanama	Workshop on "Rubber based products manufacture" in Galle district – Yakkala	Thurusaviya Fund
MK Mahanama	Two workshops on "Rubber based products manufacture" in Gampaha district – Alawala & Nikahatikanda	Thurusaviya Fund
SLG Ranjith PL Perera	Workshop on "Rubber based products manufacture" in Kalutara district – Batugampala South	Thurusaviya Fund

Officer/s	Subject/Theme	Beneficiary/Client
PC Wettasinghe G Bhagyawedha	Training of latex extraction officers on "Rubber based products manufacture" in Bulathsinhala	Rubber Development Department & National Institute of Plantation Management
WDM Sampath SLG Ranjith	Training of latex extraction officers on "Rubber based products manufacture" in Ratnapura district – Godakawela	Rubber Development Department & National Institute of Plantation Management
PL Perera KIDP Perera	Workshop on "Rubber based products manufacture" in Horana	Rubber Development Department & National Institute of Plantation Management
MK Mahanama M Abhayawardhana	Workshop on "Rubber based products manufacture" in Galle district – Thawalama	Rubber Development Department
PL Perera, SLG Ranjith, PC Wettasinghe SI Yapa	Three day educational exhibition	Dharmapala Vidyalaya, Pannipitiya
PL Perera SLG Ranjith	Workshop on "Rubber based products manufacture" in Monaragala district – Badalkumbura	Rubber Development Department
Priyanthi Perera	Educational exhibition	Maliyadeva Model School, Kurunegala
Priyanthi Perera	Workshop on "Rubber based products manufacture" in Kegalle district – RDD Regional Office	Rubber Development Department
MK Mahanama	Workshop on "Rubber based products manufacture" in Galle district – Naragasdeniya	Thurusaviya
PC Wettasinghe SI Yapa	Workshop on "Rubber based products manufacture" in Kalutara district – Welipenna	Rubber Development Department
MK Mahanama G Bhaguawedha	Workshop on "Rubber based products manufacture" in Hambantota district – Katuwana and Galle district – Akuressa	Rubber Development Department

Officer/s	Subject/Theme	Beneficiary/Client
WDM Sampath PL Perera	Three workshops on "Rubber based products manufacture" in Kegalle district - Weragoda, Monaragala district - Badalkumbura & Wellawaya	National Institute of Plantation Management & Rubber Development Department
PL Perera M Abhayawardena	Workshop on "Rubber based products manufacture" in Ratnapura district - RDD Regional Office	National Institute of Plantation Management & Rubber Development Department
SLG Ranjith	Workshop on "Rubber based products manufacture" in Deraniyagala	National Institute of Plantation Management & Rubber Development Department
SLG Ranjith	Workshop on "Rubber based products manufacture" in Kegalle district – Yatiyantota	National Institute of Plantation Management & Rubber Development Department
Priyanthi Perera	Workshop on "Rubber based products manufacture" in Kegalle district – Dehiowita	National Institute of Plantation Management & Rubber Development Department
PC Wettasinghe Priyanthi Perera	Workshop on "Rubber based products manufacture" in Hettimulla	National Institute of Plantation Management & Rubber Development Department
MK Mahanama SI Yapa	Workshop on "Rubber based products manufacture" in Kegalle district – Amithirigala	National Institute of Plantation Management & Rubber Development Department
MK Mahanama	Workshop on "Rubber based products manufacture" in Hambantota district – Lunumadalawala	Thurusaviya
PL Perera	Educational exhibition in Dharmapala Park, Galle	Southern Province Agriculture Department
Staff of the department	Dry rubber and latex based products manufacture	Grade 13 students of St. Sebastians College, Moratuwa
Staff of the department	Training on "Rubber processing and machinery" for the 75th anniversary exhibition – Scientia 2015	Grade 11 students of St. Sylvester's College, Kandy

Industrial visits

The following industries were visited during the year for development/trouble shooting work.

Officer	Industry/Organization
DG Edirisinghe, UN Ratnayake, WDM Sampath and DGMJ Abeywardena	Ranaviru Sevena, Ragama
DG Edirisinghe, MK Mahanama, Priyanthi Perera and A K D Warnajith Prasad	Lak Methodic, Baduraliya
DG Edirisinghe	Inter Coir Ltd., Ja-ela
DG Edirisinghe and MK Mahanama	Lalan Rubbers Ltd. – Mahaoya Plantations, Dehiowita
DG Edirisinghe, SI Yapa and PC Wettasinghe	Douglas & Sons Ltd. (DSL), Biyagama Export Processing Zone, Biyagama
M K Mahanama	Ceylon Rubbers, Padukka

LABORATORY INVESTIGATIONS

Latex technology

Evaluation of suitability of a novel preservative in low ammonia centrifuged latex used to manufacture latex based products

Low ammonia centrifuged latex is generally preserved with the secondary preservative system, tetramethylthiuram disulphide (TMTD) and zinc oxide (ZnO). This system is known to be carcinogenic due to the generation of nitrosamines. The aim of this research was to evaluate the suitability of urea, a low cost, readily available and water soluble chemical as an alternative for the above system. Six low ammonia centrifuged latex samples were prepared with the conventional TMTD/ZnO system [(Sample 6-Control] and varying quantities [(Sample 1-0.016%), (Sample 2-0.021%), (Sample 3-0.026%), (Sample 4-0.031%) and (Sample 5-0.036%)] of urea. Characterisation of the latex was carried out after a storage period of 0, 15, 45 and 60 days. Physico-mechanical and ageing properties were evaluated using cast films. Tests for total extractable proteins, nitrosamines and microbiological examination were conducted.

Volatile fatty acid (VFA) number of all the samples was below 0.024 even at 60 days of storage period (Fig. 1). Mechanical stability time (MST) of urea preserved latex samples was higher than that of the Control (Fig. 2).

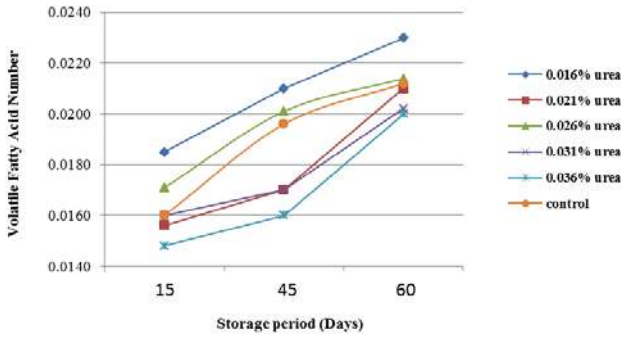


Fig. 1. Variation of VFA No. of the centrifuged latex samples with storage period

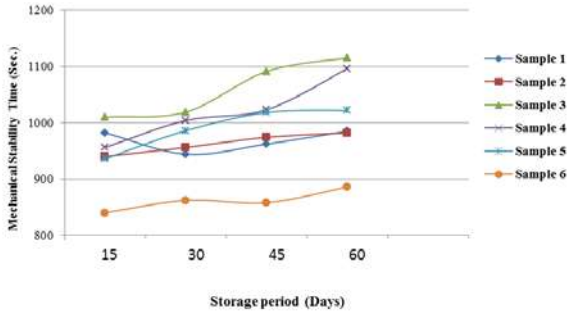


Fig. 2. Variation of MST of the centrifuged latex samples with storage period

Urea treated latex samples did not show a significant contamination of bacteria (Tables 1 and 2).

Table 1. *Microbial count*

Urea concentration	Dilution	Rough count (visual)	Dilution factor	Count x dilution factor
0.016%	10^{-1}	1	x10	10
0.021%	10^{-1}	1	x10	10
0.026%	10^{-1}	1	x10	10
0.031%	10^{-1}	1	x10	10
0.036%	10^{-1}	0	x10	0
Control	10^{-1}	3	x10	30
Blank	10^{-1}	0	x10	0

Table 2. *Interpretation of microbial count*

Count	Interpretation
Below 30	No significant contamination
= 10^3	Slight contamination
Above 10^4	Contamination
Above 10^5	Heavy contamination

All the urea treated latex samples show a markedly lower amount of extractable proteins than the Control (Fig. 3). This behavior could be due to the protein denaturing ability of urea.

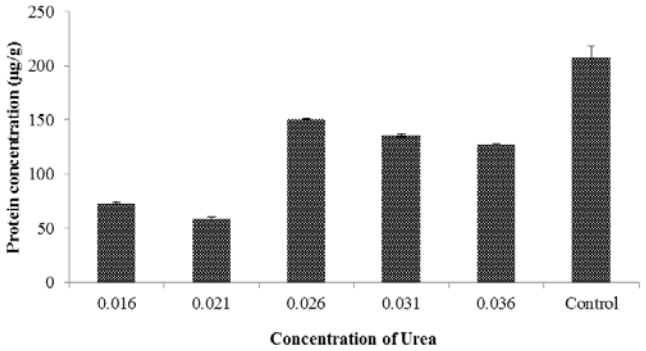


Fig. 3. Total extractable protein content of cast films

Results in overall indicated that urea, which does not indicate generation of nitrosamines as indicated by GC/MS analysis may be an alternative for the preservative system TMTD/ZnO. The 0.021% urea treated latex sample and its cast film showed the best properties and hence it could be suitable to manufacture toys and infant items (D G Edirisinghe, E A K D Edirisinghe - MSc student, University of Sri Jayewardenepura, M K Mahanama, L Karunanayake and S D M Chinthaka - Dept. of Chemistry, University of Sri Jayewardenepura).

Development of natural rubber latex compounds with citronella oil for rubberized-coir fenders

Citronella oil is known to act as a mosquito repellent. Compounded latex was prepared with citronella oil in order to see its effect on properties of latex based products. The ultimate aim was to assess the suitability of this oil as an animal

repellent in latex compounds, which could be used to manufacture rubberized-coir based fenders.

A series of latex compounds was prepared by varying the amount of the citronella oil emulsion from 0 to 7.5g (for 20g of compounded latex) at 1.5g intervals followed by the preparation of cast films and vulcanization of the same. The strong odor released from the films due to the presence of citronella was in existence only for few days. It was suggested to improve the compound formulation by combining citronella with another animal repellent substance.

Further, physico-mechanical and ageing properties of the films were evaluated. Hardness and tear strength, two important properties for fenders were higher in the films prepared with citronella oil in comparison to the film prepared without any oil. However, all the films exhibited good ageing properties (D G Edirisinghe, M K Mahanama and Ovini Jayewardena – BSc undergraduate student from University of Sri Jayewardenepura, Sri Lanka)**.**

Property improvement of NR latex based products with aloe vera

NR latex foam samples were produced in the laboratory and at Richard Pieris Natural Foams Ltd., Biyagama by varying the amount of the juice of aloe vera, a natural product. Aloe vera was selected for the study as it contains six antiseptic agents, which have inhibitory action on fungi, bacteria and viruses. Also, phenolic compounds in aloe vera have potent antioxidant activity. Indentation hardness index, compression set and density of the samples were evaluated. Figure 4 shows the variation of indentation hardness index of the foam samples prepared at the factory of Richard Peiris Natural Foams Ltd. Indentation hardness index was higher in the foam samples prepared with 5, 10 and 20% (on weight of rubber) aloe vera in comparison to that of the Control prepared without any aloe vera.

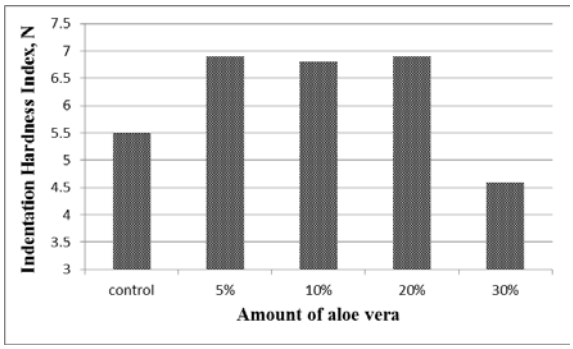


Fig. 4. Variation of indentation hardness index of NR latex foam with amount of aloe vera

Also, a series of compounded latex samples was prepared by varying the aloe vera content from 10 to 100 phr at 10 phr intervals and cast films were produced. Tensile properties and ageing resistance of these films were evaluated. Moduli and tensile strength of the films prepared with aloe vera were not significantly different to those of the Control prepared without any aloe vera. However, elongation at break of the cast films prepared with aloe vera was higher than that of the Control (Fig. 5).

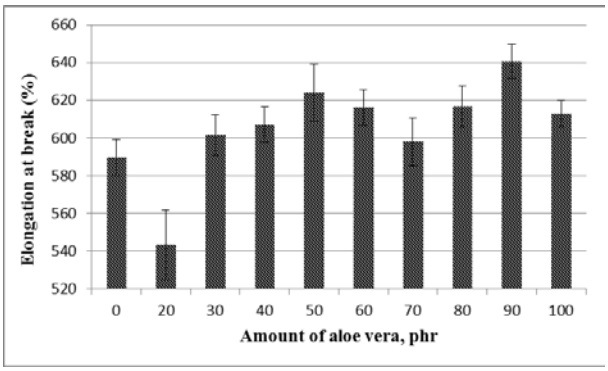


Fig. 5. Variation of elongation at break of cast films with amount of aloe vera

Retention of tensile strength of all the cast films, after ageing was above 90%. Further, retention of tensile strength of most of the films prepared with aloe vera was higher than that of the Control and this could be attributed to the presence of phenolic compounds in the former films, having antioxidative effects.

Further, microbial growth of latex films was assessed with the assistance of the Plant Pathology department of RRISL. After 48 hours of incubation at 35°C, there was no sign of microbial growth. However after 6 days of incubation, the film prepared without any aloe vera (Control) and the film prepared with 10% aloe vera showed microbial growth. According to the results, spreading of microbial growth was lower in 10% aloe vera containing film than in the Control. Films containing 90% and 50% aloe vera were free from spreading of microbial growth even after 6 days of incubation. This indicates that aloe vera may probably have an anti-bacterial effect (D G Edirisinghe, S I Yapa, M K Mahanama, Sarojini Fernando (Plant Pathology and Microbiology Dept.) and Melani Mahanama, a BSc (Palm and Latex Technology) undergraduate student from the Uva Wellassa University of Sri Lanka).

Dry rubber technology

Effect of a titanate coupling agent on properties of calcium carbonate filled NR/LDPE composites

A series of 70:30 Natural rubber (NR)/Low density polyethylene (LDPE) blends was prepared by varying the titanate coupling agent loading from 0 to 1.5% (by weight of polymer) at 0.2% intervals. The blends were prepared using a Brabender Plasticorder by melt mixing at a temperature of 150 ^{o}C, and at a rotor speed of 60 rpm. Physical, chemical, thermal, ageing, dynamic and morphological properties were evaluated. The curves in Figure 6, which was obtained from tensile testing show almost a similar pattern of variation. The highest stress and strain values were shown by the composite prepared with 0.7% coupling agent and hence it indicates good surface adhesion and interaction compared to the others.

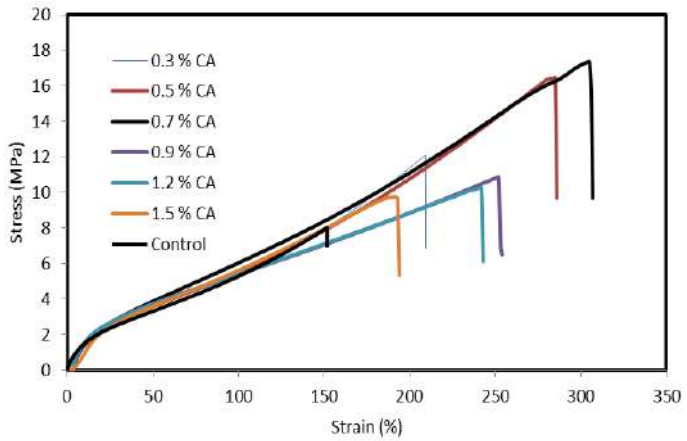


Fig. 6. Stress–strain curves of NR/LDPE blends prepared with different loadings of titanate coupling agent

Further, the composite prepared with 0.7% titanate coupling agent exhibited the highest gel content and lowest percentage of swelling (Fig. 7) and indicates a high crosslink density.

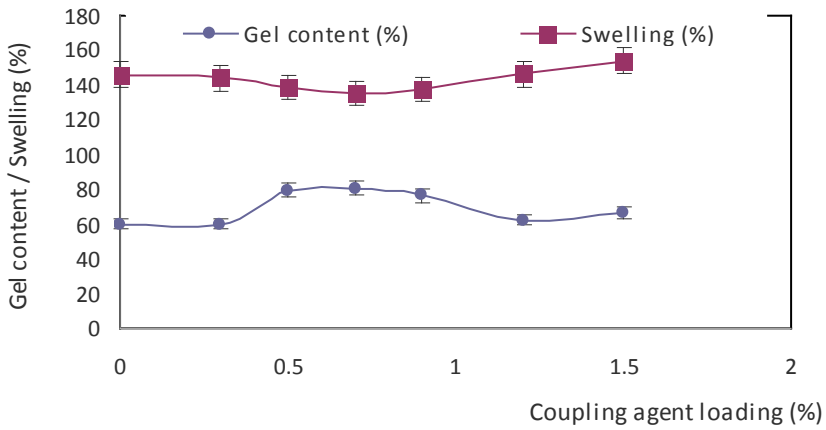


Fig. 7. Variation of gel content and percentage swelling of NR/LDPE blends with the loading of titanate coupling agent

There was no significant change in the glass transition temperature (Tg) and melting temperature (Tm), when the loading of coupling agent was varied (Table 3). In all the composites, Tg was around -62^{o}C. However, the composites prepared with 0.5 and 0.7% coupling agent loadings showed a higher melting point and higher degree of crystallinity in comparison to the others.

Table 3. *Thermal properties of NR/LDPE blends prepared with different loadings of titanate coupling agent*

Coupling agent loading	Glass transition temperature (ºC)	Melting temperature (ºC)	Degree of crystallinity (%)
0.3%	-62.02	109.8	8.9
0.5%	-62.55	110.3	13.7
0.7%	-62.64	110.2	13.8
0.9%	-62.12	107.5	11.8
1.2%	-62.29	107.8	12.2
1.5%	-61.69	107.0	9.3

The composite prepared with 0.7% coupling agent showed the highest tensile strength and elongation at break, after ageing (Fig. 8) and indicates higher heat resistance compared to the others. Results in overall indicated that physico-mechanical, chemical, thermal and ageing properties are highest in the former

composite compared to the latter composites (W D M Sampath, D G Edirisinghe and S M Egodage).

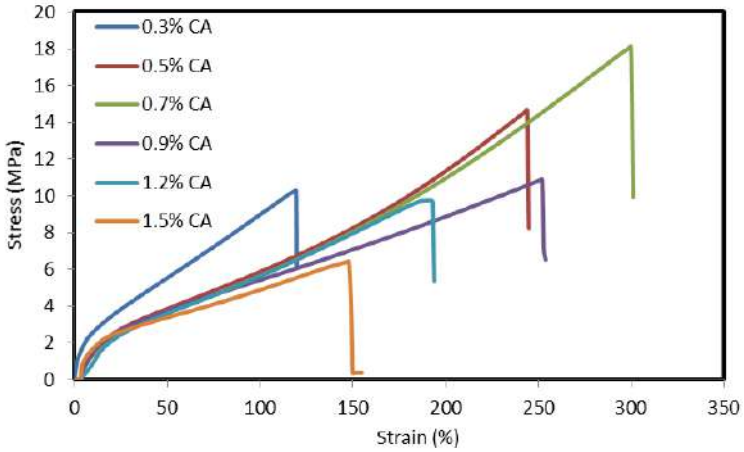


Fig. 8. Stress – strain curves of NR/LDPE blends prepared with different loadings of titanate coupling agent, after ageing

Effect of a titanate coupling agent on properties of NR/LDPE/rLDPE blends

Six 70:30 NR/LDPE and rLDPE blends S1, S2, S3, S4, S5 and S6 were prepared with 30/0, 20/10, 15/15, 10/20, 5/20 and 0/30 phr LDPE/rLDPE loadings, respectively. Physico-mechanical, chemical, ageing and morphological properties of the blends were evaluated and compared. Highest tensile strength was shown by the S1 blend (22 MPa), whereas there was no significant difference between the tensile strength of the S3 (17MPa) and S4 (18MPa) blends. The S1 blend showed the highest tear strength (67 KN/m) and hardness (67.5 IRHD), whilst the S2 blend showed the highest gel content (97%). Water absorption and percentage swelling of S2, S3 and S4 blends were almost similar and higher than those of the S1 blend. Ageing resistance was lowest in the S1 blend compared to the other blends (W D M Sampath and C K Ranasooriya – BSc undergraduate student from the University of Sri Jayewardenepura, Sri Lanka).

Effect of maleic anhydride on properties of NR/LDPE/rLDPE composites

Five NR/LDPE/rLDPE composites were prepared with maleic anhydride (MAH) by varying the rLDPE loading from 5-25% at 5% intervals. The total LDPE and rLDPE loading was 30 phr. A Control was prepared without any rLDPE. 20 parts by weight of calcium carbonate per 100 parts of combined polymer was incorporated

into every blend composition. Physico-mechanical properties were evaluated and compared. Composites were characterized using FTIR and morphological analyses of tensile fracture surfaces. Water absorption and gel content of the composites were investigated.

Tensile properties of the composite improved significantly with the addition of rLDPE. Composite prepared with 20% rLDPE showed the highest improvement in regard to all physical properties. Percentage of water absorption, swelling properties and hardness increased with the addition of rLDPE, while gel content and elongation at break reduced with the addition of the same. Thermal stability of NR/LDPE/rLDPE blend improved, when MAH was added. These composites prepared with MAH can be used for indoor as well as outdoor applications (W D M Sampath and N B H M Bandara – BSc (Export Agriculture) undergraduate student from Sabaragamuwa University of Sri Lanka).

Development of a paving material for jogging tracks

Five ground rubber tyre (GRT)/bitumen blends were prepared with a latex binder by varying the bitumen loading from 13-25% by weight, at an interval of 3%. Physico-mechanical properties such as tensile properties, hardness, rebound resilience, abrasion volume loss and compression test as well as deflection height of the blends were studied. Chemical properties such as swelling behavior, gel content and water absorption were evaluated. In overall, physical and chemical performance of the 78:22 GRT/bitumen blend was higher than those of the other four blends (W D M Sampath and I P U I Gunathilake – BSc (Sports Science) undergraduate student from Sabaragamuwa University of Sri Lanka).

Effect of silane coupling agent on properties of rice husk filled natural rubber/ low density polyethylene composites

A series of NR/LDPE blends with silane coupling agent were prepared by varying the LDPE loading from 10-90% at 10% intervals. 20 parts by weight of rice husk per 100 parts of combined polymer was incorporated into each blend composition. The research is being continued (W D M Sampath and W M S L Dissanayake – BSc (Chemistry special) undergraduate student from Sabaragamuwa University of Sri Lanka).

Development of NR/SBR composites with modified palmyra fibre for tyre treads

Short palmyra fibre was modified according to four treatment techniques and 80:20 NR/SBR composites were prepared with 30 phr each of carbon black and treated palmyra fibre. Cure characteristics and physico-mechanical properties of the

composites were evaluated and compared. The best composite in regard to properties was selected. The composite prepared with compounded NR latex coated palmyra fibre exhibited the best properties.

Further a series of composites was prepared using the selected composite, but varying the ratio of carbon black : modified palmyra fibre from 60:0 to 20:40 (in phr) at 5 phr loadings. Cure characteristics and physico-mechanical properties of the composites were evaluated. Hardness, resilience, compression set and abrasion volume loss did not change significantly when carbon black was partially replaced with NR latex coated palmyra fibre, however there was a significant drop in tensile and tear strength (D G Edirisinghe and Kosalani Dhanapala – MSc (Polymer Science & Technology) student, University of Sri Jayewardenepura).

Modification of nitrile latex compound waste for oil seal applications

Mechanochemical reclaiming of nitrile (acrylonitrile-butadiene rubber - NBR) latex compound waste was performed at low temperature with an amino compound as the reclaiming agent to produce a novel reclaimed rubber. Reclaimed rubber was characterized and characterization techniques indicated that 6 phr and 2.5 min. are the optimum loading and milling time, respectively for reclaiming with this amino compound.

Thereafter, virgin NBR was blended with the novel reclaimed rubber according to the standard ASTM oil seal formulation. A series of virgin NBR/novel reclaimed rubber composites was prepared by replacement of virgin NBR with novel reclaim rubber at 10 phr intervals as shown in Table 4. The maximum loading of reclaimed rubber was 70 phr.

Table 4. *Virgin NBR: reclaimed rubber blend ratios of the composites*

Sample No.	W0	W10	W20	W30	W40	W50	W60	W70
Virgin NBR	100	90	80	70	60	50	40	30
Reclaimed rubber	0	10	20	30	40	50	60	70

All the properties varied according to a cyclic pattern with the increase in the amount of reclaimed rubber and could be attributed to scission and formation of crosslinks in the presence of the reclaiming agent. The percentage swelling of the composite prepared with 50-60 phr of reclaimed rubber was lower than that of the composite prepared solely with virgin NBR (Fig. 9).

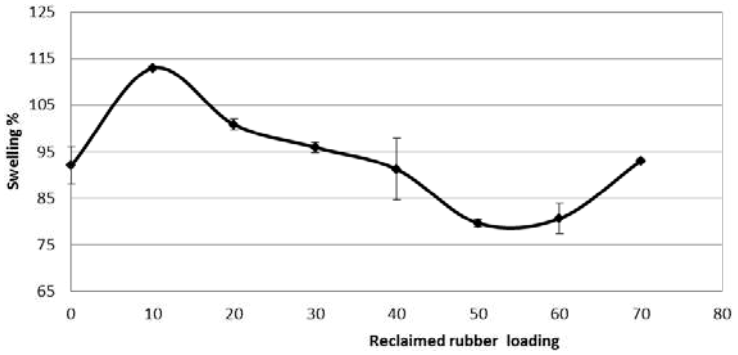


Fig. 9. Variation of percentage swelling with the increase of the amount of reclaimed rubber

(D G Edirisinghe and Indika Perera – MSc (Polymer Science & Technology) student, University of Sri Jayewardenepura)

Development of rubber wood pyrogenic carbon filled NR/SBR composites for tyres

Project on development of rubber wood pyrogenic carbon (PyC) filled rubber composite for tyre treads was continued during the year. In 2014, a NR composite filled with 40 phr carbon black and 10 phr rubber wood PyC suitable for tyre treads was developed. As further work of the project, pyrogenic carbon filled 80:20 NR/SBR blend composite suitable for tyre treads was developed (D G Edirisinghe, R S Dharmakeerthi – Senior Lecturer, Dept. of Soil Science, Faculty of Agriculture, University of Peradeniya, C N De Silva - MSc (Polymer Science & Technology) student, University of Sri Jayewardenepura).

Development of a weather resistant rubber compound for stopper bands

Few trials were conducted to develop a low cost, weather resistant rubber compound suitable to produce stopper bands used for an agricultural purpose, at the request of Lalan Rubbers (Pvt.) Ltd. A 80:20 NR/EPDM blend compound with the required properties was developed within two weeks and the formulation was forwarded to the company to carry out production of the stopper bands. Factory trials were successful and the bands produced were supplied to the Japanese buyer to evaluate performance in agricultural fields (D G Edirisinghe, P C Wettasinghe, P L Perera and Mahesh Abeywardena).

Development of low resilient and high abrasion resistant rubber balls

Several trials were conducted to develop a rubber compound with high hardness, low resilience and high abrasion resistance for cricket practicing purpose at the request of a cricket coach. Styrene-butadiene rubber (SBR) based compound with the required properties was developed and rubber balls were produced using a newly fabricated mould (D G Edirisinghe and Mahesh Abeywardena).

Industrial extension

The following properties were tested and test reports were issued to the companies at their request.

Hardness of sole crepe samples	Physico-mechanical properties of rubber/plastic compounds	Physico-mechanical properties of rubber/plastic products
Malwatta Valley Plantations	Gamini Rubber Industries	ATG Lanka (Pvt.) Ltd.
Kegalle Plantations, Pallegama Estate	Polymer Products Impex (Pvt.) Ltd.	Jetwing Hotels
Kegalle Plantations, Atale Estate	Sharmini Rubber Industries	Textrip (Pvt.) Ltd.
Elpitiya Estate	BGN Tyre Industries	Sumith Tyre Centre (Pvt.) Ltd.
Panawatta Estate	Bogala Graphite Lanka PLC.	Sri Lanka Institute of Textile and Apparel
Dewalakanda Estate	Elastomeric Engineering Ltd.	Quality Latex Products
Kelani Valley Plantations	Laugfs Corporation (Rubber) Ltd.	Greenland Rubber Products
		SGS Lanka Ltd.
	Global Rubber Industries	
	US Lanka Rubber Solutions (Pvt.) Ltd.	

The following developments were conducted on request.

Development	Client
Natural rubber latex foam backing for coir mats.	National Design Centre, Katubedda, Moratuwa.
Rubber ball with high abrasion resistance and low resilience for cricket practicing purpose	Cricket Coach
Latex compound to produce mould free infant items	Douglas & Sons Ltd. - Soft toy manufacturer

POLYMER CHEMISTRY

Nilmini Liyanage

DETAILED REVIEW

Staff

Dr (Mrs) A H L Nilmini, Principal Research Officer, was promoted to the Head of the department since March 2015. Mr Kasun Adikari, Research Officer was on duty throughout the year. Mrs Nirmala Jayawardena, Experimental Officer was on duty throughout the year. Mrs Hiruni Hewamulla, Technical Officer was on duty throughout the year. Two Technical Officers, Mr Tharindu Perera and Ms Kalani Edirisinghe joined the department as Technical Officers since September 2015.

Mr Damith Perera, a MSc postgraduate student from University of Sri Jayawardenapura commenced one year research projects on "Novel acrylic based adhesives for printing industry" under supervision of Dr A H L R Nilmini.

Mr Sameera Mendis, a MSc postgraduate student from University of Sri Jayawardenapura commenced one year research projects on "Synthesis and characterization of alkyd resin for a special purpose to improve quality of nitrocellulose surface coating under supervision of Dr A H L R Nilmini.

Mr Arunasiri Gunesekera, a MSc postgraduate student from University of Moratuwa commenced one year research projects on "plant based antioxidants in rubber compounding" under supervision of Dr A H L R Nilmini.

Lectures/Seminars/Training/Workshops/Conferences attended

Officer/s	Subject/Theme	Organization
AHLR Nilmini	Scientific Committee Meetings	Rubber Research Institute of Sri Lanka
AHLR Nilmini	Diploma in Polymer Technology	Plastic and Rubber Institute
AHLR Nilmini	MSc in Polymer Technology	University of Sri Jayawardenapura
AHLR Nilmini	Wood Processing Technology	University of Uva Wellassa

LABORATORY INVESTIGATIONS

Development of an environmental friendly preservative system for NR latex as a replacement for TMTD/ZnO preservative system

Although several systems have already been developed for the short-term and long-term preservation of fresh natural rubber latex, many of them still suffer from one or more disadvantages or drawbacks. At present, one of the widely used and

industrially accepted preservative systems for NR latex is the combination of ammonia, with Tetramethylthiuamdisulphide/Zinc Oxide (TMTD/ZnO) dispersion. Nevertheless, the use of TMTD would cause generation of carcinogenic nitrosamines during product manufacturing process using the TMTD/ZnO preserved latex. To overcome this problem, the present work attempted to develop a new preservative system free from nitrosamines generation during the subsequent processes.

This work was done in collaboration with Materials Accelerators-New Zealand. They kindly supplied the new preservative material which is based on a plant based extract. Several laboratory trials were done with new chemical. It was observed that preservative action of this new chemical is excellent comparing with currently used TMTD/ZnO system. In terms of volatile fatty acid number (VFA) and mechanical stability time (MST), new chemical exhibits comparatively better values with control system. The testing of VFA with novel chemical is being done for another three months time before reach to a final conclusion (A H L R Nilmini, Karnika de Silva - Materials Acceleration, New Zealand, Kasun Adhikari, Hiruni Dhanukamalee and Tharindu Perera).

Plant based anti-oxidants in rubber compounding

This project is aimed to study the feasibility of use of bio-based polymeric phenolics such as lignin and tannin as antioxidants to replace low molecular weight chemical antioxidants in rubber compounding. However, this research will encompass the existing information on the applications of the antioxidant properties of lignin and tannin in the context of rubber compounding, to identify trends and gaps in existing data, and to create a base and scope for future research. Use of bio-materials in rubber compounding has the potential to reduce the environmental impact caused by toxic and leachable chemicals used in rubber formulations, to make the final product safer and to reduce costs during both production and in service.

The main focus of this study was to evaluate the performance of Kraft lignin and tannin in NR as antioxidants and to compare their effectiveness with two conventional, widely used antioxidants in rubber products manufacturing industry. It is known that oxidation of a polymer can occur at all stages, *i.e.* from synthesis to final use, causing undesirable changes in mechanical, aesthetic and electrical properties. Therefore, to protect the polymer from oxidation, low molecular weight phenolic or amine antioxidants are widely used in all polymer based product manufacturing industries.

The effect of two bio based polymeric antioxidants from Scion (kraft lignin KL and Tanin T) in natural rubber based tyre tread formulation was evaluated. A formulation used by the rubber manufacturing industry to manufacture tyre treads by extrusion process was selected as a suitable formulation in this study. All experiments were conducted in a commercial environment, *i.e*. at Camso Loardstar (Pvt) Ltd.

The processing characteristics and mechanical properties before and after ageing were compared with two commercially available antioxidants as controls. The antioxidants used in this study included an amine type one – 6PPD and a sterically hindered polynuclear phenolic antioxidant – SKF. These compounds have some drawbacks like surface blooming and volatilization, with a consequent loss of activity. Other problems with these compounds include, leaching and migration in contact with solvents/chemicals and deterioration of mechanical properties of the vulcanizate by causing disruption of the stress propagation through the polymer chains. These problems could be solved by using a polymeric antioxidant which is thermally stable, non-toxic and compatible with the base polymer. Processing parameters such as Mooney viscosity, minimum and maximum torques, time values, cure characteristics were reordered. Specific gravity, hardness, tensile strength, elongation at break, modulus and retention on tensile properties were also recorded (A H L R Nilmini, Karnika de Silva, Materials Accelerator, New Zealand, Kasun Adhikari and Nirmala Jayawardena).

Development of tyre paint for inner heal compound

This project was initiated upon a request made by Camso Loadstar (Pvt) Ltd. A problem addressed was to minimize large number of rejects of solid tiers per year associated with the poor quality of tyre paint being used such as low temperature resistance, peel off of the paint during rim mounting and less tensile strength of the paint film. Several polymer base formulations were developed and carried out laboratory scale trials at Camso Loadstar (Pvt.) Ltd. A formulation based on Crepe rubber and imported synthetic resin made a remarkable improvement on all the properties mentioned and three large scale trails were conducted at the factory to commission the product. Technology know how of the paint was transferred to the company and patent application was made in December 2015.

Upon request made by the same company, another project was initiated to developed Ash colour paint for tyre tread area which is with very good cold climate resistance and abrasion resistance. This project is still in progress (A H L R Nilmini, Nirmala Jayawardena and Hiruni Dhanukamalee).

Screen printing ink

Dipped Products (Pvt) Ltd made a request to initiate a project on screen printing ink, as ink being used at present gives poor quality prints on both Natural rubber and Nitrile rubber based gloves. As two different polymers, it had to develop two different inks with same physical properties such as good colour fastness, chemical, rub and weather resistance properties. This was successfully achieved and laboratory scale trails confirmed the achievement of the required quality of the products. Large quantities of the both products were given to the company to conduct factory scale trails. Samples of the inks were sent to India by the DPL group in order

to test the suitability of use of those inks in food contact application (A H L R Nilmini, Kalani Edirisinghe and Tharindu Perera).

Industrial extensions

DSI	Type of polymer analysis
Lalan Rubber (Pvt) Ltd	Testing of rubber chemicals
Water Board	Type of polymer analysis
ITI	Type of polymer analysis
AMW (Pvt) Ltd	Type of polymer analysis
Elastomeric Engineering (Pvt) Ltd	Polymer and bloom analysis
Trellerbog	Testing of rubber chemicals
Customs	Type of polymer analysis
Chemlink industries	Adhesive analysis
HOVAEL (Pvt) Ltd	Type of polymer analysis
Dipped Products	Type of polymer analysis
ANTLER (Pvt) Ltd	Textile binder analysis
Hands International (Pvt) Ltd	Silicone oil analysis in glove samples
ATG Gloves	Silicone oil analysis in glove samples
Ceylon Electricity Board	Type of polymer analysis of Meter boxes
OMNIPRO Industries (Pvt) Ltd	Type of polymer analysis of Meter boxes

RAW RUBBER AND CHEMICAL ANALYSIS

A P Attanayake

DETAILED REVIEW

Staff

Mrs A P Attanayake, Research Officer was in charge of overall activities of the department throughout the year. Mrs I H K Samarasinghe, Research Officer was on duty throughout the year.

Experimental Officers, Mrs L Wanigatunga, Mrs H V K Gamage, Mrs C Lokuge, Miss M Wijesekera and Mr Vitharana were on duty throughout the year. Technical Officers, Miss S P Wijewardana was on duty throughout the year. Miss Dushanthi Lakmini assumed duties as a Technical Officer on 12th May 2015. Technical Officers Mrs Imesha Nuwangi and Miss Chathurika Jayasinghe resigned from RRISL with effect from 27th November and 11th December 2015 respectively. Management Assistants Miss W D Disna Samanmali and Mr Gayan Gunasena were on duty throughout the year.

Research students

- H W O C Delmon, a BSc student from Faculty of Animal Science and Export Agriculture, University of Uva Wellassa, completed her final year research project on "Effect of clone type on Storage Hardening and Gel Content of Raw Natural Rubber" under the supervision of Mrs Anusha Attanyake.

- W M T H Weerakoon, a BSc student from Faculty of Animal Science and Export Agriculture, University of Uva Wellassa, completed her final year research project on "Effect of processing conditions on Storage Hardening and Gel Content of Raw Natural Rubber" under the supervision of Mrs Anusha Attanayake.

- Miss E Lakma Hansani, a BSc student from Department of Chemistry, University of Sri Jayawardhanapura completed her one month industrial training on "Characterisation of RRISL 203 clone" under the supervision of Mrs Anusha Attanayake.

- Miss W G A R Weerasinghe, a BSc student from Department of Chemistry, University of Sri Jayawardhanapura completed her one month industrial training on "Effect of temperature on gel formation of natural rubber" under the supervision of Mrs Hasara Samarasinghe.

Training programmes

Training programmes were carried out for the following officers/students as detailed below.

Client	Subject
MN Fathima Najla & NGSS Nawarathne, Aroma Natural Rubber (Pvt) Ltd	Initial Wallace Plasticity and Nitrogen Testing
TD Anushka Dilhari, Lak Latex Centrifuge (Pvt) Ltd	Mg content
Associated Speciality Rubbers (Pvt) Ltd	VFA & MST Testing
GKPR Wijewardhane, University of Sri Jayawardhanapura	Raw rubber testing
PDK Peiris, University of Sri Jayawardhanapura	Raw rubber testing
HP Sumudu Chamara, University of Sri Jayawardhanapura	Raw rubber testing
UK Manushi, University of Kelaniya	Raw rubber testing
P Yashodha Perera, University of Kelaniya	Raw rubber testing
RY Wickramarathne, Plastic and Rubber Institute	Raw rubber testing
SML Prabhath, University of Sabaragamuwa	Volatile matter
VTM Anuralanka and RD Illeperuma, University of UvaWellassa	Raw rubber testing
Taniya Darshani, University of Sri Jayawardhanapura	Raw rubber testing

Lectures/Seminars/Workshops/Meetings attended

Officer/s	Subject	Organization
AP Attanayake	Special Meeting with Hon. Minister	Dartonfield, RRISL
AP Attanayake	Smart Meeting	Dartonfield, RRISL
AP Attanayake	Technical Session	PRI, Rajagiriya
AP Attanayake	Meeting with the Secretary	MPI
AP Attanayake	Progress Review Meeting	MPI
AP Attanayake	Workshop on office procedures	Dartonfield, RRISL
AP Attanayake	Workshop on "Scientific writing"	Hector Kobbakaduwa Agrarian Research Institute
AP Attanayake IHK Samarasinghe	Smart meeting	Dartonfield, RRISL
IHK Samarasinghe	Technical Update Meeting	Dartonfield, RRISL

Lectures/Seminars/Workshops/Meetings conducted

Officer/s	Subject	Organization
AP Attanayake	Lecture on "Sampling of latex and dry rubber" for students from National Diploma in Plantation extension management2014/2016"	National Institute of Plantation Management

LABORATORY INVESTIGATIONS

Visco-elastic characterization of raw natural rubber (RR&CA/01/c)

Effect of high temperatures and non-rubber content on Visco-elastic properties of Yellow fraction (YE) fractioned bleached (FB) crepe rubber were investigated under accelerated storage conditions. The samples were aged at 40, 60, 80 and 100 ^{0}C for a 10 hour period. Samples were drawn at every two hour intervals and Mooney viscosity, stress relaxation time and Gel content were measured. Results have shown that temperatures above 80 ^{0}C does have a significant influence on Mooney viscosity and Mooney elasticity of FB crepe rubber at all time intervals studied. Low shear strain rate visco-elasticity data of YF rubber has revealed that non rubber substances have a considerable impact on viscous component and less impact on elastic component.

The research paper titled 'Effect of storage conditions on visco-elastic properties of different grades of latex crepe rubber' was presented at International Rubber Conference, 2015 held from 1st – 3rd November 2015, Hochi Minch Vietnam U N Rathnayake, I H K Samarasinghe, A P Attanayake and W M G Seneviratne).

Effect of ethephon concentration on latex biosynthesis

The effect of ethephon on some physiological and latex parameters related to latex Production were studied. The role of ethephon concentration on quality and quantity of dry rubber produced, correlations between rubber yield and sucrose concentration and rubber yield and magnesium concentration were studied simultaneously.

Sucrose level change with polynomial pattern with a minimum sucrose level at 3% ethephon concentration. As shown in Figure 1, a transient decrease in serum sucrose concentration was observed up to 3% ethephon concentration, followed by continuous increment afterwards. Yield response to ethephon greatly depends on sucrose availability in latex vessels determining the possibilities for an enhancement of invertase activity after treatment. There is a negative correlation exist between rubber yield and sucrose level as shown in Figure 1b.

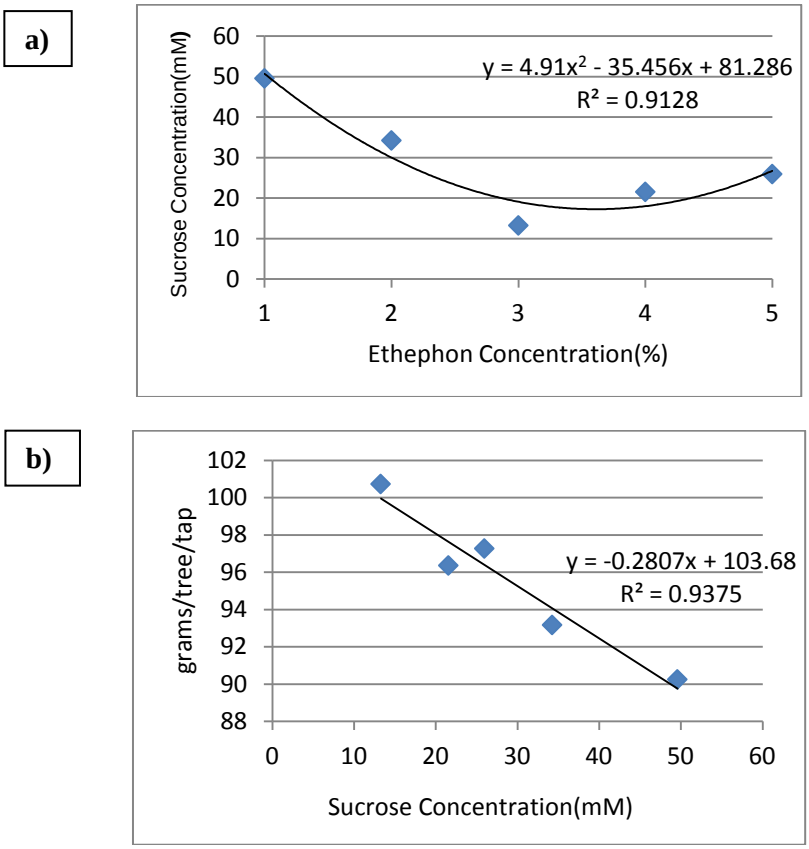


Fig. 1. (a). Variation of serum sucrose concentration with ethephon concentration and **(b)** correlation between sucrose concentration with yield in RRISL 121 clone, S/2 d/3 tapping system

These studies indicate that serum sucrose level and serum magnesium levels are significantly affected by ethephon concentration. There is a negative correlation between serum sucrose level and rubber yield (Fig. 1). There is a positive correlation between magnesium level and the yield (Fig. 2). It could be concluded that the maximum ethephon concentration would be 3% to get higher yield, after 3% there is no significant increment in yield in S/2 d/3 tapping system (Anusha Attanayake and C Lokuge).

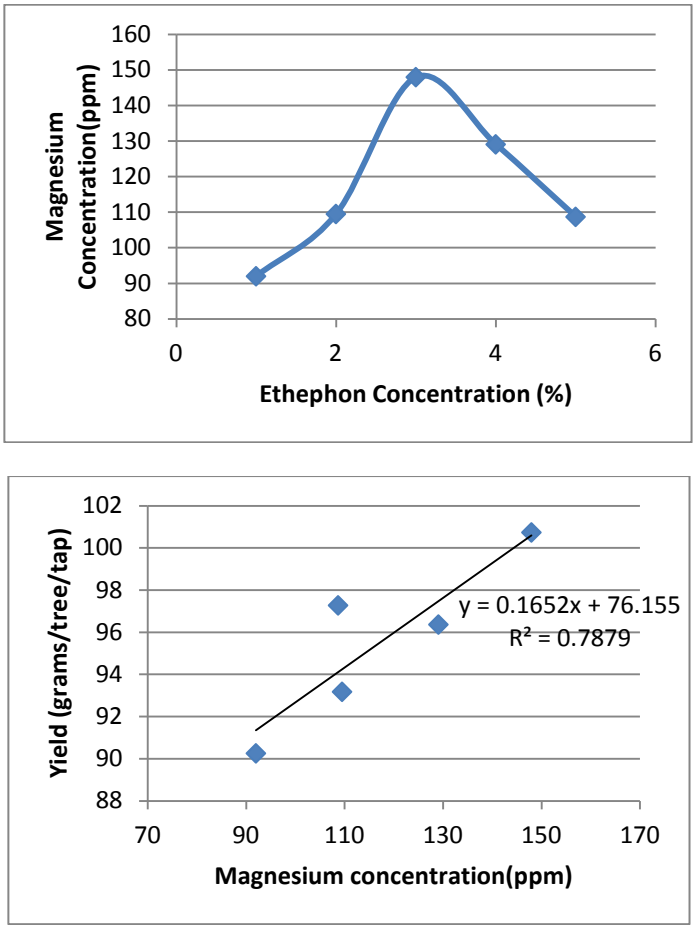


Fig. 2. Variation of magnesium concentration with ethephon concentration and correlations between serum magnesim level and yield (g/t/t) in RRISL 121 clone, S/2 d/3 tapping system with ethephon treatment

Short term projects

Raw rubber property variations of RRISL 200 series new clones

Effect of clone type on gel content and storage hardening, Mooney Viscosity, Wallace Plasticity, Mooney Elasticity were investigated. RRISL 201, 202, 203, 205, 206, 211, 216 217, 219 and RRISL 222 were selected for the study and RRISL 121 was used as the control. Properties of raw rubber were evaluated according to ISO test methods for the parameters Gel Content, Mooney Viscosity, Stress Relaxation rate, Initial Plasticity and Hardening Plasticity. Minitab 16 statistical software was

used to analyze the variance of the quantitative characters by each nine replicate samples from ten different clones.

The study has revealed that there are clonal differences in almost all the properties examined (Table 1). Determination of the P_o and Mooney viscosity of the raw rubber showed that RRISL 203 clone gave relatively high Po and Mooney viscosity value while RRISL 217, 219 and 222 recorded moderate Po value and Mooney viscosity with compared to RRISL 121. A recommendation can be made for RRISL 217 as it showed the acceptable range of viscosity for manufacturing tire.

Table 1. *Average raw rubber properties of crepe rubber*

Clone	P_0 (Wallace Units)	Storage Hardening (Wallace Units)	Mooney Viscosity (MU)	Stress Relaxation Rate (a)	Gel Content (%) w/w
RRISL 121	38.7	26.9	73.7	-0.22	19.5
RRISL 201	39.4	13.3	73.68	-0.25	56.42
RRISL 202	39.2	12.8	72.61	-0.26	58.07
RRISL 203	58.6	17.2	104.30	-0.17	27.58
RRISL 205	38.0	16.6	70.68	-0.25	55.14
RRISL 206	47.3	15.1	86.60	-0.21	25.7
RRISL 211	46.7	19.4	86.65	-0.20	19.11
RRISL 216	48.7	20.6	84.60	-0.22	23.43
RRISL 217	42.7	15.0	79.91	-0.20	23.26
RRISL 219	42.8	19.2	74.74	-0.24	48.86
RRISL 222	45.5	19.6	82.61	-0.24	62.49

Low storage hardening was exhibited by RRISL 201, 202, 206, 217 clone types, which decrease the susceptibility to the hardening process of rubber that ultimately improve the keeping quality of rubber during the storage. Stress relaxation rate depends on the extent of branching in each clone. The moderate stress relaxation rates were exhibited by RRISL 206, 211, 216, 217, 219 and RRISL 222 clones. RRISL 206 and RRISL 217 showed lowest stress relaxation rate. The percentage of gel content of RRISL 211 clone was same as the control, but it shown relatively low storage hardening compared with the control, this may be due to the differences in molecular weight and molecular weight distribution of the clones. RRISL 201, 202 was shown best storage hardening, but those clones have relatively high percentage of gel content than other clones (H W O C Delmon, A P Attanayake and Imesha Nuwangi).

Effect of processing conditions on storage hardening and gel content of raw natural rubber

Freshly tapped latex can be processed into various raw rubber types using different processing methods. There are main two types of crepe rubber namely, fractioned bleached (FB) and Un-Fractioned Un-Bleached (UFUB) crepe rubber. Sheet rubber can be categorized as Ribbed Smoked Sheets (RSS) and Sun Dried Sheets (SDS). Manner in which the natural rubber latex is coagulated, dried, processed and stored, they may affect raw rubber properties and the performance of rubber products made out of them. The nature of the processing conditions could increase the gel content of the rubber which associated with storage hardening. Rise in natural rubber viscosity during the storage affects the processability of raw rubber. Therefore, the aim of this study is to identify the effect of processing conditions on gel content and storage hardening of raw rubber and make recommendations accordingly. During this study, latex samples were collected from the same source of latex (specific clone: RRIC 121) from Dartonfield, Agalawatta. The collected latex was processed into four rubber categories namely, Fractioned bleached (FB) crepe rubber, un-fractioned un-bleached (UFUB) crepe rubber, ribbed smoked sheets (RSS) and sun dried sheets (SDS). Rubber properties were then measured in accordance to ISO standards (Table 2).

Table 2. *Raw rubber properties of FB, UFUB, SDS and RSS*

Rubber type	Mooney viscosity	Mooney elasticity	Initial plasticity (P_o)	Storage hardening (P)	Gel content (%)
FB	76.68	0.690	43.17	20.55	2.84
UFUB	78.27	0.765	46.57	34.28	14.97
SDS	79.80	0.831	53.17	26.28	32.13
RSS	80.30	0.814	51.88	33.97	32.62
P-Value	0.001	0.000	0.000	0.000	0.001

Table 3. *Summary of the P-Values Obtained for Crepe Rubber and Sheet Rubber*

Rubber type	Mooney viscosity	Mooney elasticity	Initial plasticity (P_o)	Storage hardening (P)	Gel content (%)
FB UFUB	0.002	0.000	0.000	0.000	0.021
SDS RSS	0.674	0.081	0.264	0.000	0.958

*P<0.05

The results of the study reveal that four tested processing conditions significantly affect on gel content and storage hardening (ΔP) together with Mooney viscosity, Mooney elasticity and initial Wallace plasticity (P_0) of raw rubber. There was a significant difference between FB and UFUB crepe rubber with respect to Mooney viscosity, Mooney elasticity, initial Wallace plasticity (P_0), gel content and storage hardening (Δ P). UFUB can cause processing difficulties due to its high Mooney viscosity, Mooney elasticity and storage hardening. When consider about sheet rubber, most of the raw rubber properties of RSS and SDS were similar except storage hardening. The degree of storage hardening of RSS was higher than that of SDS, suggesting the smoke drying process can have some effect on the storage hardening of RSS. Due to the lower degree of storage hardening, FB crepe rubber and SDS can be recommended for long term storage purposes and shipment (W M T H Weerakoon, A P Attanayake and A C C Jayasinghe).

Analytical service

Samples tested during the year were as follows.

Miscellaneous analysis	**No. of samples**
Raw rubber samples	583
Latex sample	365
Chemical sample	38
Bleaching agent samples	33
Polythene samples	38
Gloves samples	21
Technically Specified Rubber (TSR)	40
Testing certificates	522

RAW RUBBER PROCESS DEVELOPMENT AND CHEMICAL ENGINEERING

U N Ratnayake

DETAILED REVIEW

Staff

Dr Upul N Ratnayake, Principal Research Officer, was promoted to the post of Head of the Department with effect from 20th March 2015. Messrs Chandrika Nalini, Shirani Priyanka, A K D Warnajith Prasad, C Rohanadepa, Experimental Officers and Miss K G P M Dharmathilaka, Technical Officer were on duty throughout the year. Mr Shehan Ghouse, B A D M Balasuriya and Miss Bimani Kannangara were recruited to the Department as Technical Officers with effect from 24th April, 2015.

Research students

PhD students

- Malindu Alwis, a PhD student from Dept. of Chemistry, University of Sri Jayewardenepura carried out a joint research project (RRI and University of Sri Jayewardenepura) titled "Rubber nanocomposites: Effects of hybrid nanomaterial systems on mechanical and flame retardant properties" under the supervision of Dr Upul Ratnayake.

MPhil students

- W D Ranganath Wijesinge, a MPhil student from the Dept. Chemistry, University of Jayewardenepura carried out a research project titled "Value addition to waste NBR through nanotechnology application" under the supervision of Dr Upul Ratnayake.

MSc students

- B A D M Balasooriya, a MSc student from the Dept. Chemistry, University of Sri Jayewardenepura, carried out a research project titled "Mechanical properties and processability of skim rubber/polyethylene blends" under the supervision of Dr Susantha Siriwardena.
- Mrs Anuradhi Liyanapathirana, a MSc student from the Dept. Chemistry, University of Sri Jayewardenepura, carried out a research project titled "Value addition to skim natural rubber through the addition of nanoclay" under the supervision of Dr Upul Ratnayake.

- Ms Sashika, a MSc student from the Dept. Chemistry, University of Sri Jayewardenepura, carried out a research project titled "Effect of non-rubber substances on nanoclay filled natural rubber crepe rubber" under the supervision of Dr Upul Ratnayake.
- Ms Tania, a MSc student from the Dept. of Chemistry, University of Sri Jayewardenepura, carried out a research project titled "Effect of clay on bioderadable polymer" under the supervision of Dr Upul Ratnayake.

Undergraduate students

- Thilina Amarabandu, an undergraduate student from University of Uva-Wellassa, Badulla, carried out his final year research project on "Urea as an anticoagulant for natural rubber field latex" under the supervision of Dr Susantha Siriwardena.
- Ms Taniya Darshani, an undergraduate student from University of Sri Jayewardenepura, carried out her final year research project on "Air dried sheets as a substitute for unfractioned and unbleached crepe rubber in rubber product manufacture" under the supervision of Dr Susantha Siriwardena.
- S M L Prabath, an undergraduate student from Sabaragamuwa University of Sri Lanka carried out his final year research project on "Natural rubber latex coagulation methods and their influence on raw rubber and vulcanized properties under the supervision of Dr Susantha Siriwardena.
- Ms Piumali, an undergraduate student from University of Uva-Wellassa, Badulla, carried out her final year research project on "Raw rubber and mechanical properties of crepe rubber made out of nano clay incorporated natural rubber latex" under the supervision of Dr Upul Ratnyake.

Achievements

- Dr Upul N Ratnayake was awarded National Research Council (NRC) Merit Award for Scientific Publications - 2013 organized by National Research Council (NRC) in 2015.

Lectures/Seminars/Meetings and Workshops

Officer/s	Subject	Organization
S Siriwardena	Progress Review Meeting	SPEnDP, MPI
	Progress Review Meeting	National Science Foundation
	Msc Lectures - on Rubber Chemistry	University of Sri Jayawardenapura
	Undergraduate -Lectures on raw rubber processing	Uva Wellassa University

Officer/s	Subject	Organization
S Siriwardena	Undergraduate Lecture on Rubber Technology	University of Sri Jayawardenapura
	Diploma in Plantation Management	NIPM
	Consultative Committee Meetings on Greener Procurement	Ministry of Mahaveli Development & Environment (MMDE)
	Consultative Committee Meetings on Kellanivelly River Basin	MMDE
	IRRDB, International Rubber Conference (IRC)	RRIV, Vietnam
UN Ratnayake	Diploma on Plantation Management	National Institute of Plantation Management
	Lectures- MSc; Polymer Science and Technology- Polymer rheology and mixing	University of Moratuwa
	MSc Lectures on Polymer Science and technology- Polymer rheology	University of Kelaniya
	MSc Lectures on Industrial and Environmental Chemistry - Polymers and polymer related materials	University of Kelaniya
	IRRDB, International Rubber Conference (IRC)	RRIV, Vietnam

Invited lectures/presentations

- Dr Susantha Siriwardena, delivered an invited lecture on "**Current research and development activities of RRI**" at the Annual General Meeting of PRI at 06th February, 2015.
- Dr Upul Ratnayake delivered an invited lecture on "**Value addition to Sri Lankan rubber industry"** SLAAS Workshop on value addition and commercialization of natural resources for economic development in Sri Lanka, 4th June 2015.
- U N Ratnayake made a presentation on **"Advances in rubber reinforcement: Micro to Nano"** 2nd International Symposium on Polymer Science and Technology, 03rd - 4th April 2015, organized by University of Sri Jayewardenepura.
- U N Ratnayake made a presentation on **"Natural rubber applications in tyre manufacturing".** Technical Symposium. The Institute of Automotive Engineers, Sri Lanka, 21st March 2015, ICTAD.

Services

Technical and advisory services to trouble shooting on all types of raw rubber processing and treatment of rubber waste water were provided throughout the year on

requests made by both Regional Plantation Companies (RPC) and small and medium scale raw rubber manufactures.

Technical assistance was also given to Thurusaviya annual programs by serving in technical expert panels for evaluating quotations, issuing smoke house plans, inspection of construction and operation activities of sheet rubber processing centers and single day smoke drying units.

Technical services were provided to Smallholder Plantations Entrepreneurship Development Program (SPEnDP) for evaluation of the progress of establishment of 40 Latex Processing Centers (LPC) with 100 kg daily capacity each in Moneragala District.

Collection of waste water samples from raw rubber processing and allied industries and analysis of waste water parameters were carried out throughout the year.

Training programs conducted

Two training programs were conducted on "Manufacture of quality improved sheet rubber" and "Single day drying system" to a group of smallholders organized by Thurusaviya. Areas covered included latex composition, latex preservation and estimation of dry rubber in latex at the field, manufacture of ribbed sheet rubber, and efficient operation of SS drying system and decision making process for commencement of raw rubber processing *etc*.

A training program was conducted on latex processing and raw rubber manufacture to a group of MSc students from University of Kelaniya.

The staff of the department continued to train farmers on latex collection, preservation and manufacture of sheet rubber at a series of awareness programs organized by Smallholder Plantations Entrepreneurship Development Program (SPEnDP) for farmers in Moneragala District.

Special assignments

- Dr Susantha Siriwardena served as the consultant - Rubber Processing Specialist of the Project Design Completion Mission of Smallholder Tea and Rubber Revitalization (STARR) Project funded by International Fund for Agriculture Development (IFAD), United Nations organization for a period of fourteen days from 25th June, 2015.

- A special assignment was undertaken to provide consultancy services of Dr Susantha Siriwardena, Dr Upul Ratnayake and Mr A K D Warnajith to the IFAD in monitoring the technical aspects and progress review in establishment of latex processing centres in Monergala District.

Advisory visits

Services provided	No. of factories/visits
Process and quality improvements	08
Waste water treatment	75
Implementation of SS drying system in estate sector	03
Plans issued for construction of new SS drying systems with capacity less than 100 kg	14
Plans issued for construction of new SS drying systems and modifications of existing systems to new SS drying systems with capacity more than 100 kg	02
Miscellaneous	13

Sample testing and certificates issued

Samples tested	Number of samples/certificates
Waste water – rubber related	66/73
Waste water – non rubber related	51/27
Processing water	13/08
Miscellaneous samples (metal ions, ZnO, *etc*.)	18/05
Analysis of extractable proteins	26/24
No of "certificates of epidemic prevention" issued for sole crepe	26/09

LABORATORY AND FIELD INVESTIGATIONS

RRPD-01-d: Natural rubber latex sludge as filler for rubber compounds

The project which was initiated to add value to NR latex sludge was continued throughout the year. Particle size reduction of the sludge material using a mechanical grinder was carried out in order to achieve better reinforcement and to optimize the surface treatment. Particle size distribution was analyzed. Analysis results reviled that average particle size of the mechanically ground sludge material was 25 µm (small particles). Marked improvement in tensile strength, elongation at break, (Figs.1-2) observed in particle size reduced sludge/NR compound. Abrasion loss in particle size reduced sludge incorporated compound is relatively less with compared to large particle incorporated sludge/NR compound. In order to achieve a better reinforcement particle size reduced sludge, it was subjected to surface modification with stearic acid, Triethoxy vinyl silain (TEVS) and zinc stearate (U N Ratnayake and Shirani Priyanka).

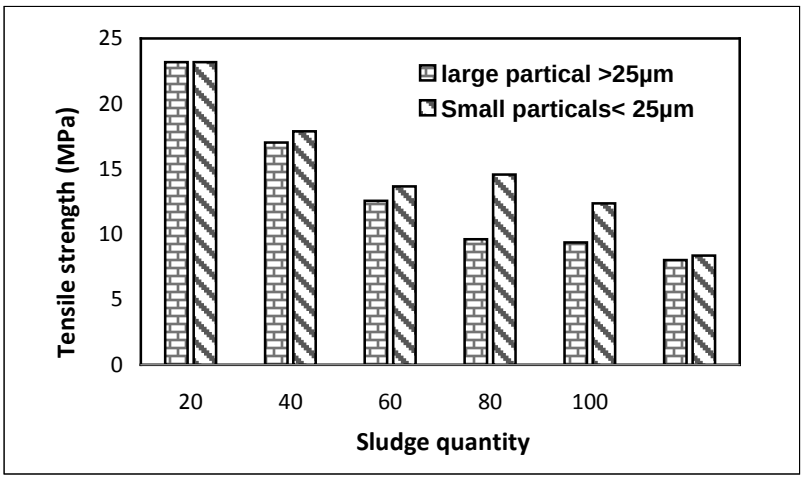


Fig.1. Effect of particle size on tensile strength

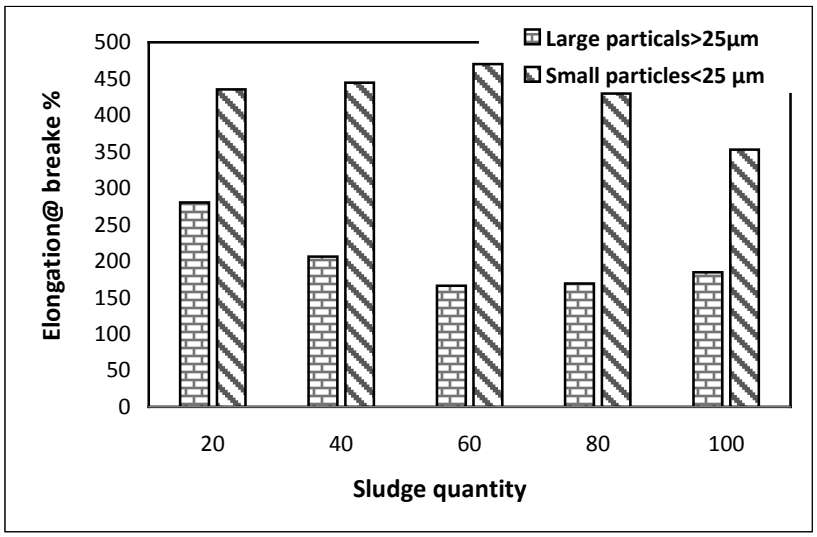


Fig. 2. Effect of particle size on elongation at brake percentage

RRPD-03b: Rubber nanocomposites: Effects of hybrid nanomaterial systems on mechanical and flame retardant properties

Above titled joint research project with University of Sri Jayewardenepura, funded by National Research Council (NRC) was continued throughout the year.

A novel preparation technique were successfully developed to prepare layered silicate filled NR nanocomposite, starting from NR latex stage. In this work, both NR latex and the layered silicates were modified simultaneously before coagulation.

Optimum concentration of the layered silicates was determined by evaluating the percentage recovery of rubber from the latex (Table 1) and the X-ray diffraction data of the aqueous dispersion of the layered silicates (Fig. 2).

Table 1. *Percentage recovery of rubber during the preparation of layered silicate filled NR nanocomposite*

Dispersion (%)	Rubber recovery (100g of dry rubber)
D-1	92.70
D-2	90.85
D-3	88.36
D-4	84.37
D-5	75.21

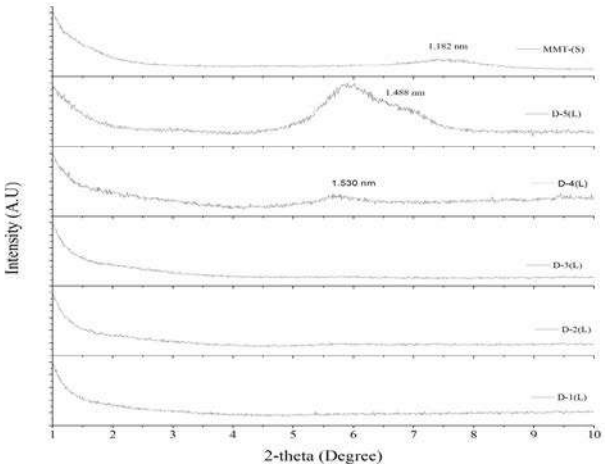


Fig. 3. X-ray diffraction spectra for layered silicate dispersions with different concentrations

Considering the degree of exfoliation of layered silicates in the dispersion as measured by X-ray diffraction and rubber recovery data, it is clear that lower concentration of aqueous dispersions of layered silicates, especially 2 wt % (D-2) and 3 wt.% (D-3), are the most suitable for the preparation the NR nanocomposite.

Figure 3 represents the low shear strain rate viscosity measured with Mooney Viscometer to study the interaction between nanostructured layered silicates and rubber molecules of the NR nanocomposites. As shown in Figure 4, Mooney

viscosity of the all layered silicate filled NR nanocomposites is higher than the UFUB crepe rubber and the layered silicate filled natural rubber prepared as per the conventional latex coagulation method. Higher Mooney viscosity of the NR nanocomposites suggests the interaction between exfoliated nanostructured layered silicates and rubber molecules indicating the formation of NR nanocomposite with improved reinforcement. PhD Research student – Malindu Alwis, Dept. of Chemistry, University of Sri Jayewardenepura,U N Ratnayake and N Kottegoda - USJP).

RRPD-03c: High performance lighter weight prosthetic foot based on hybrid nanomaterial filled natural rubber composites

Technology Grant awarded to the above titled development project by National Science Foundation (NSF) under the Technology Grant Scheme "Support for Technology Development" was continued throughout the year.

This development project is focused to develop a natural rubber based high performance and lighter weight prosthetic foot using nanotechnology/nanomaterial approach, as an alternative for the present prosthetic foot fabricated by Army Rehabilitation Center, Ranaviru Sevena, Ragama. In addition, the project has also concentrated to improve the processability of the prosthetic foot and thereby achieving a higher productivity.

A novel high performance and lighter weight prosthetic foot based on hybrid nanomaterial filled natural rubber compound along with improved processability was developed. The hybrid nanomaterial filled natural rubber nanocomposite with improved strength, better abrasion resistance, higher thermo-oxidative stability was developed for the outer layer of the prosthetic foot.

Nanostructured natural rubber cellular compound with a lighter weight as a result of fine pore structure and with good set properties was developed as the inner layer/component of the prosthetic foot.

Table 2 shows the physico-mechanical properties of newly developed hybrid nanomaterial filled natural rubber nanocomposite and conventional NR compound used to fabricate the present prosthetic foot at Ranaviru Sevena (RVS), Army rehabilitation center. As shown in Table 2, reinforcement without scarifying the elasticity of the hybrid nanomaterial filled NR compound is achieved because of the nanomaterial approach. Experimental results clearly shows the effectiveness of this NR nanocomposite material as the outer layer of the prosthetic foot.

As shown in property comparison, Figure 5, NR nanocomposite material has a better reinforcement while maintaining similar density and elasticity as NR compound presently used at RVS. Prosthetic feet were fabricated by compression moulding using the hybrid nanomaterial filled NR nanocomposite material and nanostructured NR cellular compound in different percentages to achieve the optimum performances and the reduced weight.

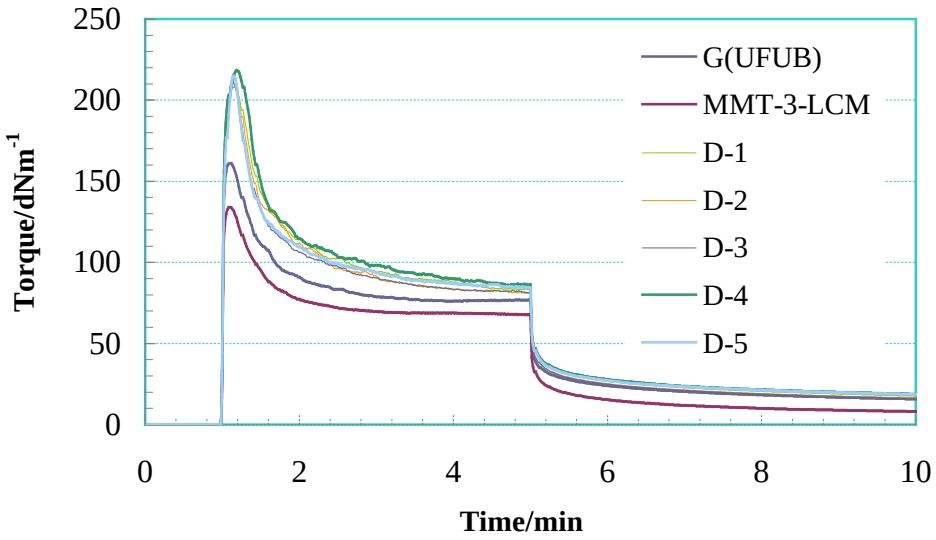


Fig.4. Low shear strain rate Mooney Viscosity of Layered silicates filled NR nanocomposites

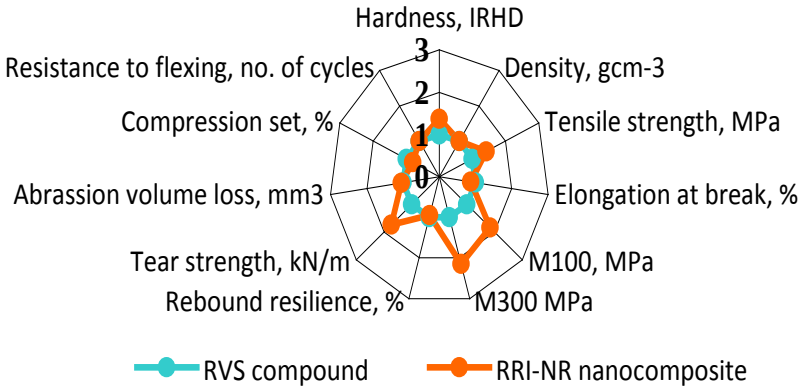


Fig. 5. Comparison of properties of the NR nanocomposite and NR compound used at RVS (Ratio analysis refereeing the RVS compound as 1, higher the ratio better)

Table 2. *Physico-mechanical properties of NR compound used at RVS and hybrid nanomaterial filled NR compound*

Physico-mechanical properties	NR vulcanizate used at RVS	Hybrid nanomaterial filled NR nanocomposite vulcanizate
Density, gcm^{-3}	1.10	1.1
Hardness,(IRHD)	35 – 42	52
Tensile strength, MPa	14 – 19	24
Modulus@ 100 % elongation, MPa	0.86 – 1.10	1.8
Modulus @ 300 % elongation, MPa	2.06 – 2.90	6.4
Modulus @ 500 % elongation, MPa	6.49 – 9.54	22.3
Elongation @ break, %	570 – 580	502
Tear strength, kN/m	24.5 – 28.0	45
Abrasion volume loss, mm^3	147 – 210	162
Resilience, %	73 – 74	71
Compression set, %	12.47 – 18.5	19.3
Resistance to flexing, No. of cycles	> 30,000	> 30,000

Based on the novel approach developed, a patent application titled "Novel high performance lighter weight prosthetic foot based on nanomaterial filled natural rubber compounds" was filled at Sri Lanka Patent Office (U N Ratnayake, Dilhara Edirisinghe, Sampath Wickramage and Maheesh Abeywardhana, Collaborator: Ranaviru Sevena, Army Rehabilitation Centre).

Fig. 6. Schematic diagram of compression moulded prosthetic foot1-Hybrid nanomaterial filled NR nanocomposite, 2- Wooden socket, 3-Canvas belt, 4-4- Nano tructured natural rubber cellular compound

RRPD-03d: Value addition to waste acrylonitrile butadiene rubber (NBR) through nanotechnology application

The above research project initiated to make a value addition to waste NBR, which contains significant percentage of sulphur and accelerator, generated from one of the leading latex glove manufacturing companies was continued throughout the year.

Initial results revealed that addition of above 30 phr of carbon black (CB) to enhance the mechanical performances was not feasible due to processing difficulties. However, processability of CB filled waste NBR was improved by blending of NBR with a small percentage of NR.

Studies were continued to further improve the reinforcement whilst optimizing the processability through the application of nanomaterial, organically modified montmorillonite clay (OMMT). Three compound formulations were developed with the addition of OMMT, CB and NR and evaluated the mechanical performances. Below is explained the three different formulations developed.

1. Waste NBR with only OMMT (OM series)
2. Waste NBR/NR with OMMT (NR series)
3. Waste NBR/NR with CB and OMMT (CB series)

As shown below mechanical performances of vulcanizates (Fig. 7-9), addition of OMMT at lower loadings, especially 4 to 6 phr, of nanomaterial (OMMT) to the waste NBR compounds further increases the reinforcement. Interaction of nanostructured OMMT clay layers with NBR molecules would cause to significant improvement in reinforcement at lower loading of OMMT. Evaluation of chemical resistance of above three compounds, especially resistance to oil and solvents are being progressed (MPhil Research student - Ranganath Wijesinghe, USJP).

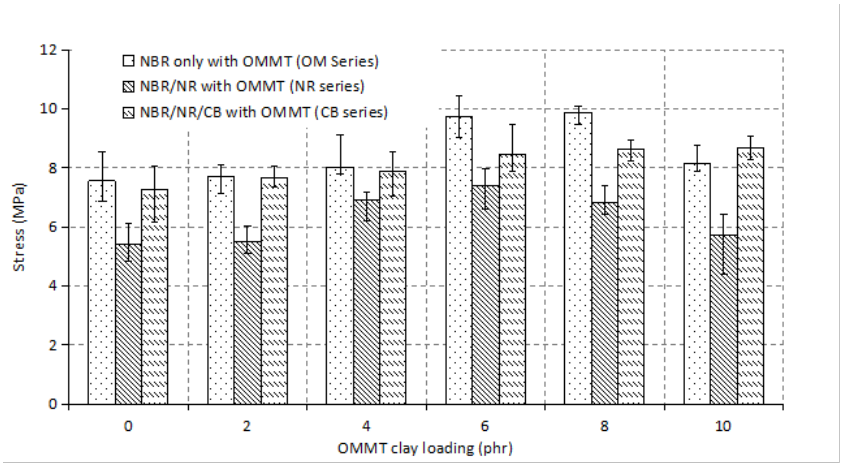


Fig. 7. Tensile strength of compounds with different OMMT clay loadings

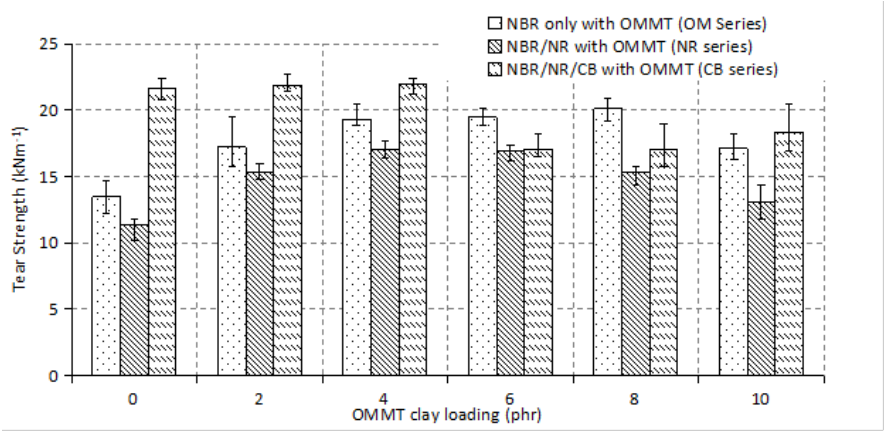


Fig. 8. Tear strength of compounds with different OMMT clay loadings

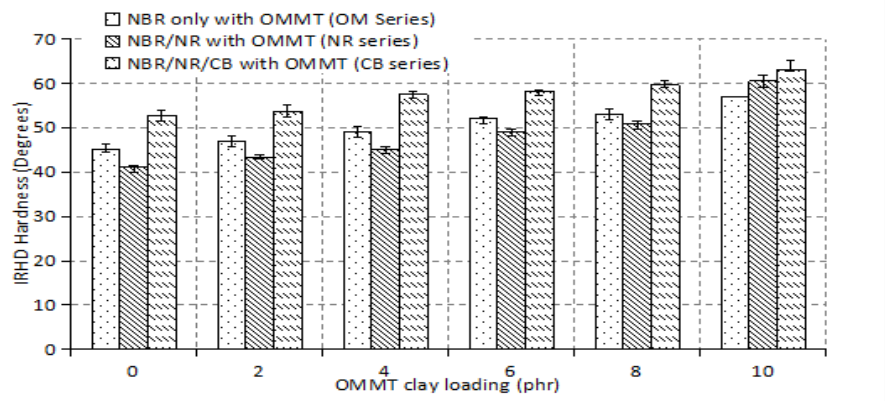


Fig. 9. IRHD Hardness of compounds with different OMMT clay loadings

RRPD-03e: Value addition to different raw natural rubbers through nanotechnology applications

RRPD-03e-1: Nanomaterial enabled skim natural rubber as a value added raw rubber

Skim natural rubber (SNR), a by-product of centrifuged latex manufacturing process, is generally considered as a lower grade of natural rubber (NR) and hence, applications of SNR is limited due to inherited properties and processability, especially vulcanization characteristics.

A new project was initiated to develop valued added skim natural rubber through nanomaterial approach thereby increase the skim rubber usage in different

applications. Nanomaterial enabled skim natural rubber was prepared by incorporating aqueous dispersion of nanomaterial into skim natural rubber latex followed by coagulation and standard procedure of milling.

The effect of nanomaterial structure on Po and PRI was investigated since one of the characteristic draw backs of SNR is lower resistance to thermal oxidation. As shown in Figure 10, PRI increases with the increase of nanomaterial loading up to 12 and beyond that PRI shows a reduction. However, all SNR nanocomposites with MMT clay have shown a better resistance to thermal oxidation than conventional skim natural rubber, indicating that nanostructures of nanomaterial improves the thermo-oxidative stability of the SNR nanocomposites.

Mooney viscosities of the SNR, as shown in Figure 11, suggest that nanostructured materials interacts with latex particles and as a result, hinder the flow behaviour at the low shear strain rate measured in the Mooney viscosity analysis. In addition, elasticity of the nanomaterial filled SNR (Table 4) has slightly increased in comparison to conventional SNR.

These viscoelastic responses of the SNR have clearly shown that processability is negatively affected by nanomaterials, although thermos-oxidative resistance is enhanced significantly.

Table 4. *Mooney viscosity and elastic energy retention exponent*

Composite code	Nanomaterial loading Phr	Mooney Viscosity MU	Elastic energy retention exponent (a+1)
SNR	0	93.8	0.79
SNR-3	3	95.4	0.82
SNR-6	6	96.4	0.82
SNR-9	9	98.4	0.81
SNR-12	12	104.8	0.81
SNR-15	15	109.3	0.80

Studies are in progress to evaluate the effect of nanomaterial on stress-strain behaviour of uncured SNR which measures the green strength of the skim rubber (U N Ratnayake, Anuradhi Liyanapathirana – MSc student, University of Sri Jayawardenapura and A K D W Warnajith).

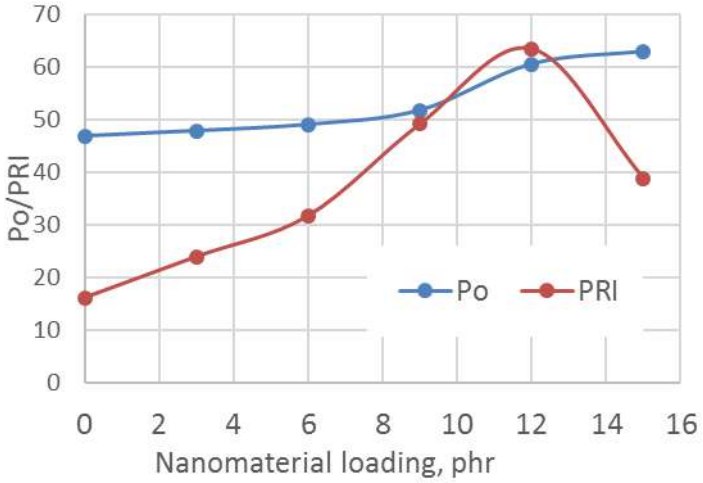


Fig.10. Wallace Plasticity No. (Po) and Plasticity Retention Index (PRI) of nanomaterial enabled SNR

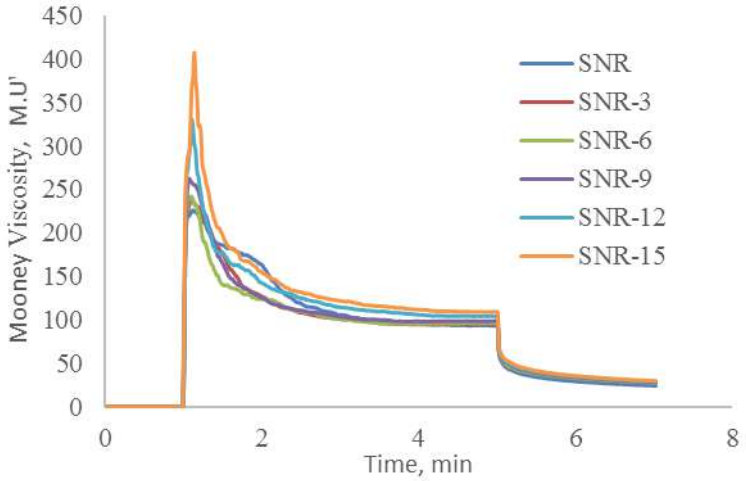


Fig.11. Mooney viscosity and Mooney stress-relaxation curves of nanomaterial enabled SNR

RRPD-05 (a): Urea as an anticoagulant for natural rubber field latex

Aqueous solutions of ammonia and sodium sulphite are the commonly used anticoagulants to prevent the pre-coagulation of latex. The active ingredients of both the solutions are easily escaped from the solutions with a repugnant smell demanding strict handling precautions for its effective use in the field. As an alternative, urea which has shown a potential to replace tetramethylthiuramdisulphide and ZnO, a

secondary preservative used in low ammonia centrifuged latex manufacture was used in this study to preserve natural rubber field latex. Natural rubber latex was preserved by addition of three different ratios of 25% urea solution. Sodium sulphite treated natural rubber field latex was used as the control. Both Ribbed Smoked Sheets (RSS) and Un-fractioned and Unbleached (UFUB) crepe rubber were manufactured using the treated latex.

Preservation efficiency and properties of raw rubber manufactured from treated latex were studied. Rubber compounds were prepared with the raw rubber produced with treated latex and 90 % cure time of these compounds were measured.

NR latex preservation ability of urea was similar to that of sodium sulphite. It was found that urea or its dosage has no significant effect on nitrogen content, Wallace plasticity number and Mooney viscosity of the raw rubber manufactured. However, addition of urea has resulted in reduction of plasticity retention index (PRI) of UFUB crepe rubber. As urea dosage increases, PRI decreases gradually. It could be due to interactions of urea with the naturally present antioxidants in natural rubber latex. However, similar trend was not observed for RSS. During the hot smoke drying process, antioxidants in the smoke get adsorbed on to the sheet rubber and may offer additional resistance to oxidation overcoming the negative effect of interactions between urea and antioxidants present in the latex.

Urea has caused a significant reduction in cure time of RSS compounds with increasing urea dose. This shows the acceleration effect of urea on curing process in rubber compounds. However, similar trend was not observed for the UFUB crepe rubber compounds. Addition of urea has resulted in a decrease in abrasion resistance of both types of rubber vulcanizates. Abrasion resistance of vulcanizates of urea treated UFUB crepe rubber decreases with the increasing urea dose. This trend was not clear for the vulcanizates of RSS probably due to the effect of antioxidants present in the smoke. Tensile strength of urea treated UFUB crepe rubber vulcanizates decreases with the addition of urea, while urea treated RSS vulcanizates do not show any significant change in tensile strength. For both the rubbers, hardness values have decreased with the increase of urea dose suggesting that urea or its reactant products impart a certain plasticizing effect into the rubber compounds (Thilina Amarabandu, B A D M Balasooriya, W D M Sampath, D G Edirisinghe and S Siriwardena).

RRPD-05 (b): Air dried sheets as a substitute for unfractionated and unbleached crepe rubber in rubber product manufacture

Two types of natural rubber; un-fractioned un-bleached crepe rubber (UFUB) and air dried rubber sheets (ADS) were used in this study. Both are manufactured without removing fraction which mainly consists of the non-rubbers present in the latex. They are dried in hot air achieving the pale yellow colour. Since the difference between the chemical compositions of these two types are expected to be more or less

similar, the main objective of this study is to evaluate the performance of ADS as a substitute for commonly used UFUB crepe rubber in coloured rubber product manufacture. The raw rubber properties of UFUB and ADS were tested according to the ISO procedures and subsequently the curing characteristics of gum compounds based on UFUB and ADS were studied. In the second phase of this study, the rubber samples were filled using hybrid filler of $CaCO_3$ and china clay according to the formulation used in the industry. The curing characteristics of the two samples were studied. The mechanical properties of the filled vulcanizates prepared using both types of rubber were compared. It was found out that the curing characteristics of both rubber compounds show similar values except for slightly higher torque values obtained for the ADS compound. The gel content and acetone extraction of natural rubber are a measure of non-rubbers present in them. The gel content of ADS was slightly higher than that of UFUB (UFUB-22%, ADS-24%). The nitrogen content in ADS was slightly higher than in UFUB (UFUB-0.353%, ADS-0.415%). Even though the non-rubber content in ADS was slightly higher than in UFUB, the vulcanizate properties (tear, hardness, compression) were quite the same. However, the tensile strength of UFUB was slightly higher than that of ADS while the abrasion resistance of UFUB shows a low value. The observations made through colour comparison made using a modified method of Lovibond colour test showed that there is no colour variations of the both vulcanizates made out of UFUB and ADS rubber. Therefore, these results indicate that UFUB can be substituted by ADS perhaps with a slight modification to the present recipe (Taniya, B A D M Balasooriya and S Siriwardena).

RRPD-05 (c): Influence of coagulation method of latex on raw rubber properties

The aim of the study was to investigate the possibility of using different coagulation methods to improve the natural rubber coagulation efficiency in term of rate of coagulation. The experiment based on three different methods. In the first method, formic acid having four different concentrations (1%, 5%, 10%, 15% and 20%) were added to the diluted latex. In the second method, formic acid having same different concentrations above) were sprayed to the diluted natural rubber field latex. Undiluted natural rubber latex sample was used in the third method. Results revealed that the use of higher concentration of formic acid in coagulation process will not adversely affect the raw rubber properties such as Wallace plasticity, plasticity retention index, Mooney viscosity, volatile matter content and the nitrogen content. However, the use of high concentrated formic acid sprayed samples yielded the high Mooney viscosity value such as 84.70 and 81.97 for 15% and 10% formic acid sprayed samples respectively (S M L Prabath, B A D M Balasooriya and S Siriwardena).

RRPD-05 (d): Mechanical properties and processability of skim rubber/ polyethylene thermoplastic elastomers

In an attempt to value addition to skim rubber, thermoplastic elastomers based on polyethylene (PE) and skim rubber which is a byproduct of natural rubber latex centrifugation process containing high proportions of non rubbers were prepared. Melt mixing was carried out in an internal mixer. The skim phase was dynamically vulcanized at different sulphur concentrations from 0 to 1phr with 0.25 increments. Blends based on PE and Technically Specified Rubber (TSR) were also prepared following the same conditions. The effect of curing agent concentration on processability was evaluated.

The Hakke torque *vs*. time curves of Skim/PE blends and TSR/PE vulcanized at different sulphur concentrations are shown in Figure 12 and Figure 13 respectively. The melt temperature *vs*. time for blends cured at 0.25 is also shown in the graphs. The variation of maximum final torque values obtained for both Skim/PE and TSR/PE blends are presented in Figure 14. It could be seen in Figure 12 and Figure 13 that basic characteristic features of torque development curves derived during the preparation of both blends through melt mixing are similar to each other. For all the blends, LDPE was charged into the mixing chamber and kept for four minutes for preheating. The rotors were then started and torque increases comparatively a slow rate starting from zero torque value due to the resistance exerted by the melted LDPE against the rotation of the rotors. After second minute of the commencement of the rotors, NR was added into the mixing chamber. The torque then rises again at an alarming rate due to the resistance exerted by the un-melted NR and the increased fill factor in the mixing chamber. However, as the NR also gets melted and heated upto the mixing temperature, the viscosity of the material becomes low and consequently torque starts to decrease achieving stabilize torque within a period of three minutes. At the end of this period (total blending time is five minutes) curing ingredients namely ZnO, Stearic acid and IPPD were charged into the chamber through the feeding unit. At this point, it could be seen a sudden decrease of torque probably due to the quick opening of the feeding unit and the lubricant action of the ingredients that were incorporated at this stage. After further two minutes, accelerators were added followed by addition of sulphur (the curing agent). It could be seen that the torque started to increase gradually indicating the progress of dynamic vulcanization of rubber phase of the both blends. The progress of vulcanization on elastomer phase further evidenced by the slight increase in the melt temperature recorded as the Sulphur vulcanization process is exothermic reaction. The slight decrease in the torque after passing the maximum value after addition of sulphur may be due to the resultant decrease of the viscosity of the material due to the increase of the material temperature. However, both blends did not show a significant drop of the torque during the mixing cycle studied indicating that there was no degradation of the materials generated during the blending period at question. Therefore, it could be

inferred that Skim rubber/PE blends are also can be prepared similar to the preparation of TSR/PE blends without a significant deterioration of the blend properties. When compare the total mixing time of the Skim and NR/PE blends latter is blended for extended period (3 minutes) as the onset curing of the blends was delayed in these blends. Higher levels of naturally occurring of accelerators in Skim phase may be the reason for this faster onset of curing of skim phase of the blend.

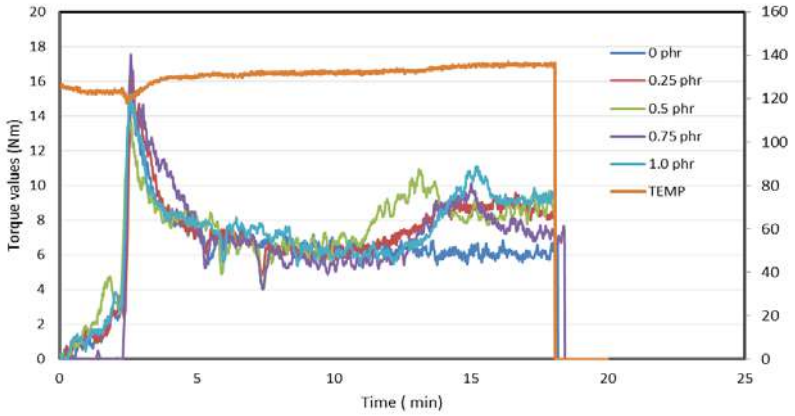


Fig. 12. Torque development in skim/PE blends cured at different sulphur concentrations

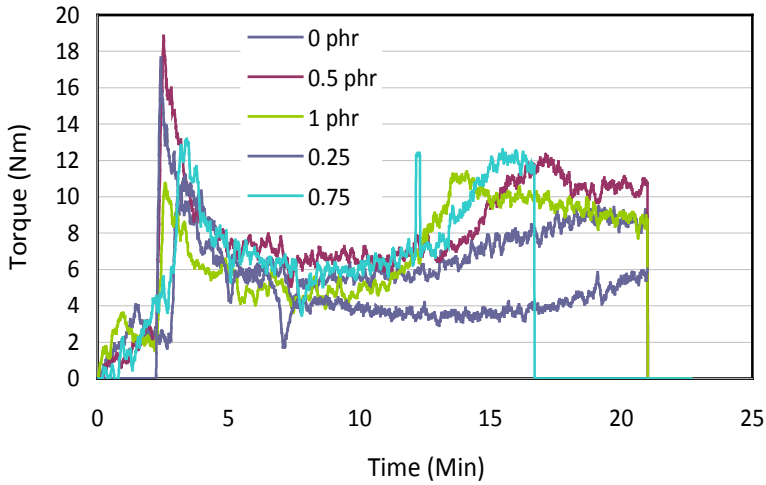


Fig. 13. Torque development in PE/TSR blends cured at different sulphur concentrations

On comparison of stabilization torque after the maximum torque, for both Skim and TSR samples as shown in Figure 14, it can be seen that the stabilization torque at an increasing trend with increasing of sulfur concentration in the both

blends. Controls (uncured counterparts) were performed without sulfur and no increase in the torque values was observed. Therefore, it could be concluded that crosslink density has increased with the sulfur concentration in the cured blends. Also there is around two unit gap between maximum torque and stabilization torque for each sample. The temperature inside the chamber is increased due the exothermic nature of the cross linking reactions. Therefore, viscosity of the materials (blends) drop and torque values was decreased.

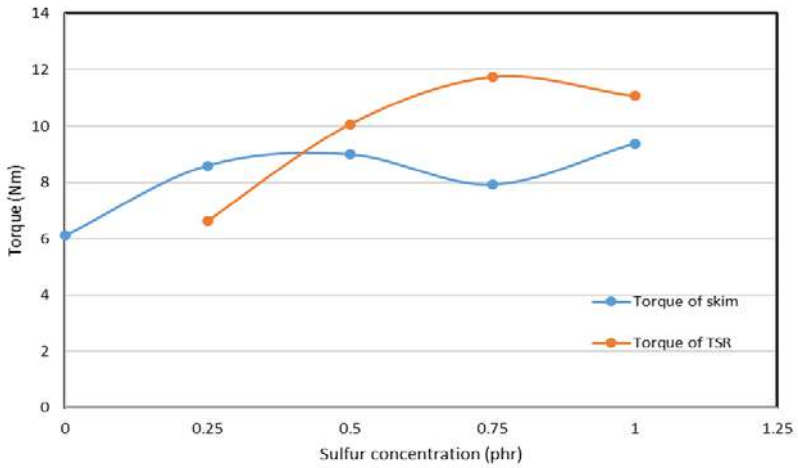


Fig. 14. Stabilization torque of the blends cured at different sulfur concentrations

When consider the higher stabilization torque registered, it can be seen that TSR and PE blends exhibits higher value than the Skim/PE blends at all Sulphur concentrations. However, mooney viscosity of skim raw rubber is higher than the TSR rubber due to the presence of high content of proteins in skim rubber. Therefore, it is expected higher maximum torque for NR skim/PE blends. The opposite trend observed may be explained as follows. Even though skim rubber contains higher protein content, Skim rubber agglomerates are reported to be smaller in size. In the cross-linked samples also these vulcanized Skim rubber particles may smaller than the vulcanized TSR particles making viscosity of the continuous PE phase more viscous in the vulcanized TSR/PE blends. Therefore, it can be inferred that vulcanized skim rubber particles have lesser influence on the flow properties of the material (B A D M Balasooriya and S Siriwardena).

ADAPTIVE RESEARCH

V H L Rodrigo and S M M Iqbal

DETAILED REVIEW

Staff

Dr V H L Rodrigo coordinated the activities of this unit. Dr S M M Iqbal, Principal Agronomist, Dr (Mrs) E S Munasinghe, Senior Research Officer, Mrs B M D C Balasooriya, Research Officer, Mr P M M Jayathilake, Technical Officer and Mrs M A R Srimali, Management Assistant were on duty throughout the year. Mrs C Weeramanthree, Accounts Clerk was on duty throughout the year at Polgahawela Substation. Mr T B K H Neranjana assumed duties with effect from 27th April as a Technical Officer in Polgahawela Sub-station and resigned from RRISL on 01st November. Mrs W G Piyumi Harshika assumed duties on 23rd February as a Temporary Technical Assistant under the Negenehira Navodaya Programme and was on duty up to the 31st December.

Seminars/Training/Workshops/Exhibitions conducted

Officer/s	Subject/Theme	Beneficiary/Client
SMM Iqbal	Rubber cultivation in non-traditional areas	Induction Course for Planter Trainees 2015 National Institute of Plantation Management

Seminars/Training/Workshops/Meetings/Conferences attended

Officer/s	Subject/Theme	Organization
SMM Iqbal	Rubber cultivation in the Eastern Province - Progress Review Meetings	Ministry of Plantation Industries
	Krushi Exhibition - Labuduwa, Matara	Department of Agriculture
	Annual Symposium on Minor Export Crops – Participation as a Reviewer	Department of Export Agriculture
	Presentation of a research paper titled "Identification of suitable species and genotypes for cut foliage cultivation on rubber lands"	International Rubber Conference 2015, IRRDB Vietnam
ES Munasinghe	Preparation of National Action Plan for Climate Change	Ministry of Mahaweli Development and Environment
	Preparation of GHG Inventory of Sri Lanka	Ministry of Mahaweli Development and Environment

Officer/s	Subject/Theme	Organization
ES Munasinghe	Programme Advisory Committee Agriculture	Higher National Diploma in Technology (Agriculture)
	Presentation of a research paper titled "Carbon footprint of rubber/sugarcane intercropping system in Sri Lanka"	University of Sabaragamuwa
BMDC Balasooriya	Workshop on Risk Assessment of Alien Invasive Species in Sri Lanka	Biodiversity Secretariat, Central Environmental Authority
SMM Iqbal, ES Munasinghe, BMDC Balasooriya	Workshop on project management	Rubber Research Institute of Sri Lanka

Research students

- H M P S K Herath, an undergraduate student of Department of Export Agriculture, Faculty of Animal Science and Export Agriculture, Uva Wellassa University of Sri Lanka, carried out his final year research project on 'Impact of rubber plantations on environmental conditions of Eastern Province of Sri Lanka' under the supervision of Dr S M M Iqbal.
- P S V Rupasinghe, an undergraduate student of Department of Export Agriculture, Faculty of Animal Science and Export Agriculture, Uva Wellassa University of Sri Lanka, carried out her final year research project on 'Effect of anti-transpirant in sustaining rubber leaf physiology under dry climatic condition' under the supervision of Dr (Mrs) E S Munasinghe.

Visits

Experimental visits - 82
Advisory visits - 18

FIELD INVESTIGATIONS

Adaptive Research Programme

Expansion of rubber cultivation to Eastern province (ARU/01/a)

Objectives and the initial actions taken to establish rubber in this region appeared in Annual Review for 2004.

Impact assessment on crop climate in the dry period completed at Komana village

Main observations during the year were,

Four sites were inspected which were established in Uhana in 2013.

Studies of crop micro climate under rubber and effect of anti-transpirant in sustaining rubber leaf physiology under dry climatic condition completed at Komana village, Padiythalawa. Details are as follows:

Impact of rubber plantations on environmental conditions of Eastern Province of Sri Lanka

A study was aimed to assess the microclimatic conditions under mature rubber lands in Komana Village at Padiyatalawa in Ampara district of Eastern Province during the dry period from 30th May to 22nd July 2015. In this study, manmade forest, natural forest and chena (an open area) cultivations are included in comparison and to assess the microclimatic conditions. To facilitate the assessments, three replicates from each site were included and importantly automated weather station was also established closed to the trial site. Six parameters were assessed namely soil moisture content, soil temperature, air temperature, relative humidity, wind speed and solar radiation. Soil moisture content under rubber lands recorded 5.49% higher than chena cultivation and also, the mean values of both rubber and natural forest recorded the highest values of relative humidity and the lowest values of soil temperature, air temperature, wind speed and solar radiation over the chena cultivation. Mature rubber plantation performed similar to natural forest and simulated the micro environmental condition of a natural forest. Overall results of this study indicated that rubber cultivation provides better working environmental conditions for farmers.

Effect of anti-transpirant in sustaining rubber leaf physiology under dry climatic condition

The study was conducted to assess the benefits of anti-transpirant application in sustaining leaf physiology of rubber plant under dry climatic condition. Five months old clone RRIC 121 rubber plants, established in Komana village of Padiyathalawa GN division in Ampara district of Eastern Province were used for the study during the period from May to July, 2015. Three concentration levels (0.3 ml/l, 0.45 ml/l and 0.6 ml/l) of anti-transpirant were tested against three application intervals (2, 3 and 4 weeks) over untreated control. Environmental parameters *viz*, rainfall, maximum and minimum temperatures, solar radiation, relative humidity, wind speed and soil moisture content; physiological parameters *viz*, stomatal conductance, chlorophyll content, photosynthesis and relative water content; growth parameters *viz*, plant diameter, plant height and total leaf count of the plants were observed over the study period. A dry weather condition (average rainfall of 2.7 mm/day) prevailed throughout the study period with high temperature (average maximum temperature of 33°C and average minimum temperature of 27°C) and low RH (average 67%).

Rubber plants with the application of anti-transpirant at different concentrations and application intervals outer performed over the untreated control in terms of both physiological and growth parameters of plants. Out of treatment combinations, application of anti-transpirant with a concentration of 0.45 ml/l at 2 weeks interval contributes to a significant increase in stomatal conductance and

chlorophyll content of leaves together with better results for photosynthesis rate and relative water content at the end of the study period (Table 1).

Table 1. *Response of physiological parameters of rubber plants to different concentration levels and application intervals of anti transpirant at the end of drought period*

Concentration level of anti transpirant	Application interval of antitranspirant	Mid day stomatal conductance (cms^{-1})	Change in chlorophyll content (SPAD units)	Photosynthesis rate at high light level ($\mu mol\ m^{-2}\ s^{-1}$)	Relative water content (%)
0.3 ml/l	2 week	^{bc}0.0173	^{abc}3.067	3.6183	88.95
	3 week	^{c}0.0056	^{bc}-0.333	3.7916	87.997
	4 week	^{c}0	^{bc}-0.353	3.0066	88.417
0.45 ml/l	2 week	^{a}0.0973	^{a}10.144	6.8	90.127
	3 week	^{bc}0.0103	^{ab}4.98	5.01	88.72
	4 week	^{c}0.0036	^{ab}4.423	4.635	87.82
0.6 ml/l	2 week	^{b}0.0406	^{ab}7.2	5.6516	89.24
	3 week	^{bc}0.01	^{ab}7.91	6.145	88.607
	4 week	^{bc}0.0086	^{a}8.653	3.39	87.607
Control (no anti transpirant)		^{c}0.0003	^{c}-4.19	4.4333	88.07

Application of anti-transpirant with a concentration of 0.6 ml/l at 2 weeks interval contributes better results for studied growth parameters (Table 2).

Table 2. *Response of growth parameters of rubber plants to different concentration levels and application intervals of anti transpirant at the end of the drought period*

Concentration level of anti transpirant	Application interval of antitranspirant	% Increment in plant diameter	% Increment in plant height	% Increment in leaf count
0.3 ml/l	2 week	^{ab}25.25	^{bc}46.11	^{ab}18.43
	3 week	^{ab}22.77	^{abc}52.16	^{ab}16.38
	4 week	^{ab}23.24	^{abc}55.67	^{a}29.45
0.45 ml/l	2 week	^{ab}22.10	^{ab}60.57	^{a}30.17
	3 week	^{b}17.79	^{bc}44.44	^{ab}14.59
	4 week	^{ab}22.37	^{bc}45.72	^{ab}28.40
0.6 ml/l	2 week	^{a}30.27	^{a}67.01	^{a}35.88
	3 week	^{ab}25.16	^{abc}49.10	^{a}40.64
	4 week	^{ab}19.11	^{c}39.92	^{ab}18.77
Control (no anti transpirant)		^{ab}19.38	^{bc}46.49	^{b}-6.91

- Assessment of socioeconomic impact of rubber cultivation on rural livelihood was continued in Komana and Marawa villages in Padiyathalawa.

- In general, lack of transport facilities affected the research activities of this region

(V H L Rodrigo, S M M Iqbal, E S Munasinghe, B M D C Balasooriya and P M M Jayathilake)

Polgahawela Sub-station (ARU/01/b)

Expansion of rubber cultivation in Wayamba region (North Western Province)

Field activities were supervised by Senior Estate Manager of RRISL. Rubber harvested was delivered to Dartonfield estate in the form of RSS.

Upkeep of crops

General estate management practices of immature and mature rubber and rubber/cinnamon intercrops and also of cashew plants were done. Latex collected from the mature rubber fields was processed to RSS and 30245 sheets with the weight of 10978kg were produced within the year (V H L Rodrigo, S M M Iqbal, P A Lakshman, T B K H Neranjana, B M D C Balasooriya, E S Munasinghe and P M M Jayathilake).

Branch induction trial

This study was started in a field planted in 2008 with the objective of assessing the effect of artificial branch induction on growth and development of rubber plant. Details of the study were mentioned in Annual Review 2009. Naturally branched plants were categorized into three groups according to the time of branching. Summary of the tree girth of the rubber plants from 2009 to 2015 is given in Table 3 under four categories.

Table 3. *Girth of rubber plants associated with branch induction in the trees planted in year 2008*

	Average girth (cm) of the tree measured at 120cm						
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Artificially induced (one year after planting)	10.22	20.97	32.10	42.75	51.75	59.12	62.87
Naturally branched (one year after planting)	11.42	23.47	35.08	43.42	54.06	61.83	66.89
Naturally branched (18 months after planting)	8.69	20.00	30.68	38.68	48.85	56.33	60.29
Naturally branched (30months after planting)	7.76	15.60	25.28	34.04	44.30	51.07	55.41

Initial girth of rubber trees where natural and artificial branched trees of one year after planting comparatively higher than that of plants subjected to natural branched trees of 18 and 30 months after planting (Table 3). Similar trends were observed throughout the period up to 2015. In general, plants with comparatively low girth tends to branch late in its growth cycle while well grown plants; plants with high girth tends to branch early. However, the growth of the plants subjected to branch induction was in line with the growth performance of naturally branched plants at the right time (B M D C Balasooriya, V H L Rodrigo and S M M Iqbal).

Incorporation of coconut husks to planting holes as moisture conservation method

This trial was started in 2010 with the objective of assessing the impact of incorporating coconut husks to the planting hole as a moisture conservation method. Details of the study were given in Annual Review for 2010.Tree girth of the rubber plants was measured to assess the effect of coconut husks on the growth of the rubber plant. Average girth of the rubber plants from 2012 to 2015 is given in Table 4.

Table 4. *Growth of rubber plants which were incorporated with and without coconut husk to the planting hole established in year 2010*

Year of measurements	Average girth (cm)	
	With coconut husk	Without coconut husk
2012	16.62	15.68
2013	29.19	28.18
2014	39.10	38.20
2015	48.86	48.06

There is a slight increase in tree girth of the plants with coconut husks added to the planting hole. The growth difference between plants with treatment and control was observed less with the time since the impact of coconut husk become not much more with the time (Table 4) (B M D C Balasooriya, V H L Rodrigo and S M M Iqbal in collaboration with Soils & Plant Nutrition Department).

Monaragala Substation (ARU/01/c)

Rubber/Sugarcane intercrop

Details of this experiment were given in Annual Review 2009.

Information on growth parameters of rubber such as girth and total height were gathered. Average girth (at 150 cm height) and total height declined with the delay in planting and two whorl plants performed better than one whorl plants (Table 5).

Table 5. *Growth of rubber plants (6 years after planting)*

	Girth(cm) (at 150 cm height)		Height (m)	
	One leaf whorl plants	**Two leaf whorl plants**	**One leaf whorl plants**	**Two leaf whorl plants**
Onset of rainy season	39.92	40.67	13.26	13.54
2 weeks after	39.59	40.20	12.93	13.04
4 weeks after	38.16	38.75	12.39	12.49
6 weeks after	37.46	37.50	12.03	12.29
8 weeks after	36.61	37.00	11.58	11.80
10 weeks after	32.94	35.06	11.06	11.31

Rubber/Banana intercrop

Details of this experiment were given in Annual Review 2011.

Information on growth parameters of rubber such as girth and total height were gathered. Average girth (at 150 cm height) and total height declined with the delay in planting and two whorl plants performed better than one whorl plants (Table 6).

Table 6. *Growth of rubber plants (4 years after planting)*

	Girth (cm) (at 150 cm height)		Height (m)	
	One leaf whorl plants	**Two leaf whorl plants**	**One leaf whorl plants**	**Two leaf whorl plants**
Onset of rainy season	24.9	25.8	7.96	8.61
2 weeks after	24.2	25.3	7.85	8.23
4 weeks after	23.7	24.3	7.63	7.79
6 weeks after	22.7	23.9	7.47	7.60
8 weeks after	22.0	23.5	7.30	7.30
10 weeks after	21.9	22.4	6.89	7.14

(E S Munasinghe, V H L Rodrigo, S M M Iqbal, P M M Jayathilake and V G D N Gunaseela)

Rubber cultivation in the North of Sri Lanka (ARU/01/d)

A summary of the updates of Rubber cultivation in Northern Province is given bellow:

- Establishment of Rubber from 2010 to 2014 in Northern Province under the subsidy scheme by Rubber Development and selected holdings as an adaptive research is showed in Table 7.

Table 7. *Details of the rubber established from 2010 to 2014 in Northern Province*

Year	District	Area	Rubber planted in North		In progress as an Adaptive Research	
			No hold	Ac	No hold	Ac
2010	Vavunia	Vavunia South	2	4	2	4
		Vavunia North	3	1.5	-	-
	Mullaitivue	Oddusuddan	1	0.5	-	-
	Kilinochchi	Ilaktchchi	1	0.5	-	-
2011	Vavunia	Vavunia South	9	41	3	6
	Mullaitivue	Oddusuddan	6	3	-	-
2012	Vavunia	Vavunia South	5	3	3	4
	Mullaitivue	Oddusuddan/mallavi	7	1.75	1	0.25
	Kilinochchi	Akkaryankulam	3	1	1	0.25
2013	Vavunia	Vavunia South	98	60	3	3
	Mullaitivue	Mudiyankattuweva/ Mankulam	12	12	2	1.5
	Kilinochchi	Vishwamadu	3	6	1	2
2014	Vavunia	Vavunia South	1	15	1	2

- Annual girth increment rate of 8.0 cm was achieved in adaptive research plots established during the period of 2010 to 2013
- Papaya and Banana have successfully been cultivated as an intercrop with immature rubber.

The followings were done in year 2015

- Land selection programme at Faculty of Agriculture, Kilinochchi
- Application of fertilizer was done in all Adaptive research trials
- Two field visits were carried out by the staff of adaptive research unit.
- One field visit was made with all Head of Agronomic Departments to inspect the rubber plantation in North
- Attended the District Agriculture progress meeting at Kilillinochchi District Secretariat and selected two innovative farmers to establish participatory adaptive research trials
- Land clearing and lining for rubber in selected fields were completed

In general, lack of transport facilities and monitoring affected the research activities of this region (V H L Rodrigo, S M M Iqbal, E S Munasinghe, B M D C Balasooriya and P M M Jayathilake in collaborations with all Agronomic Departments).

Assessment of smallholder response on new clones (ARU/02/a)

High yielding new clones have been introduced to the estate and smallholder sectors by the Rubber Research Institute during past decades. All these clones have high yield potentials and show high response to fertilizer. But, most of the smallholders have not been able to achieve the potential yield. Main reason for this is the poor adoption level of recommended agronomic practices in the smallholder sector. Still there are occasions, that some farmers continuously request for old clones instead of new clones saying that those clones are more suitable for their farming conditions. Though there are such requests old clones are not encouraged to be distributed among farmers. Prior to make a firm decision on this issue, a systematic study should be done in order to evaluate respective situations at farmer level. Therefore, a smallholder survey has been planned to get the smallholder perception on new clones. Kalutara district was selected as the study area with a proper sampling plan. The smallholder survey is in progress (B M D C Balasooriya, E S Munasinghe, V H L Rodrigo S M M Iqbaland P M M Jayathilake).

Assessment of availability, demand and use of rubber fertilizer in Monaragala district (ARU/02/b)

Sulphate of Ammonia (SA) based 7:9:9:3 fertilizer mixture has recently been recommended to the non traditional rubber growing areas instead of urea based 12: 14: 14 mixture due to the low urease activity in those areas. But, there is persisting issue regarding the availability of new fertilizer mixture in the Monaragala district. Consequently, a study was planned to assess the availability, demand and use of new fertilizer in the Monaragala district.

This study consisted of a market survey and a smallholder survey. Lak pohora and several private companies are handling the fertilizer market in the area. Details of the local agents of respective companies were collected. Further, smallholder distribution in the district was collected from the Rubber Development Department. Based on the smallholder distribution collected from the rubber development department, the smallholder survey is carried out.

According to the market survey, private agrochemical company agents and thier dealers in the area were aware about the SA based 7:9:9:3 fertilizer mixture and it was available during the early part of the year. However, at the end of the year, rubber fertilizer was not available with the most of the dealers. According to the fertilizer dealers, there was no demand for rubber fertilizer at the end of the year. The reason may be the low rubber prices at the market which results low profit margin at the growers end. And also Lakpohora agents in the area were not aware about the SA based 7:9:9:3 fertilizer mixture and urea based rubber fertilizer was available in their stores. This survey is continued (B M D C Balasooriya, E S Munasinghe, V H L Rodrigo S M M Iqbal and P M M Jayathilake).

BIOMETRY

Wasana Wijesuriya

DETAILED REVIEW

Staff

Dr (Mrs) Wasana Wijesuriya (Biometrician) and Experimental Officers; Mrs Chintha Munasinghe and Mr Vidura Abeywardene were on duty throughout the year.

Seminars/Trainings/Workshops addressed/conducted

Mrs WasanaWijesuriya conducted the following trainings.

Subject/Theme	Beneficiary/Client
Climate conditions and rainfall distribution in rubber growing areas	Trainees of National Diploma in Plantation Extension Management, National Institute of Plantation Management
Climate conditions and rainfall distribution in rubber growing areas	Induction course for Planter Trainees - 2015, National Institute of Plantation Management
Statistical applications relevant to the rubber sector	Students of Kelaniya University in the Statistics degree programme

Seminars/Conferences/Meetings/Workshops attended

Mrs Wasana Wijesuriya attended the following Meetings/Conferences.

Subject/Theme	Organization
Mapping of tea and rubber lands using GIS	Ministry of Plantation Industries/Land Use Planning
11th Monsoon Forum	Department of Meteorology (DoM)
12th Monsoon Forum	(DoM)
Progress Review Meetings	Ministry of Plantation Industries (MPI)
Scientific Committee Meetings of RRISL	RRISL
International conference on promoting Socio-Economic equity in South Asia: Challenges and prospects	National Science Foundation (NSF)
NSF National Thematic Research Programme (NTRP) on food security (3rd Research and Coordination Committee)	National Science Foundation (NSF)

Seminars/Conferences/Workshops addressed

Mrs WasanaWijesuriya addressed the following Seminars/Conferences/Workshops.

Subject/Theme	Organization
Experiences and lessons learnt : 2014/15 North East Monsoon season (December 2014 to February 2015)	11th Monsoon Forum, Department of Meteorology (DoM)
Experiences and lessons learnt: 2015 Southwest Monsoon Season (May to September 2015) and Part of the 2nd Inter-Monsoon Season (October to mid-November 2015)	12th Monsoon Forum, DoM

Research students

PhD students

- Mr Keminda Herath of the Wayamba University completed his thesis titled "Non-conventional methods for modeling time series" under the supervision of Prof. S Samita and Dr (Mrs) Wasana Wijesuriya at the Postgraduate Institute of Agriculture, University of Peradeniya.

MSc students

The following students are working on their MSc studies at the Faculty of Agriculture, University of Ruhuna under the guidance of Dr (Mrs) Wasana Wijesuriya.

- Mr M W H Gayan is currently working on a research titled "Suitability of different drought indices under Sri Lankan conditions based on statistical considerations and practical use"
- Ms Sunetra Priyangika is focusing her research on "Developing a Growth Performance Index to evaluate the growth status of immature rubber plantations in Moneragala district"

Undergraduate students

- Mr Sangeeth Liyannaarachchi of the Wayamba University completed his undergraduate research study titled "Can we cultivate rubber in Northern Dry Zone of Sri Lanka: A case study on Vavuniya district using GIS approach" under the guidance of Dr (Mrs) Wasana Wijesuriya and Mr J K S Sankalpa.
- Mr M A V N Padmathilake from the Uva Wellassa University completed his undergraduate research study titled "Interference on tapping due to rainfall and effectiveness of rainguards under different rainfall scenarios: A case study in the Dartonfield rubber estate" under the guidance of Dr (Mrs) Wasana Wijesuriya.

- Mrs Chamali Siriwardene of the Faculty of Agriculture, University of Ruhuna completed her undergraduate research study on "Identification of rainfall anomalies in the Wet Zone rubber growing areas using the Standardized Precipitation Index (SPI)" under the guidance of Dr (Mrs) Wasana Wijesuriya.

RESEARCH

Developments, modifications and applications of statistical techniques for the rubber sector (BM/01/a&b)

Different activities are involved in this long term project. The objectives are to develop or modify statistical methods and to apply existing methods to suit experiments in the rubber sector to improve the accuracy and reliability of research findings. The activities conducted during the year under review are listed below.

Logit models for binary responses

Logit models can be used to describe impact of different variables on a binary response. During the year under review, a study was done to investigate the interference of tapping due to rainfall and effectiveness of rainguards under different rainfall scenarios employing rainfall data and tapping records in the Dartonfield estate.

Two rubber fields; one with rainguards and the other without rainguards from the Gallewatta division of Dartonfield Estate were selected for the study. Rainy days (with a rainfall greater than 1mm/day) during 2014 were selected for the study. Whether tapping was possible (1) or not (0) during these rainy days was used as the binary response (Y). The day is divided into 8 categories as given below.

Category	Time period (hrs.)
D1	06:00 to 09:00
D2	09:00 to 12:00
D3	12:00 to 15:00
D4	15:00 to 18:00
N1	18:00 to 21:00
N2	21:00 to 24.00
N3	24:00 to 03:00
N4	03:00 to 06:00

Predictor Variables used in the study were; X_1 = Period during which rain occurred, X_2 = Total duration of the rain (Minutes), X_3 = Season of the year (monsoon or inter-monsoon), X_4 = Total rainfall amount (mm), X_5 = Highest intensity of the rain during the day (mm/hr), X_6 = Intensity of the longest rainfall duration (mm/hr), X_7 = Whether rainfall is received during N4 and D1 periods or not (1 or 0), X_8 = Intensity

of the rain if X7=1 for N4 and D1 periods (mm/hr) and X_9 = Time duration of the longest rainfall event (Minutes).

Since Y is a binary response (tapped or not tapped), the proportion of success was considered. Instead of using a linear model for the dependence of the success probability on explanatory variables, the probability scale is first transformed from the range (0, 1) to (-∞, ∞). A linear model is then adopted for the transformed value of the success probability.

The study used a logit transformation as given below.

$$logit(p) = ln\left(\frac{p}{1-p}\right) = \text{Y}$$

$$ln\left(\frac{p}{1-p}\right) = \beta_\circ + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \cdots + \beta_9 X_9$$

Models were fitted for with and without rainguard situations.

Model for without rainguard situation

Y = -0.504 – 0.01205 Duration (X_2) – 0.0528 Intensity of the rain in N4 and D1periods (X_8)

Model for with rainguard situation

Y = -0.217 – 0.00283 Duration (X_2) – 0.0210 Highest intensity of the rain (X_5)

The graphical presentation is given in Fig. 1. The probability values are higher in with rainguard situation compared to the without rainguard situation. For instance, under the average rainfall duration, which is 139 minutes for this study, the possibility of tapping was 26% under with rainguard situation and it was 8% under without rainguard situation. This empirical information is useful in economic evaluation of using rainguards in the rubber sector.

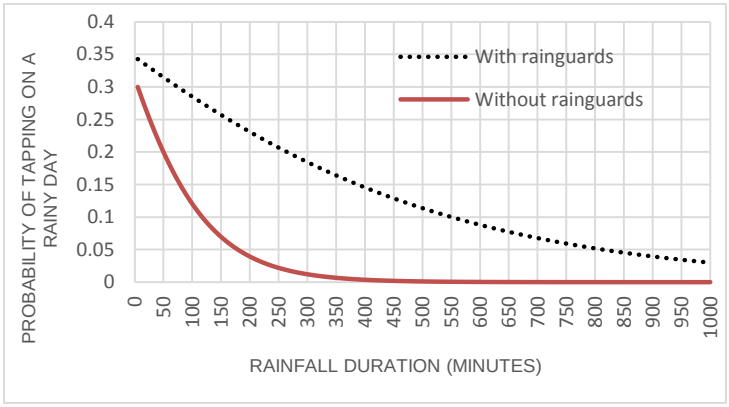


Fig. 1. Change in probability of tapping on a rainy day with the duration of rainfall under rainguarded and non-rainguarded situation
(Wasana Wijesuriya and M A V N Padmathilake (Research student)

Statistical approaches for GIS work

Geographic Information Systems (GIS) play a vital role where it acts as a decision support tool where spatial statistics is part and parcel of it. The main advantage of the GIS approach is that it provides capability of Multi Criteria Evaluation (MCE) *i.e.* to use a variety of digital data layers simultaneously and come-up with more realistic solutions. One particular approach commonly used to determine weights in MCE is through Analytical Hierarchical Process (AHP). It is a decision making tool to derive priorities through pair wise comparison of variables and where weights are determined based on a priority index. Biometry section involved with several collaborative GIS studies during this year, giving inputs on spatial modeling. The outputs of these studies are presented under the review of the Agricultural Economics Unit (Wasana Wijesuriya, J K S Sankalpa, Senani Karunaratne and Sangeeth Liyanaarachchi (Research student).

Research on climate change and variability (BM/02/a)

The objectives of this study are to assess the impact of climate change on the rubber sector, analysis of meteorological data in existing rubber areas and in potential areas for expansion of rubber and application of GIS in the rubber sector.

Identification of rainfall anomalies in the Wet Zone rubber growing areas using the Standardized Precipitation Index (SPI)

The main objective of this study was to illustrate the potential uses of SPI in identifying rainfall anomalies as a tool for better management of rubber plantations in rubber growing areas of the Wet Zone of Sri Lanka. The specific objectives were; a) to identify the rainfall behavior in rubber growing areas in the Wet Zone through descriptive analysis, b) to study the rainfall anomalies employing SPI for different time intervals considering the major operations; planting and establishment and harvesting of latex and c) to identify whether temporal changes in SPI are evident in rubber growing areas of the Wet Zone.

The analysis was confined to the stations listed in Table 1.

Table 1. *Details of the meteorological stations selected for the study*

District	Station	Agro-ecological zone
Colombo	Awissawella	WL3
Kalutara	Agalawatte	WL1a
Ratnapura	Ratnapura	WL1
Galle	Galle	WL2a
Matara	Mapalana	WL1b

SPI is a simple tool for identifying rainfall anaomalies (Please refer Annual Review of RRISL-2014 for details of analysis of SPI). The SPI time series for the selected locations were computed using the open source programme available from National Drought Mitigation Center (http://drought.uni.edu/monitor/spi/program/spi_program. htm). The SPI time scales selected for the study in relation to rubber growing is given in Table 2. Monthly rainfall data from 1980 to 2014 were used for the study.

Table 2. *Selected SPI timescales regarding the major operations*

Major operation	Considering time scale of SPI	Time period
Planting and Establishment	3	May-July
Harvesting of latex	3	August-October (High yielding) November-January (Peak yielding) February-April (Wintering) May-July (Post wintering)

Variation in 3 month SPI

May-July: Planting season of rubber

The 3 month SPI compares precipitation for 3 consecutive months with that recorded in the same 3 consecutive months in all previous years. Tables 3, 4 and 5 depict the years under different SPI categories which corresponds to planting of rubber, high yielding season of rubber and peak yielding season of rubber, respectively. Rest of the years which are not mentioned in Table 3 are in the near normal category of SPI (-0.99 to 0.99).

Table 3. *Drought and wet years in each station according to 3 month SPI (May-July) corresponding to planting season of rubber*

Station	Drought years			Wet years		
	Moderate SPI[-1 to -1.49]	Severe SPI[-1.5 to -1.99)	Extreme SPI[-2 & less]	Moderate SPI[1 to 1.49]	Severe SPI[1.5-1.99]	Extreme SPI[2 or more]
Agalawatta	1986,1996, 2000, 2001, 2002	1987	2012	1984,1993, 1995,1998, 2010	2008	-
Rathnapura	2000, 2005 2007	-	1986,1987 2012	1993, 1995, 1998, 2003	1982, 1989	-
Awissawella	2000	1986	1987,2012	1984,1989, 1995,1998, 2008	1982, 1985	-

Station	Drought years			Wet years		
	Moderate SPI[-1 to -1.49]	Severe SPI[-1.5 to -1.99)	Extreme SPI[-2 & less]	Moderate SPI[1 to 1.49]	Severe SPI[1.5-1.99]	Extreme SPI[2 or more]
Mapalana	1983,2000, 2005,2012	1987, 2001	1986, 2001	1982,1984, 1985,1988, 2010	1993	-
Galle	1986,1987, 2011	1980, 2001	2012	1995,2009	1992,1993, 2010	-

August – October: High yielding period of rubber tree

Table 4. *Drought and wet years in each station according to 3 month SPI (August to October) corresponding to high yielding period of rubber tree*

Station	Drought years			Wet years		
	Moderate SPI[-1 to -1.49]	Severe SPI[-1.5 to -1.99)	Extreme SPI[-2 & less]	Moderate SPI[1 to 1.49]	Severe SPI[1.5-1.99]	Extreme SPI[2 or more]
Agalawatte	1980,2001, 2013		1984,1990	1998,2006	1997,2014	
Rathnapura	1983,1984, 1991,2000, 2008		2013	1982,1986, 1993,2005		1997, 2014
Awissawella	1986		1984,1991,	1998,2006	1997,2014	
Mapalana	1983	1990,2001	1984	1994,2012	1987,2007	
Galle	1986,1990, 1993,2005	1984		1987	1994,1999, 2007,2012, 2014	1997

November – January: Peak yielding period of rubber tree

Table 5. *Drought and wet years in each station according to 3 month SPI (November to January) corresponding to high peak yielding period of rubber tree*

Station	Drought years			Wet years		
	Moderate SPI[-1 to -1.49]	Severe SPI[-1.5 to -1.99)	Extreme SPI[-2 & less]	Moderate SPI[1 to 1.49]	Severe SPI[1.5-1.99]	Extreme SPI[2 or more]
Agalawatte	1981,1987, 1994,2003	1989,1996				
Ratnapura	1988,1992, 1996,2008		2013	1985,1998, 2000,2010	1999	1983

Station	Drought years			Wet years		
	Moderate SPI[-1 to -1.49]	Severe SPI[-1.5 to -1.99)	Extreme SPI[-2 & less]	Moderate SPI[1 to 1.49]	Severe SPI[1.5-1.99]	Extreme SPI[2 or more]
Awissawella	1986, 1993, 2013	2003	1988	1980,2006, 2010	1983, 1997, 2005	
Mapalana		1981	1990	1983, 1998, 2000, 2010	2009	
Galle	1989, 2003	1994	1996	1982	1998, 2007	2010

The study is in progress to investigate the relationship with drought/wet years with latex yield in tapping blocks of the Dartonfield estate (Wasana Wijesuriya, Vidura Abeywardene and Chamali Siriwardene (Research student).

Rainfall partitioning in rubber plantations

A study was initiated in the latter part of 2015 to quantify different components of rainfall, *viz.* stem flow, through fall and interception by the rubber tree canopy. This information is scarce and important for ecological modeling studies. During the year under review, different types of collecting devices for stem flow were tested and recorded in a few trees as a pilot study. This study is in progress. A device used to measure the stem flow is depicted in Fig. 2 (Wasana Wijesuriya and Vidura Abeywardene).

Fig. 2. The devise used to measure the stem flow of rubber trees

Modeling rainfall using Markov chain models

This study is a continuation from last year and focused on the areas; *viz.* Agalawatta, Ratnapura and Avissawella in the Low Country Wet Zone (LCWZ). Rainfall totals for standard weeks from 1960 to 2013 were used for the study. According to the water requirement of rubber, a wet week is defined with a rainfall ≥20mm. Probability of a given week being wet when the previous was a wet week [P(W|W)] is an important criteria for various agronomic practices of rubber. Consequently, P(W|W) was calculated using the Markov process for the periods; 1960-1990 and 1991-2013. The standard weeks were categorized based on tendency for being wet; very low - $P(W|W)<0.25$, low - $0.25\leq P(W|W)<0.50$, high - $0.5\leq P(W|W)<0.75$ and very high - $P(W|W)\geq 0.75$ and subsequently used to compare the two time periods.

The major findings are listed below.

- The initial dry period (IDP) in Agalawatta before 1990 was from 1st to 9th week but continued up to the 13th week starting from the 52nd week of the previous year after 1990. The mid-year dry period (MDP) in this location extended from 31st to 37th week before 1990, but after 1990 it was not detected.
- In Ratnapura there exists a 16 week long IDP (49th week of the previous year to 12th week) after 1990, while before 1990, the IDP started from 51st week and extended till the 12th week.
- In Avissawella, the IDP started from the 50th week and extended to 12th and 13th weeks, respectively for the periods, before and after 1990. Within this 16 weeks dry spell after 1990, 11 weeks were observed with, $P(W|W)<0.25$, compared to 6 such weeks out of 15, before 1990. MDP in this location before 1990 (31st-36th week) is comparatively shorter than that of after 1990 (29th-37th week).

The above-mentioned phenomena are depicted in Fig. 3.

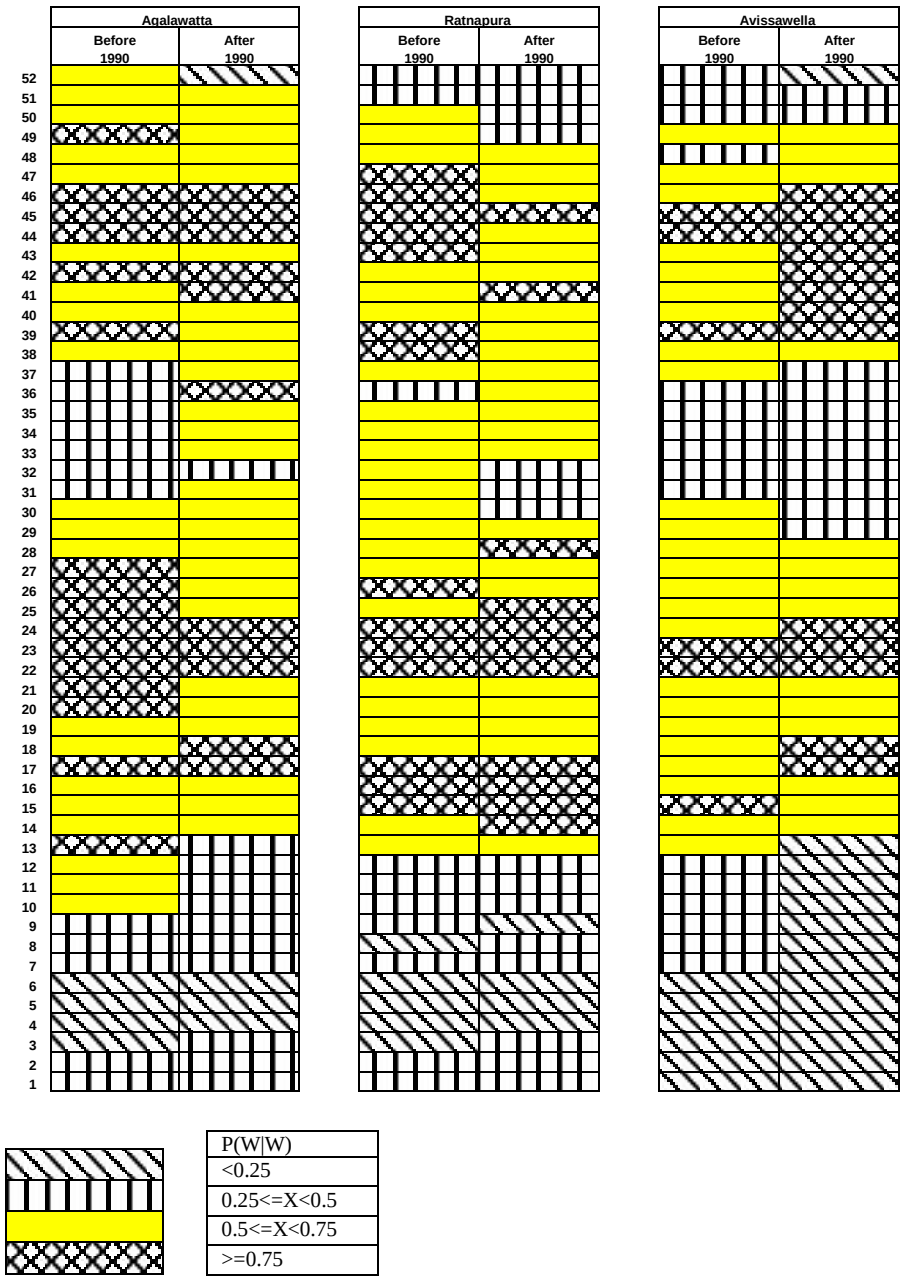


Fig. 3. Observed changes before and after 1990 in the selected locations (WasanaWijesuriya and W P Jeewanthi (Research student)

Collaborative research (BM/03/c)

Empowering rubber farmers in non-traditional rubber growing areas through knowledge on combating adverse impacts of environment for better productivity

This study is a collaborative project between Biometry Section, Advisory Services Department, Soils and Plant Nutrition Department and Wayamba University, funded by the National Research Council (NRC) of Sri Lanka. The project commenced in 2011 and was completed in December 2015. During the year estate and on-farm trials in smallholder lands were maintained and data on growth parameters were recorded and analyzed. Compilation of the final report is in progress (Wasana Wijesuriya and Vidura Abeywardene are involved in the project from the Biometry Section).

Assessing internal and external trade policies and practices affecting food security in Sri Lanka and identifying areas for improvement

This is a collaborative project between Biometry Section and the Wayamba University, funded by the National Science Foundation under National Thematic Research Programme (NTRP). The project commenced in 2013 and will be completed in 2016. Dr (Mrs) Wasana Wijesuriya is involved as a co-investigator and is responsible for the Objective 2 of this project, which is; modeling the behavior of food prices for major food items imported to, exported from and produced domestically in Sri Lanka. Further analysis on how different policies acted upon the price variations of essential commodities is in progress.

Indicator based identification and forecasting of droughts in Sri Lanka

This study is funded by NRC for 2 years commencing from September 2015. It is a collaborative study with 2 Universities; Peradeniya and Wayamba and 2 institutions; Natural Resources Management Centre (NRMC) and Department of Meteorology (DoM). Mr M W H Gayan is registered for a MSc under this project and is working on a research titled "Suitability of different drought indices under Sri Lankan conditions based on statistical considerations and practical use". This study is in progress and will continue up to August 2017 (Wasana Wijesuriya and J K S Sankalpa from RRISL, B L Peiris from University of Peradeniya, Keminda Herath from Wayamba University, B V R Punyawardene from NRMC and S Premalal from DoM).

Identification of parents for the development of core-collections of sugarcane for breeding for high yield and disease resistance

This study is funded by NRC for 3 years commencing from September 2015. It is a collaborative study with the Sugarcane Research Institute. Dr (Mrs) Wasana Wijesuriya is involved in this project as a statistical expert.

SERVICES

Statistical consultancy (BM/03/a)

Statistical consultancy is provided on designing of experiments and questionnaires, statistical analyses, designing and developing databases and interpretation of experimental results to the fellow scientists at RRISL and industry stakeholders on request (W Wijesuriya).

Developments in meteorological and agro-meteorological stations (BM/02/b)

Database management

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 (W Wijesuriya, C Munasinghe and V Abeywardene).

Maintenance and establishment of meteorological and agro-meteorological stations

The Meteorological station at the premises of Kuruwita substation was established and data collection was started during this year (W Wijesuriya and V Abeywardene).

Other involvements

- Mapping of rubber and tea lands using GIS techniques – RRI is also involved in this activity which is coordinated by MPI. Mapping is done by Land Use Policy Planning Department in collaboration with Survey Department. Mapping process was completed in Galle district during the year under review (Wasana Wijesuriya and J K S Sankalpa).

AGRICULTURAL ECONOMICS

J K S Sankalpa

DETAILED REVIEW

Staff

Mr J K S Sankalpa, Agricultural Economist was on duty throughout the year.

Seminars/Conferences/ Meetings/Workshops attended

Mr Sankalpa attended the following during the year under review.

Activity	Organization
Scientific Committee Meeting	Rubber Research Institute of Sri Lanka
Workshop on Agricultural statistical data compilation	Department of Census and Statistics Sri Lanka
Socio-economic committee meetings in Agriculture sector	Sri Lanka Council for Agricultural Research Policy, Ministry of Agriculture
Mapping of tea and rubber lands using GIS	Ministry of Plantation Industries/Land Use Planning
International conference on promoting Socio-Economic equity in South Asia: Challenges and prospects	National Science Foundation (NSF)

Services

Research support

Various cost-benefit and economic analyses were carried out on the request of other researchers.

Database management

A database on auction prices in Sri Lanka and International rubber prices were updated throughout the year. Agricultural Economics Unit analyzed the rubber price and rubber products exports performance in quarterly basis and presented the information to the industry as well as the plantation sector.

Rubber marketing in Sri Lanka

Colombo auction is the main mode of disposal of rubber manufactured in factories. Number of auctions conducted by Ceylon Chamber of Commerce under Colombo Rubber Traders' Association (CRTA) accounted for 93 during this year. All these were updated and recorded in a database.

Prices of Ribbed Smoked Sheets (RSS)

Monthly average of RSS1 and RSS3 are given in Figure 1(a) and 1(b), respectively. The highest average price of RSS1 was Rs.305.80, recorded in January. Prices of all grades of RSS were lower than that of the previous year (2014) throughout the year. Prices of all RSS grades have decreased by 9-13% from 2014 to 2015 due to poor demand prevailed for all grades of RSS caused by falling the International prices.

(a) (b)

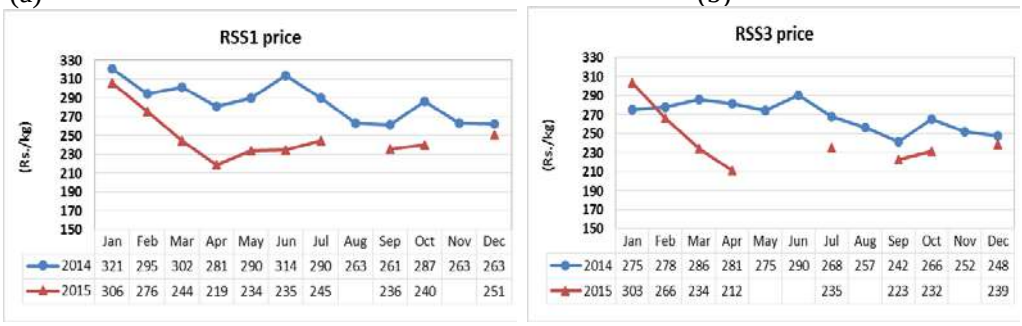


Fig. 1. Monthly average prices of RSS 1 (a) and RSS 3 (b) in 2014 and 2015

Prices of Latex Crepe (LC)

Prices of Latex Crepe 1X for 2014 and 2015 are shown in Figure 2. LC1X prices increased during the latter part of 2015 against the previous year. The gap in prices was higher during the first half of the year than the latter part of the year when compared to the previous year. The average LC1X price ranged from Rs.250 (March) to Rs.342 (October) during 2015. The average price of LC1X was Rs.301 which was a 3% reduction compared to the previous year.

Fig. 2. Monthly average of nominal LC1X price in years 2014 and 2015

Monthly changes of RSS 1 and LC1X from 2012 to 2015 are depicted in Fig. 3. Monthly average of LC1X and RSS1 reached the highest in April 2012. The price differences between the LC1X and RSS1 were higher in year 2015.

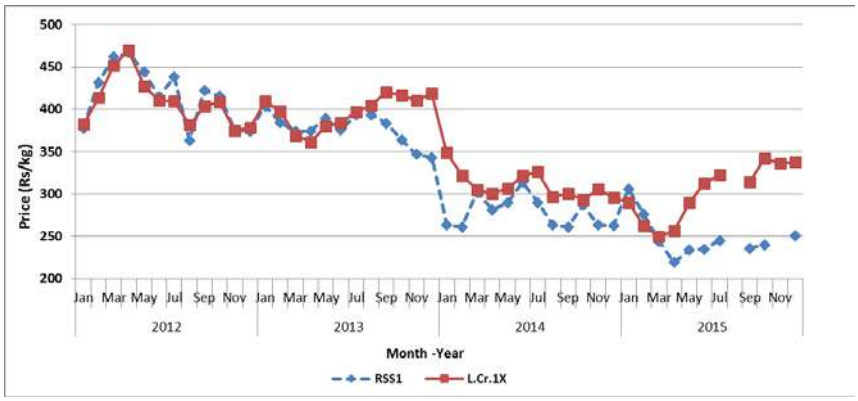


Fig. 3. Monthly nominal average prices of LC1X and RSS 1

Research

The following studies were conducted in the year 2015.

Estimation of Cost of Production in rubber smallholder sector (AE/01/b)

The cost of production (COP) is a key factor which determines the economic viability of a particular firm. This study aims to investigate the variation in COP for different activities that take place during the immature period and mature period, change in COP with different production processes and how to minimize the COP in various steps. Agricultural Economics Unit conducted an island wide survey covering all the main rubber growing districts in Sri Lanka. Data were collected by the Regional Extension Officers in the respective districts. The sample survey was completed by the end of 2015. Collected data were analyzed and the survey has to be continued for the year 2016 covering a large sample in the key rubber growing areas. Average cost of production in RSS processing was Rs.153.85 per kg as at end of the year 2015 based on the sample survey, meanwhile the Average COP in Latex harvesting was 123.20 per kg. Tapping cost was the largest item of the COP break down and it was about 57% in RSS processing. Summary of the analysis is shown in Figure 4 (J K S Sankalpa, Wasana Wijesuriya and O V Abeywardana).

a) Cost incurred up to harvesting of Latex **b).** Cost incurred up to processing of RSS

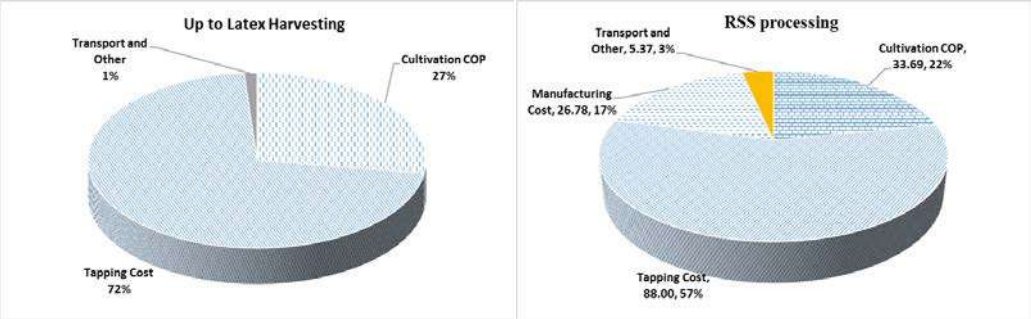


Fig. 4. Breakdown of COP as Rs./kg and share percentage of each category in the smallholder sector **a)** cost incurred up to harvesting of latex and **b)** cost incurred up to processing of RSS

Analysis of financial viability of rubber planting in traditional rubber growing areas in Sri Lanka (AE/03/e)

Agricultural Economics Unit conducted an analysis on financial viability of Rubber cultivation in traditional rubber growing areas. This study was focused on input costs and benefit generated during the cultivation and processing based on actual data available in the Dartonfield estate. Sensitivity analysis results have shown that Net Present Value (NPV) was positive at 10% Discount Rate (DR) and it was about Rs.800,000 per hectare of land. Benefit Cost Ratio (BCR) was 1.31 at 10% discount rate while the payback period for compensate the initial investment was about 13 years from planting rubber in the land and Internal Rate of Return (IRR) was 29.64 (Table 2).

Table 2. *Financial analysis of rubber cultivation in Dartonfield estate RRSIL*

Sensitivity analysis	10% D.R.	15% D.R.	25% D.R.	50% D.R.
Sum of Present Value of Income ***(PVB)***	3,404,593	2,118,287	950,821	218,976
Sum of Present Value of Costs ***(PVC)***	2,604,096	2,006,423	1,444,881	1,048,686
Net Present Value = ***(PVB-PVC)***	**800,498**	**111,865**	**-494,060**	**-829,710**
Benefit/Cost ratio ***(BCR)***	**1.31**	**1.06**		

Assumption for analysis: Net Sales Average of L.Cr.1X (Rs. 380/kg)

Analysis of productivity of rubber lands in Kalutara district (AE/03/b)

Low productivity has been a big challenge in rubber plantations in the country in recent years. Focusing on this problem, Agricultural Economics Unit and Biometry section have conducted a study to estimate productivity of rubber lands in Kalutara District employing primary data of a survey conducted by the Advisory Services Department in 2014. The objective of this study was to identify spatial variation in productivity and to present the results using Geographic Information Science (GIS). The productivity of smallholder sector in Kalutara district varied from 718 to 1666 kg/ha/year (Table 3), while the highest productivity was recorded in the Horana and Palindanuwara Divisional Secretariat (DS) divisions. Low productivity values were recorded in Bandaragma, Ingiriya and Matugama DS divisions (Fig. 5). Average productivity is related to the mature extent of those areas as well as the management of lands and environmental and physiographic factors in the lands. The yield curve developed from the data revealed that the high yielding period of rubber lands was observed during the age class from year 10 to 19 in the district. Productivity Variation explained by the age class distribution was modeled by the geographically weighted regression and subsequently model parameters were developed for the Kalutara district (J K S Sankalpa and Wasana Wijesuriya).

Table 3. *Average productivity variation in Kalutara district*

DS Divisions	Minimum	Maximum	Mean	Standard deviation
Agalawatta	1050	1264	1158	53.8
Bandaragama	774	1137	1013	79.2
Beruwala	1154	1429	1254	71.8
Bulathsinhala	1041	1336	1209	65.4
Dodangoda	1053	1484	1252	92.2
Horana	718	1666	1194	204
Ingiriya	997	1163	1092	45.8
Kalutara	982	1623	1242	180
Madurawala	1061	1212	1157	32.7
Matugama	1049	1258	1127	43.5
Millaniya	785	1267	1093	123.2
Palindanuwara	1024	1554	1268	118
Panadura	1046	1155	1112	29.2
Walallawita	1108	1253	1177	38

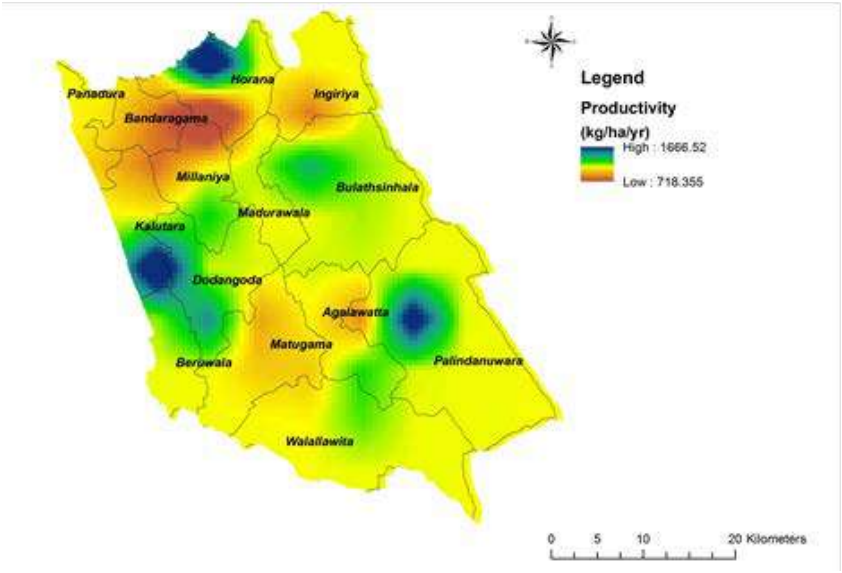


Fig. 5. Predicted productivity raster map for the Kalutara district

Ecological and economic suitability of rubber cultivation in non-traditional Areas in Sri Lanka (AE/03/b)

Agricultural Economics Unit and Biometry section extended their research on examination of resource quality and accessibility for rubber farming in Sri Lanka using multi criteria and GIS approach of land suitability evaluation. The aim of this multi criteria evaluation with Geographical Information Systems (GIS) is to provide more flexible and effective mechanism to the decision makers for efficient planning and management in rubber farming. Analysis was based on Land evaluation in Vavuniya district. It has been identified that about 19,750 ha of moderately suitable lands are available in the Vavuniya district (Fig. 6). Identified land areas were depicted in Table 4 (Wasana Wijesuriya and J K S Sankalpa).

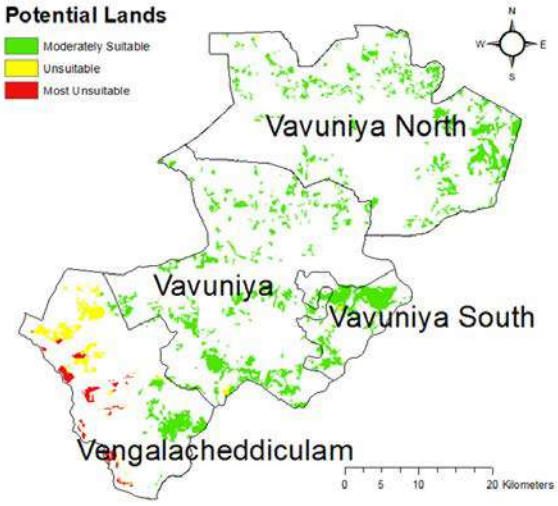


Fig. 6. Potential lands for the rubber cultivation in Vavuniya district

Table 4. *Potential land extent for rubber cultivation in Vavuniya district*

DS divisions	**Extent under each suitability class (ha)**		
	Moderately suitable	Unsuitable	Most unsuitable
Vavuniya	7,530	92	-
Vavuniya North	6,990	22	-
Vavuniya South	3,150	49	-
Vengalacheddikulam	2,081	2,090	1,044
Total	19,751	2,253	1,044

Table 1. *Monthly auction prices of rubber in year 2015*

Month	**RSS prices (Rs.)**					**Latex Crepe prices (Rs.)**					**Scrap Crepe prices (Rs.)**			
	RSS1	**RSS2**	**RSS3**	**RSS4**	**RSS5**	**LC1X**	**LC1**	**LC2**	**LC3**	**LC4**	**1Xbr**	**2Xbr**	**3Xbr**	**4Xbr**
Jan	305.80	296.56	303.33	267.67	258.00	289.94	284.60	263.50	229.50	205.58	196.00	185.00	180.50	171.25
Feb	275.75	277.17	266.00	246.25	243.00	262.50	258.60	228.43	211.13	199.79	190.25	175.00	156.40	151.93
Mar	244.30	239.00	234.00	232.75	217.50	250.00	241.29	225.14	211.13	186.25	176.00	163.33	150.97	146.13
Apr	219.20	217.20	211.50	208.00	203.00	256.36	222.29	226.14	215.71	177.50	166.33	157.67	152.92	146.50
May	233.67	-	-	222.50	-	289.43	280.75	268.38	245.88	188.56	170.43	162.88	167.50	155.75
Jun	235.00	-	-	-	-	312.67	306.14	285.14	266.86	218.00	189.71	175.29	177.96	170.14
Jul	245.00	235.77	235.00	225.00	-	322.50	320.00	297.71	278.29	225.33	207.86	196.50	190.30	178.39
Aug	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sep	236.00	229.50	223.00	-	-	314.01	310.14	300.14	289.29	197.07	190.00	185.90	186.83	179.21
Oct	240.00	235.60	231.50	220.00	-	342.13	338.57	326.07	311.43	197.00	191.33	188.25	185.64	180.43
Nov	-	244.50	-	220.00	-	335.72	331.86	319.21	304.29	195.57	189.07	187.67	185.00	180.00
Dec	250.75	249.00	239.00	225.50	-	337.40	336.00	313.86	287.21	184.80	180.67	178.67	178.38	175.25
2015 average	**248.55**	**247.14**	**242.97**	**229.74**	**230.38**	**301.15**	**293.66**	**277.61**	**259.15**	**197.77**	**186.15**	**177.83**	**173.85**	**166.82**

LIBRARY AND PUBLICATION

S U Amarasinghe

DETAILED REVIEW

Staff

Mr S U Amarasinghe, Librarian, Mrs Ramani Amaratunga, Library Assistant and Assistant Publication Officer, Mr P M Prema Jayantha, Miss S R Sinhabahu (up to 15/10/2015), Management Assistants, Mr N W E C Maduranga, Management Assistant (Colombo Library) and three Library Attendants were on duty during throughout the year.

Seminars and Workshops

The Librarian attended the following events.

- The AGM of the Sri Lanka Library Association
- Two AGRINET Advisory Committee Meetings at CARP Office
- The progress review seminar on National Digitization Project

Publications

The following RRISL regular publications and advisory leaflets were published during the year.

- Annual Review 2012
- Annual Review 2013
- Annual Report 2013
- RRISL Journal Vol.93 (2013)
- RRISL Journal Vol.94 (2014)
- රබර් වගාවට පොහොර යෙදීම
- කිරි කැපීම හා වැහි ආවරණ භාවිතය
- රබර් ආශ්‍රිත ගොවි නිෂ්පාදන (සිංහල හා ඉංග්‍රීසි)
- පාංශු සංරක්ෂණය (සිංහල හා ඉංග්‍රීසි)
- බද්ධ අතු තවාන් පාලනය (සිංහල හා ඉංග්‍රීසි)
- දුම්ගැසූ ෂීට් රබර් නිෂ්පාදනය (සිංහල හා ඉංග්‍රීසි)

List of books purchased during the year

	Title	Publisher	Year of published
01	Pesticide toxicology and international regulation	John Wiley	2004
02	Molecular identification of fungi	Springer – Verlag	2010
03	Smart land- use analysis: the LUCIS model	ESRI Press	2007
04	Agricultural marketing and price analysis	Prenkce Hall	2008
05	Vogel's textbook of quantitative chemical analysis: 6th ed.	Pearson	2009
06	Climatic change and plant abiotic stress tolerance: Vol.1&2	Wiley	2014
07	Formulation of microbial biopesticides, beneficial microorganisms, nematodes and seed treatments	Kluwer	1998
08	Ecology of saprotrophic basidiomycetes	Elsevier	2008
09	Trichoderma and gliocladium: Vol.2 – enzymes, biological control and commercial applications	Taylor & Francis	1998
10	Natural rubber: from the Odyssey of the hevea tree to the age of transportation	Rapra Technology Ltd	2011
11	Legislative Enactments of the Democratic Socialist Republic of Sri Lanka Vol. 1-20	Government of the Democratic Socialist Republic of Sri Lanka	1980
12	Proceeding of 14th Agricultural Research Symposium, 25th June, 2011	Wayamba University of Sri Lanka	2015
13	Sri Lanka Socio - Economic Data, 2015	Central Bank of Sri Lanka	2015
14	Statistical information on plantation crops – 2013	Ministry of Plantation Industries	2015
15	A python primer for Arc GIS Work book, Vol.1 & 2	Jennings, Nathan	2015
16	Lehninger principles of biochemistry: 6th ed.	W H Freeman	2012
17	Introduction to genetics : a molecular approach	Garland Science	2015
18	Statistical methods in biology: design and analysis of experiments and regression	CRC Press	2015
19	Microbial strategies of crop improvement	Springer	2009
20	Standard methods for the examination of water and wastewater	American Public Health Association	2012

Information services

Computerized bibliographic data up to the year 2015 were sent to the National Library of Sri Lanka and (CARP Library for Compilation of the National Union Catalogue and the National Agricultural Bibliography. The resource sharing activities were continued among the AGRINET Libraries as usual. Five literature surveys on rubber were done using CD-ROM databases available at CARP and PGIA Libraries.

DARTONFIELD GROUP

P A Lukshaman

DETAILED REVIEW

Mr P A Lukshaman Senior Estate Manager, Mr K K P Gunawardena Acting Chief Clerk, Mr T D Harsha, Mr M N S Pavinda Management Assistants, Mr Dinesh Achinda Acting Rubber Factory Officer, Mr B M Siriwardena Field Officer and Mr K A Sarath Kumara, Mr Jagath Nakandala and Mr N L D Premechandra Junior Assistant Field Officers were on duty throughout the year. Mr Ajith Basil Nakandala, Field Officer of Gallewatta Division passed away on 29th June 2015.

The Group cadre stood as follows at the end of the year.

Senior staff	1
Assistant staff	8
Minor staff	4
Total	**13**

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	32.21	121.26	27.81	181.28
Immature area	4.14	22.80	15.13	42.07
Cinnamon under power line	0.80	-	-	0.80
State land take in	0.27	-	-	0.27
Nurseries	7.27	2.62	2.00	11.89
Paddy/Deniya land	0.75	1.22	1.22	3.19
Waste land	0.19	0.18	-	0.37
Earth slipped area	4.88	1.26	-	6.14
Jungle	0.80	0.50	1.03	2.33
Rocky areas	2.14	7.02	3.04	12.20
Roads	2.92	6.86	0.36	10.14
Building	16.92	5.43	7.79	30.14
Play ground	1.00	-	-	1.00
Proposed replanting area	-	15.20	12.69	27.89
Streams	-	-	2.17	2.17
Grand total	**74.29**	**184.35**	**73.24**	**331.88**

Rainfall

The annual rainfall recorded for the year was 4014.5 mm with 210 wet days (Table 2).

Table 2. *Annual rainfall and wet days of the group for last five years*

	2011	2012	2013	2014	2015
Rainfall (mm)	3,394.6	3622.6	3565.4	4568.6	4014.5
Wet days	191	195	207	199	210

Crop

A total crop for 161,670 kg have been harvested against the estimated crop of 200,688 kg which is a decrease of 39,018 kg (19 %) (Table 3).

Table 3. *The crop and YPH (kg) Dartonfield group from 2011to 2015*

Hect.	2011		2012		2013		2014		2015	
	181.61		174.85		169.03		179.32		181.28	
Division	Crop	YPH	Crop	YPH	Crop	YPH	Crop	YPH	Crop	YPH
Dartonfield	29,451	770	34,092	891	29,451	770	28,885	897	26,878	834
Gallewatta	130,425	1,043	125,789	1,091	130,425	1,043	115,248	952	109,247	901
N'kele	24,720	1,355	31,709	1,488	24,720	1,355	28,682	1,101	25,545	919
Group total	184,596	1,016	191,590	1,096	184,596	1,016	172,815	964	161,670	892
Group estimate	190,000	1,046	187,150	1,070	190,000	1,046	199,296	1,111	200,688	1,107

Tappers productivity

The average IPT during the last five years are given in Table 4.

Table 4. *The average IPT (kg.) of Dartonfield group from 2011 to 2015*

	2011	2012	2013	2014	2015
Dartonfield	5.6	6.2	6.2	5.5	5.6
Gallewatte	9.3	9.1	8.7	6.9	7.2
Nivitigalakele	8.1	8.1	7.6	7.0	7.2
Group average	8.2	8.3	8.0	6.6	6.9

Tapping days

Annual break down of Normal tapping (NT), Late tapping (LT), Double tapping (DT) and No tapping of Dartonfield estate is given in Table 5.

Table 5. *Average number of tapping days of Dartonfield group during last five years*

	2011	2012	2013	2014	2015
Normal tapping	216	229	216	219	204
Late tapping	15	14	28	11	12
Cash/Double tapping	(11)	(13)	(18)	(21)	(23)
No tapping	72	54	56	55	79
Rainguard tapping	62	68	61	80	70
Slight rain	-	01	01	-	-

Total number of tapping days have decreased over the previous year.

Rainguard

Total of 96.43 hectares were rainguarded during the year and an additional crop of 27,852 kg was harvested which amounts to 17% of total harvested crop. Additional tapping days done due to rainguard during the year from D/F 59, G/W 73 & N/K 79 respectively. Profit generated due to rainguard Rs.1.93 million and profit per hectare Rs.10,679.57 (Table 6).

Table 6. *Additional income generated by fixing rainguards (Rs./kg)*

	Dartonfield Division	Gallewatta division	Nivithigalakale division	Total
Hectare	17.58	54.66	24.17	96.41
No. of rainguard fitted	4,611	15,610	7283	27504
Additional crop	3,383	18,953	5516	27852
Rainguard cost per kg.	53.03	32.20	40.02	36.28
Tapping cost per kg	113.04	113.04	113.04	113.04
C.O.M. Rs./kg	36.43	36.43	36.43	36.43
Total Cost Rs/kg	202.50	181.67	189.49	185.75
N.S.A. Rs./kg	255.26	255.26	255.26	255.26
Additional profit Rs./kg	52.76	73.59	67.77	69.51
Additional profit from rainguard	178,487.08	1,368,258.89	373,819.32	1,935,992.52
Additional profit per hectare	5,541.35	11,283.67	13,441.90	10,679.57

Total profit and profitability per hectare

The total loss and loss per hectare were Rs.2,475,167.70 and Rs.13,653.84 for the year under review (Table 7).

Table 7. *Comparative statement of the revenue profit per kg and profit per hectare*

	Years				
	2011	**2012**	**2013**	**2014**	**2015**
Mature area (ha.)	181.61	174.85	169.03	179.32	181.28
Total profit (Rs.)	51,814,251.24	32,020,436.70	15,071,788.05	1,987,373.99	(2,475,167.70)
Profit per ha. (Rs.)	285,305.06	183,130.89	89,166.35	11,082.83	(13653.84)

Cost of production and productivity

Table 8. *Labour rates and break down of cost of production from 2011 to 2015(Rs./kg.)*

	2011	**2012**	**2013**	**2014**	**2015**
1. Labour wages	Jan/Mar 447.75 Apr/Dec 572.00	572.00	572.00	687.50	687.50
2. Cost of production	228.96	216.33	262.39	245.06	270.57
2.1 Tapping	76.72	84.64	100.94	118.61	113.94
2.2 Manufacture	28.89	35.66	35.68	35.82	36.43
2.3 General charges	103.43	75.02	102.26	74.49	103.07
2.4 M/area upkeep	19.92	20.91	23.51	16.14	17.13
3. N.S.A.	509.65	383.36	348.74	256.56	255.26
4. Profit per kg	72.38	167.13	86.35	11.50	(15.31)

Manufacture

Out of the latex crop of 144,811 kg harvested, 107,434 kg has been sent as No.1 which is 73%. Details are given in Table 9.

Table 9. *Summary of grades manufactured during the year*

Grade	**Quantity (kg.)**	**Percentage %**
Latex crepe No.1	107,434	73
Latex crepe No.2	9,295	07
Latex crepe No.3	27,782	20
Total	**144,811**	**100**
Scrap crepe No. 1	12,702	75
Scrap crepe No.2	3,654	22
Scrap crepe No.3	503	03
Total	**16,859**	**100**
Grand total	**161,670**	**-**

KURUWITA SUB – STATION

S A R Samarasekera

DETAILED REVIEW

Staff

Mr S A R Samarasekara, Manager (Estate), Mr D S Jayasinghe, Mr K D P Senarathne, Management Assistants, Mr K K S Dinesh and Mrs E P S L Erawwala Field Supervisors were on duty throughout the year.

The estate cadre stood as follows at the end of the year.

Intermediate Staff	- 01
Assistant Staff	- 02
Minor Staff	- 02

Hactarage

A summary of the hectarage is given in Table 1.

Table 1. *Land distribution (ha) in Kuruwita Sub - station*

Land type	Extent (ha.)
Mature area	73.26
Immature area	8.90
Nurseries	2.25
Tea area	3.49
Paddy	1.00
Buildings, Gardens and Road	10.23
Water Tank	0.01
Unsuitable for planting	0.86
Total	**100.00**

Crop

A total crop of 100,170 kg was harvested from an extent of 73.26 hectares during the year. The crop harvested for the year was 99% of the estimated crop of 101,000 kg for the year.

The yield per hectare (YPH) for the past five years are given in the Table 2.

Table 2. *Yield per hectare for the past five years*

YPH (kg)	Year				
	2011	**2012**	**2013**	**2014**	**2015**
Estimated	1,471.14	1,474.26	1,366.26	1,419.82	1,378.65
Actual	1,497.03	1,403.03	1,410.77	1,378.34	1,367.32

The yield per hectare recorded (kg) for each month during the year is given in Table 3.

Table 3. *Monthly yield per hectare (kg) for the year*

Month	YPH (kg)
January	141.6
February	82.9
March	124.2
April	83.2
May	104.0
June	114.0
July	119.5
August	109.4
September	108.0
October	115.4
November	120.6
December	144.0

Tapper productivity

The average intake per tapper at the end of the year was 8.9 kg. The average IPT during the last five years are given in Table 4.

Table 4. *The average intake per tapper (IPT) (kg) for the last five years*

	Year				
	2011	**2012**	**2013**	**2014**	**2015**
Intake per tapper (kg)	8.9	8.9	8.7	8.9	8.9

Rainfall

The annual rainfall recorded during the year was 4,002.14 mm with 251 wet days and the data for the past five years are given in Table 5.

Table 5. *Annual rainfall figures and the number of wet days of the estate for the past 5 years*

	Year				
	2011	**2012**	**2013**	**2014**	**2015**
Rainfall (mm)	3,597.50	4,411.40	3,817.80	5093.10	4002.14
Wet days	105	150	174	239	251

Tapping days

There were 348 tapping days recorded during the year (Table 6). This was possible merely due to the use of rainguards.

Table 6. *The Average number of tapping days of the Kuruwita Sub Station for the last five years*

	Year				
	2011	**2012**	**2013**	**2014**	**2015**
1.Total tapping days	**346**	**342**	**338**	**335**	**348**
1.1 Normal	331	320	327	282	314
1.2 Late	11	22	11	38	32
1.3 Rain Interference	04	-	-	15	02
1.4 Rainguarded tapping	(105)	(77)	(95)	(131)	(140)
1.5 Recovery tapping	(10)	(05)	(12)	(08)	(08)
2. No tapping	19	24	27	30	17

The number of total tapping days have increased by 13 days over the previous year.

Rainguards

Due to the use of rainguards, an additional 140 tapping days were recorded in the year, which contributed to 37% of the total crop yielding an additional profit of Rs.3,478,886.28.

The performance of the use of rainguards for the last two years are given in Table 7.

Table 7. *Additional income generated by use of rainguards (Rs/kg)*

	Year	
	2014	**2015**
Hectarage (ha.)	62.34	71.00
No. of raiguards fitted	18,421	21,890
Additional tapping days	131	140
No. of kilos harvested	36,275	36,837
Raiguard cost per (kg.)	27.65	25.65
Tapping cost (Rs./kg.)	87.81	87.77
Total cost (Rs./kg.)	115.46	113.42
N.S.A (Rs./kg.)	251.92	207.86
Additional Profit (Rs./kg.)	136.46	94.44
Additional profit from rainguards (Rs.)	4,950,086.50	3,478,886.28
Additional profit per hectare (Rs.)	79,404.65	48,998.39

Total profit and profitability per hectare

The total profit and profit per hectare were Rs.1,667,830.50 and Rs.22,765.91 respectively for the year 2015.

Table 8 gives a comparative statement of the mature extent, total profit and profit per hectare for the last five years.

Table 8. *Comparative statement of the mature extent, total profit and profit per hectare for the last five years*

	Year				
	2011	**2012**	**2013**	**2014**	**2015**
Mature extent (ha.)	68.79	71.29	74.29	71.84	73.26
Total profit (Rs.)	29,545,248.90	18,760,063.36	15,975,578.58	5,339,158.40	1,667,830.50
Profit per hectare (Rs.)	429,499.18	263,151.40	215,043.46	74,320.13	22,765.91

The total profit and profit per hectare were Rs. 1,667,830.50 and Rs.22,765.91 respectively for the year 2015. This is a decrease of Rs. 3,671,327.90 and Rs. 51,554.22 respectively when compared with the last year, which is due to low N.S.A.

Cost of production and productivity

Labour rates and the breakdown of cost of production for the past five years are given in Table 9.

Table 9. *Labour rate (Rs.) and the break down of the cost of production from 2011 to 2015 (Rs./kg.)*

	Year				
	2011	**2012**	**2013**	**2014**	**2015**
Labour rate	572.00	572.00	687.50	687.50	687.50
Cost of production	155.94	178.69	187.19	198.00	191.21
Tapping cost	73.32	79.49	90.44	96.70	87.77
Manufacturing	-	-	-	-	22.14
General chargers	64.46	77.13	74.55	79.58	64.72
Field & cultivation cost	18.15	22.07	22.20	21.72	16.58
N.S.A	442.84	366.21	339.62	251.92	207.86
Profit per kg	286.90	187.52	152.43	53.92	16.65

Nursery

Total No. of 3375 young budding plants were sold to the smallholders during the year and the income generated was Rs.236,250.00.

Meteorological Summary
Dartonfield Station

Wasana Wijesuriya

During the last 16 years, an average annual rainfall of 4,138 mm was observed in the Dartonfield meteorological station located in the Agro Ecological Region, WL_{1a}. Out of the 16 years since 2000, 4,000 mm value was exceeded in 8 occasions (Fig. 1). Rainfall in 2015 exceeded the average (4,072 mm) and recorded a total rainfall of 4,168 mm which is accounted for a decline of 16% compared to the previous year.

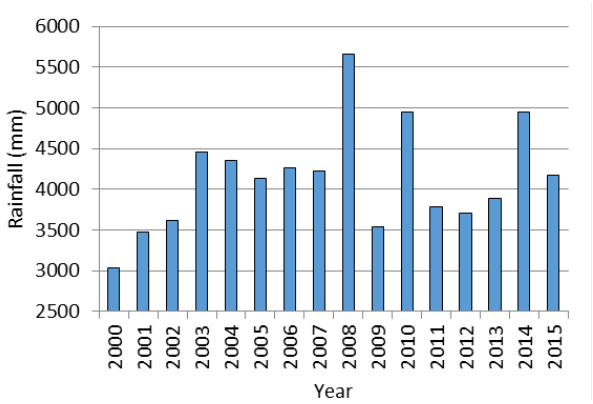


Fig. 1. Variation in annual rainfall at Dartonfield

As indicated in Fig. 2 the rainfall distribution at Dartonfield during this year departed from the usual pattern. Distribution of rainfall in different seasons at Dartonfield is given in Fig. 3. Rains during the South West season (May – September) decreased by 621 mm. Rainfall during IM1 (March & April) in 2015 is about 137 mm higher than the previous year. During North East and IM2 seasons, 2015 recorded lower values; *viz.* 95 mm and 112 mm, respectively compared to 2014.

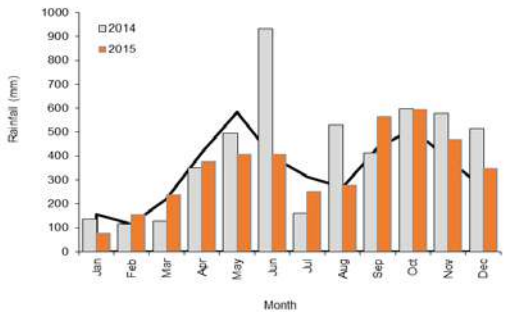


Fig. 2. Distribution of monthly rainfall in 2014 and 2015 at Dartonfield (The line chart indicates the long-term average)

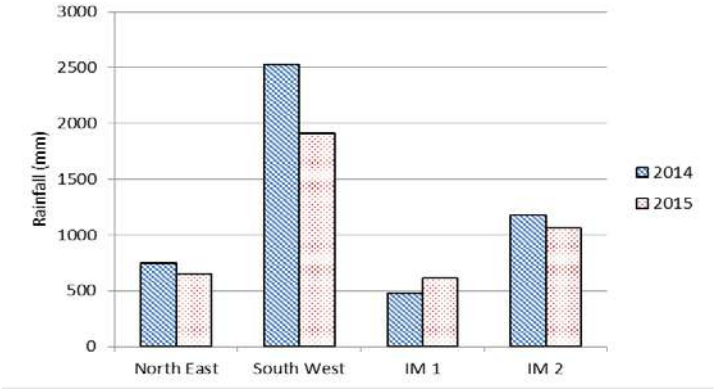


Fig. 3. Seasonal distribution of rainfall at Dartonfield in 2015

Below average monthly rainfall values were observed in January, April, May and July while above average values were recorded in September to December. In the rest of the months, the rainfall received was very close to the long term average. The minimum monthly rainfall of 76 mm and the maximum monthly rainfall of 594 mm were recorded in January and October, respectively.

The distribution of weekly rainfall is illustrated 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 349 mm was observed in the 42nd standard week, which coincided with the 3rd week of October.

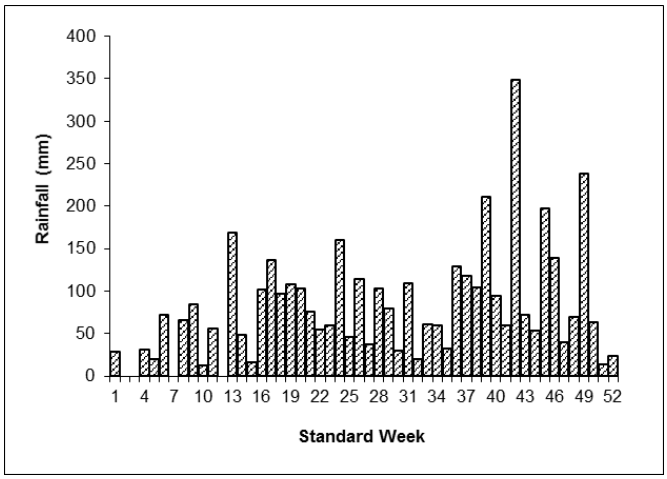


Fig. 4. Weekly variation in rainfall in 2015

There were 3 rainfall events that exceeded the hazardous limits for land slides (100 mm of rainfall during a day) reported during the year under review. The amount of rainfall and number of rainy days under low, moderate and high rainfall categories are listed in Table 1. The observed total number of rainy days of the year was 248, which exceeded the long term average (222) by 26 days. A dry spell lasted over a month or more can have adverse impacts on rubber plantations. There were only 3 dry spells greater than or equal to 7 days; the longest being 17 days, from 7th to 23rd January. The details of other dry spells are given below.

Details of dry spells at Dartonfield

Period	No. of days
7th to 23rd January	17
12th to 21st February	10
18th to 25th March	08

Rainfall at RRISL Substations

There are three substations maintained by RRISL in Kuruwita (WL_{1a}), Narampola (IL_{1a} bordering WL_{2b}), Moneragala (IL_{1c}) and Nivithigala Kele (WL_{1a}). A total rainfall of 4161 mm, 2817 mm, 2151 mm and 3651 mm were recorded respectively, in Kuruwita, Narampola, Moneragala and Nivithigalakele stations during 2015.

Distributions of monthly rainfall at Kuruwita, Narampola. Moneragala and Nivithigalakele are illustrated respectively in Fig.5 (a), (b), (c) and (d). The rainfall received in Kuruwita, Narampola and Nivithigalakele stations recorded decreases of nearly 17%, 2% and 10% in annual rainfall compared to the previous year, respectively. The annual rainfall in Moneragala recorded an increase of 42% over the last year.

Other meteorological parameters

Table 2 depicts the monthly values of some important meteorological observations together with averages from 1980 to 2005 at Dartonfield. Daily fluctuations of the minimum and maximum temperatures at Dartonfield are illustrated in Fig. 6. During the year under review, the minimum temperature dropped below 20^0C in 2 days; 1 day each in January and February.

The daily average temperature pattern was fairly steady with a mean annual temperature of 27.5^0C and standard deviation of 0.8 which could be a favourable condition for rubber plantations. The lowest mean minimum temperature of 21.1^0C was observed in January and February while the highest mean maximum temperature of 33.2^0C was observed in March. However, any signs of adverse conditions with respect to the temperature regime at Dartonfield were not reported during the year.

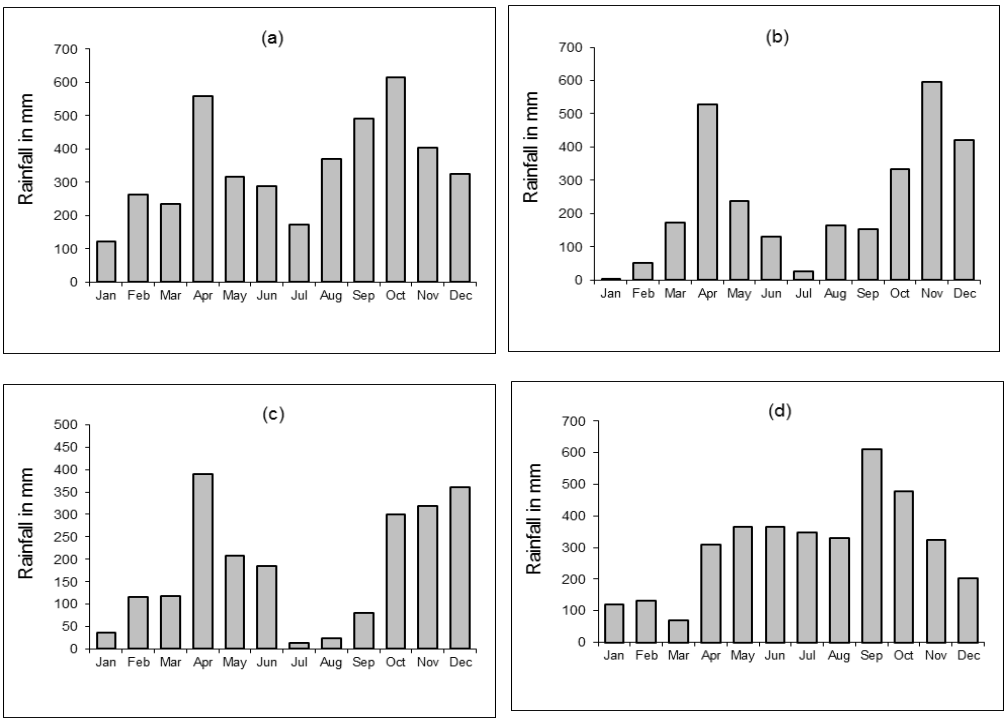


Fig. 5. Distribution of monthly rainfall in (a) Kuruwita and (b) Narampola (c) Moneragala and (d) Nivithigalakele

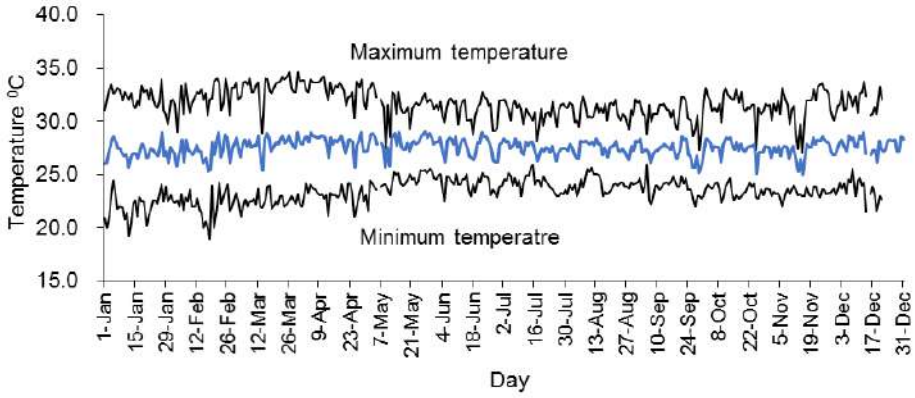


Fig. 6. Daily minimum, maximum and average temperature distributions

A total of 1828 bright sunshine hours was received at an average rate of 5 hr/day which was comparatively higher than the respective figures observed during

the last year. The distribution of bright sunshine hours during the year is depicted in Fig. 7. Bright sunshine hours exceeded 6 in 43% of the days, while in 37% 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 2015 was observed in the range, 70% to 99 %. The mean RH values recorded at 08:30 and 15:30 were 88% (SD=5.6) and 80% (SD=12), respectively. Monthly values of soil temperatures recorded at 08:30 and 15:30 hrs in 4 different depths are depicted in Figs. 8 and Fig. 9.

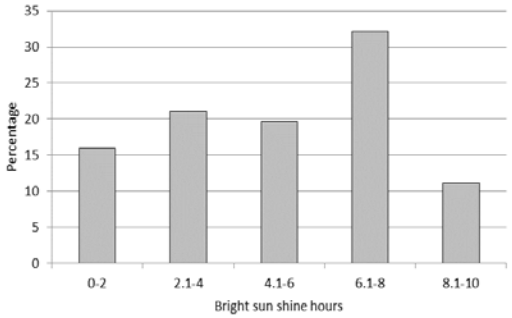


Fig. 7. Distribution of bright sunshine hours in 2015

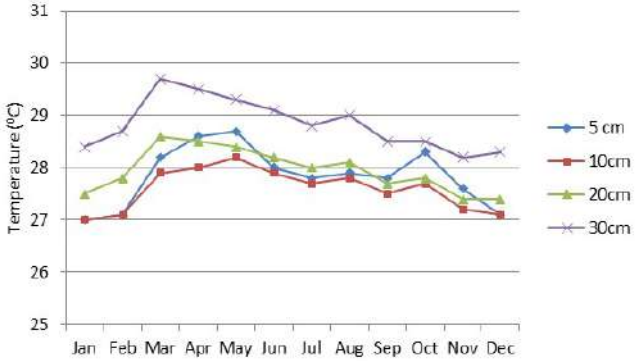


Fig. 8. Distribution of soil temperature records at 4 different depths at 08:30 hrs

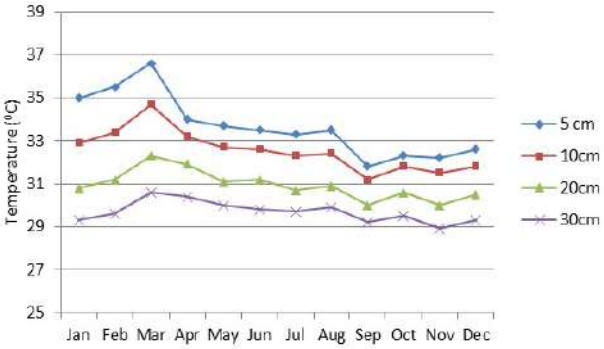


Fig. 9. Distribution of soil temperature records at 4 different depths at 15:30 hrs

Table 1. *Monthly variation of rainfall and rainy days in 2015*

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	76.4	(156)	7	(11)	-	7	0	76.4
February	154.1	(114)	13	(09)	2	10	1	91.0
March	237.2	(222)	18	(13)	3	15	-	121.9
April	377.5	(415)	21	(18)	5	14	2	112.8
May	407.0	(584)	23	(24)	4	18	1	71.2
June	408.5	(398)	24	(23)	4	19	1	90.2
July	250.5	(313)	21	(22)	4	16	1	84.8
August	277.4	(268)	26	(20)	9	16	1	79.6
September	566.7	(436)	27	(22)	3	22	2	75.3
October	594.3	(513)	24	(23)	6	13	6	71.1
November	471.0	(387)	22	(20)	3	17	2	64.3
December	347.5	(266)	22	(15)	6	15	1	67.4
Total	4,168.1	(4,072.0)	248	(220)	50	181	17	1,006.0

* A rainy day is defined as a day with a rainfall ≥ 0.3 mm
** Average values for 1980-2005 are shown in parentheses

Table 2. *Variation of observed meteorological factors at Dartonfield – 2015*

Month	*(Latitude $6^0$32'; Longitude 80.09 E; Altitude 65.50m)*								
	Temperature (^{0}C)					Relative humidity (%)			Mean Wind speed (km/hour)
	Mean Max	Mean Min	Mean	No of days Min Temp<20	Sun shine hours	8.30 am	No of days 8.30am>90%	3.30 pm	
January	32.2	22.1	27.1 (26.7)	2	5.9	87 (88)	12	63 (68)	1.60
February	32.2	22.1	27.1 (27.1)	4	6.2	86 (86)	10	69 (65)	1.50
March	33.2	22.5	27.8 (27.6)	-	6.5	85 (85)	7	79 (68)	1.40
April	33.0	23.1	28.0 (27.8)	-	5.7	88 (85)	14	93 (75)	1.40
May	31.6	24.4	28.0 (27.6)	-	4.6	88 (88)	10	85 (77)	1.50
June	31.1	24.1	27.6 (26.9)	-	4.6	92 (89)	21	84 (77)	1.50
July	30.9	24.1	27.5 (26.7)	-	4.8	91 (89)	18	83 (75)	1.90
August	30.9	24.1	27.5 (26.6)	-	5.3	89 (88)	15	83 (74)	1.90
September	30.6	23.7	27.1 (26.7)	-	3.6	89 (88)	13	87 (75)	1.70
October	31.6	23.5	27.5 (26.6)	-	4.7	86 (86)	8	83 (77)	1.30
November	31.3	23.3	27.3 (26.6)	-	4.2	86 (85)	11	79 (77)	1.00
December	32.2	23.3	27.7 (26.7)	-	4.0	86 (85)	10	78 (73)	0.80

** Average values for 1980-2005 are shown in parentheses

LIST OF PUBLICATIONS

Scientific Journals
(Bold type - Employees of Rubber Research Institute of Sri Lanka)

Kuruppu, I.V., Edirisinghe, J.C., Herath, H.M.L.K., Jayasinghe-Mudalige, U.K., **Wijesuriya**, **W.**, Udugama, J.M.M. and Fernando, A.P.S. (2015). Farmers' valuation of agro-biodiversity in Home Gardens: Case study in the Kurunegala District. *Journal of Environmental Professionals Sri Lanka* **4**, 72-83.

Nayanakantha, N.M.C., Rawat, S., Ali, S. and Grover, A. (2015). Differential expression of defense-related genes in *Sinapis alba* and *Brassica juncea* upon the infection of *Alternaria brassicae*. *Tropical Agricultural Research* **27,** 123-136.

Ratnayake, U.N., Prematunga, D.E., Peiris, C., Karunaratne, V. and Amaratunga, Gihan A.J. (2015). Effect of polyethylene glycol intercalated organoclay on vulcanization characteristics and reinforcement of natural rubber nanocomposites. *Journal of Elastomer and Plastics* (Online publication).

Bulletin/Conferences/Seminars/Workshops/Reports

Adhikari, A.M.K.S.P. and **Nilmini, A.H.L.R.** (2014). Compatibilization effect of CPE with NBR/EPDM blend. *World Science Echo*, India **2**, 1-4.

Adhikari, A.M.K.S.P., Nilmini, A.H.L.R. and **Siriwardena, S.** (2014). Physical and chemical characterization of foam rubber rejects. *World Science Echo*, India **1**, 149-151.

Alwis, G.M.C., **Ratnayake**, **U.N.**, Kottegoda, N.S. (2015). Effect of Pre-vulcanization inhibitors on quaternary alkyl ammonium modified clay filled natural rubber nanocomposites. *Proceedings of 2nd International Symposium on Polymer Science and Technology*, University of Sri Jayewardenepura, Sri Lanka. P.27.

Attanayake, **A.P**., Karunanayake, L. and **Nilmini, A.H.R.L.** (2015). Effect of ethephon concentration on rubber yield through magnesium ion and sucrose regulation in *Hevea brasiliensis. YSF Symposium 2015*, p.11.

Attanayake, **A.P.,** Karunanayake, L. and **Nilmini, A.H.R.L.** (2015). Viscoelastic properties of stimulated rubber. *International Symposium in Polymer Science*, University of Sri Jayawardenepura, p.12.

Attanayake, A.P., **Lokuge, C.** and Dharmawardana, G.T.S. (2015). Appropriate strategy to overcome potential problems in NR latex processing. *RISTCON International Conference 2015*, University of Ruhuna, p.20.

De Silva, C.N., **Edirisinghe, D.G.** and Dharmakeerthi, R.S. (2015). Effect of partial replacement of carbon black with pyrogenic carbon on properties of tyre tread compounds. *Proceedings of the IIUPST 2015*, University of Sri Jayewardenepura, p.19.

Dharmathilake, K.G.P.M. and **Ratnayake**, **U.N.** (2015). Synergistic effect of pristine clay and organoclay on elasticity and reinforcement natural rubber nanocomposites. *Proceedings of 2nd International Symposium on Polymer Science and Technology*, University of Sri Jayewardenepura, Sri Lanka. P.28.

Fernando, T.H.P.S., **Seneviratne, P., Nishantha, N.** and **Siriwardena, D.** (2015). Screening of *Hevea* clones against Corynespora leaf fall disease: The most destructive foliar disease of rubber. *Proceeding of International Conference on Multidisciplinary Approaches.* University of Sri Jayawardanepura, Sri Lanka. p.216.

Fernando, T.H.P.S., Seneviratne, P., Wijeratna, C. and Mirando, J. (2015). Recent research findings on tree injection: an advanced application technology against disease management giving special emphasis to white root disease. *Proceedings of the International Rubber Conference 2015.* IRRDB, Ho Chi Minh City, Vietnam. 252-258.

Hettiarachchi, R.P., Dharmakeerthi, R.S., Seneviratne, G., Jayakody, A.N., **De Silva, E., Gunathilaka, T**. and **Thewarapperuma, A**. (2015). Biofilmed biofertilizers as key player in improving soil fertility and plant growth of Rubber (*Hevea brasiliensis*) seedlings. *Proceedings of the Twentieth International Forestry and Environmental Symposium.* Department of Forestry and Environmental Science, University of Sri Jayawardenepura. P.85.

Iddamalgoda, I.D.H.C., **Attanayaka, A.P.**, Withanage, N.S. and Weerawansa, N.R. (2015). Property variation of centrifuged latex at different maturity stages in glove manufacturing. *Research Symposium of Uva Wellassa University*, 5-9.

Iqbal, S.M.M., Rodrigo, V.H.L., Wettasinghe, W.A.D.D.S. and **Jayathilake, P.M. M**. (2015). Identification of suitable species and genotypes for cut foliage cultivation on rubber lands. *Proceedings of the International Rubber Conference 2015.* IRRDB. Ho Chi Minh City, Vietnam. 141-142.

Jayawarna, J.C. and **Edirisinghe, D.G.** (2015). Reclaiming of natural rubber latex product waste by a mechanochemical process for production of solid tyre treads. *Proceedings of the IIUPST 2015*, University of Sri Jayewardenepura, p.20.

Jeewanthi. P.W., **Wijesuriya, W.** and **Sankalpa, J.K.S. (**2015). Use of information on rainfall behavior to assist timely management of agronomic operations in rubber plantations in the Agro Ecological Region – WL1a. *YSF Symposium 2014*, HARTI, Colombo, 100-103.

Karunathilaka, S.N., Nugawela, A., **Senevirathna, A.M.W.K**., **Nayanakantha, N.M.C., Bandara, P.K.G.S.S.** and **Samarasekara, R.K.** (2015). Effectiveness of DRC+3, ascorbic acid and sodium nitroprusside as a treatment for tapping panel dryness of rubber (*Hevea brasiliensis*). *Proceedings of 14th Agricultural Research Symposium*. Wayamba University of Sri Lanka, 278-282.

Kudaligama, K.V.V.S., Rodrigo, V.H.L. and **Randunu, R.P.S**. (2015). Commercial application of S/2 d4 harvesting system to address current issues in rubber plantations in Sri Lanka. *Proceedings of the International Rubber Conference 2015.* IRRDB. Ho Chi Minh City, Vietnam. 386-396.

Kumara, P.R., **Munasinghe, E.S., Rodrigo, V.H.L**. and Karunaratna, A.S. (2015). Carbon footprint of rubber/sugarcane intercropping system in Sri Lanka; a case study. *Fifth International Conference of Sabaragamuwa University of Sri Lanka.* Belihuloya. 50-51.

Kumari, L.D.A.N., **Ratnayake**, **U.N.** and **Prasad, A.K.D.W.** (2015). Value added Natural Rubber/Skim Rubber blend with incorporating pristine montmorillonite clay. *Proceedings of 2nd International Symposium on Polymer Science and Technology*, University of Sri Jayewardenepura, Sri Lanka. P.31.

Liyanaarachchi, L.A.T.S., Karunaratne, S.B., **Sankalpa, J.K.S., Wijesuriya, B.W.,** Gajanayake, B. and Abeysinghe, D.C. (2015). Can we cultivate rubber in Northern Dry Zone of Sri Lanka: A case study from Vavuniya district using GIS approach. *Proceedings Wayamba International Conference 2015*, Wayamba University of Sri Lanka. 337-341.

Liyanaarachchi, L.A.T.S**.,** Karunaratne, S.B., **Sankalpa, J.K.S**., **Wijesuriya, B.W.,** Gajanayake, B. and Abeysinghe, D.C. (2015). Development of a land suitability map to expand rubber in Northern Dry Zone of Sri Lanka: A case study from Vavuniya District. *Proceedings of the Peradeniya University International Research Sessions*, Sri Lanka, Vol.19, p.4.

Madushani, H.K.I., **Fernando, T.H.P.S.**, Wijesundara, R.L.C. and **Senaviratne, P.** (2015). Genetic variation of *Rigidoporus microporus* isolates from different host plants in vicinity of rubber plantation. *5th YSF Symposium*, 52-54.

Madushani H.K.I., **Fernando, T.H.P.S.**, Wijesundera, R.L.C. and **Seneviratne, P.** (2015). Physiological effect of laccase secreted by *Rigidoporus microporus* on the host pathogen interactions. *Twentieth International Forestry and Environment Symposium 2015*. University of Sri Jayawardenepura, Sri Lanka. p.122.

Madushani, H.K.I., **Fernando, T.H.P.S.**, Wijesundera, R.L.C. and **Siriwardena, D.** (2015). Significance of laccase by *Rigidoporus microporus*, the cause of WRD of rubber. *Proceeding of International Conference on Multidisciplinary Approaches.* University of Sri Jayawardanepura, Sri Lanka. p.175.

Madushani, H.K.I., Sumanasinghe, V.A. and **Liyanage, K.K.** (2012). RAPD in assessment of genetic diversity of *Hevea* breeding population in 2012. *Proceeding of Peradeniya University International Research* **18**, p.57.

Mirihana, M.K.U.L., Nugawela, A. and **Nayanakantha, N.M.C.** (2015). The effect of nitric oxide pretreatment on growth and root architecture of polybagged rubber (*Hevea brasiliensis*) seedlings. *Proceedings of 14th Agricultural Research Symposium*, Wayamba University of Sri Lanka, Sri Lanka. 273-277.

Montoro, P., Tang, C., Saha, T., Annamalainathn, K., Ismawanto, S., **Nayanakantha, N.M.C**. and Phumichi, T. (2015). Contribution of molecular biology and physiology to climate-smart natural rubber production. *Proceedings of the International Rubber Conference 2015*. IRRDB. Ho Chi Minh City, Vietnam. 101-107.

Munasinghe, E.S., Rodrigo, V.H.L. and Gunawardena, U.A.D.P. (2015). Biomass from rubber trees for renewable energy: a review of Sri Lankan scenario. *Proceedings of the Twentieth International Forestry and Environmental Symposium 2015*. Department of Forestry and Environmental Science, University of Sri Jayawardenepura, Sri Lanka, p.81.

Nayanakantha, **N.M.C**., Hettiarachchi, N.N., **Senevirathna, A.M.W.K.** and **Seneviratne, P.** (2015). Nitric oxide pre-treatment enhanced growth attributes of polybagged rubber (*Hevea brasiliensis*) seedlings. *Proceedings of the International Rubber Conference 2015.* IRRDB. Ho Chi Minh City, Vietnam. 49-58.

Nayanakantha, N.M.C., Rawat, S. and Grover, A. (2015). Identification of differentially expressed genes in *Brassica juncea* and *Camelina sativa* upon challenge inoculation with *Alternaria brassicae*. *4th YSF Symposium*, HARTI, Colombo. p.65.

Nilmini, A.H.L.R. and **Adhikari, A.M.K.S.P.** (2014). Studying the effect of a compatibilizer system on thermal properties of NBR/EPDM blend. *3rd YSF Symposium*, Sri Lanka, 1-4.

Nilmini, A.H.L.R., Seneviratne, W.M.G. and **Adhikari, A.M.K.S.P**. (2013). Nitrosoamine free preservative system for natural rubber latex. *Rubber Con.* Thailand, 137-141.

Peiris, M.M.K., **Fernando, T.H.P.S.,** Gunawardana, D., **Nishantha, E.A.D.N.** and **Seneviratne, G.P.W.P.P.** (2015). Cultural reproductive variability of *Corynespora cassiicola* from different host plants. *Twentieth International Forestry and Environment Symposium 2015*. University of Sri Jayawardenepura, Sri Lanka p.2.

Priyanka, U.M.S., Ratnayake, U.N. and Kottegoda, N.S. (2015). Surface treated natural rubber latex sludge as a potential filler for rubber compounds. *Proceedings of 2nd International Symposium on Polymer Science and Technology*, University of Sri Jayewardenepura, Sri Lanka

Ratnayake, U.N., Kumari, L.D.A.N., **Prasad, A.K.W.** and Wijesinghe, D.R. (2015). Montmorillonite clay filled skim natural rubber nanocomposite as a value added raw rubber. *Proceedings of the International Rubber Conference 2015*. IRRDB. Ho Chi Minh City, Vietnam. 483-487.

Ratnayake, **U.N.** (2015). Nano materials add value to rubber. *Rubber Asia*, 30. 74-78.

Samarasinghe, **I.H.K.**, **Ratnayake, U.N., Attanayake, A.P., Seneviratne, W.M.G.** and **Wanigatunga, L.** (2015). Effect of storage conditions on viscoelastic properties of different grades of natural latex crepe rubber. *International Rubber Conference.* IRRDB, Ho Chi Minch, Vietnam, 406-409.

Sampath, W.D.M., Egodage, S.M. and **Edirisinghe, D.G.** (2015). Effect of a titanate coupling agent on chemical and ageing properties of calcium carbonate filled natural rubber and low density polyethylene composites. *IIUPST 2015*, University of Sri Jayewardenepura, Sri Lanka, p.10.

Sampath, W.D.M., Egodage, S.M. and **Edirisinghe, D.G.** (2015). Improvement of Physico-mechanical properties of calcium carbonate filled natural rubber and low density polyethylene blends with titanate coupling agent. *IEEE Xplore Digital Library*, DOI: 10.1109/MERCon 2015. 228-233.

Sampath, W.D.M., Egodage, S.M. and **Edirisinghe, D.G.** (2015). Effects of titanate based coupling agent and mixing methods on properties of natural rubber and low density polyethylene blends. *Proceedings of the International Research Sessions (iPURSE)* 2015, University of Peradeniya, Sri Lanka. p.125.

Sampath, W.D.M., Egodage, S.M. and **Edirisinghe, D.G.** (2015). The effect of coupling agent and mixing methods on properties of natural rubber and low density polyethylene blends. *Proceedings of the International Rubber Conference 2015*. IRRDB. Ho Chi Minh City, Vietnam. 488-493.

Sandamali, P.K.N.N., **Fernando, T.H.P.S.,** Chandrasena, G. and **Siriwardena, D.,** (2015). *In vitro* evaluation of the antagonistic effect of some native *Trichoderma* stns against economically important foliar pathogens of rubber. *Twentieth International Forestry and Environment Symposium 2015*. University of Sri Jayawardenepura, Sri Lanka p.50.

Sankalpa, J.K.S., Karunaratne, S. and **Wijesuriya, W.** (2015). Land suitability evaluation for rubber cultivation using multi criteria decision approach and GIS: Special focus on Ampara district. *YSF Symposium 2014*, HARTI, Colombo, 175-178.

Silva, T.U.K. and **Rodrigo, V.H.L.** (2015). Potential of increasing the planting density of rubber in Sri Lanka. *Proceedings of the International Rubber Conference 2015*, IRRDB, Ho chi Minh City, Vietnam. 577-590.

Siriwardena, S., Ratnayake, U.N. and **Warnajith, A.K.D.** (2015). A hybrid drying system for simultaneous drying of different types of raw natural rubber. *Proceedings of the International Rubber Conference 2015*. IRRDB. Ho Chi Minh City, Vietnam. 418-425.

Udaykumari, U.N., **Kudaligama, K.V.V.S.,** Chandrasena, G., **Fernando, T.H.P.S., Seneviratne, P.** and **Siriwardena, D**. (2015). Development of a sustainable low cost liquid medium for *Trichoderma* spp. using natural rubber serum. *Twentieth International Forestry and Environment Symposium* 2015. University of Sri Jayawardenepura, Sri Lanka p.88.

Wickramarachchi, D.M.C., **Fernando, T.H.P.S**., Nugawela, A. and Adushani, H.K.I. (2015). Morphological and molecular charaterization of native Trichoderma isolates against *Rigidoporus microporus* the causative agent of white root disease of *Hevea brasiliensis*. *Proceedings Wayamba International Conference 2015*, Wayamba University of Sri Lanka. 283-287.

Patents

Patent Application titled "Novel high performance lighter weight prosthetic foot based on nanomaterial filled natural rubber compounds" was filled at Sri Lanka Patent Office in 2015. Patent Application No. LK/P/1/18468.

Abbreviations

HARTI	- Hector Kobekaduwa Agrarian Research & Training Institute
IEEE	- Institute of Electrical and Electronics Engineers
IIUPST	- Institutes, Industries and Universities Polymer Science and Technology
IRRDB	- International Rubber Research & Development Board
RISTCON	- Ruhuna International Science & Technology Conference
YSF	- Young Scientists' Forum

GENETICS AND PLANT BREEDING

The annual hand pollination program was carried out at Neuchatel estate and seventy new genotypes were raised. Three promising clones as RRISL 203, RRISL 208 and RRISL 211 were used as female parents.

Twenty selections (one third of the progeny) were made from 97 hand pollination progeny which has been evaluated for fifteen years at Clyde estate under small scale level. The existing small scale and estate collaborative trials performed well, the recording of yield data was not possible due to frequent wet spells experienced throughout the year. Ten genotypes selected from 1995 hybridization programme where non-Wickham clone GPS 1 was used as a male parent showed good genetic diversity.

Thirteen new smallholder trials were established at Uva, Central, North Western and North Central Provinces under the project "Evaluation of new clones for sub optimal conditions", to test five clones as RRISL 203, RRISL 2001, RRISL 2005, RRISL 2006 and RRISL 2100. The trials already established in Eastern Province are performing well, but few trials were given up due to poor support received from the smallholders. Existing smallholder RRI collaborative trials in traditional rubber growing areas are performed well and the growth of clone RRISL 203 is significantly higher in Matara district.

Multiplication, establishment and scientific evaluation of the Hevea germplasm collection was started with the aim of enhancement of productivity through genetic improvement and management of genetic resources of Hevea. Around 1400 accessions were planted at Nivitigalakele substation and some accessions are ready to establish in bud wood nurseries at Neuchatle estate. Selected twenty five accessions were characterized and found good performances in some accessions as MT 11-76 I, MT 11-76 II, MT 10-146 and MT 11-13.

PLANT SCIENCE

Out of 21 clones selected for seed production survey, RRISL 201 and BPM 24 showed a satisfactory seed production followed by RRISL 217, RRISL 220 and RRISL 226. Seed production in clones recommended for smallholders viz., RRIC 121, RRISL 203 and RRISL 2001 was not satisfactory. Seedlings derived from decoated seeds showed improved growth characteristics than those derived from intact seeds. Seeds treated with nitric oxide (NO) donor sodium nitroprusside (SNP) at 100µM accelerated the germination and improved germination percentage. Budded plants treated with 100µM SNP under drought condition enhanced physiological parameters viz., net photosynthesis rate, stomatal conductance, water use efficiency and chlorophyll content after two days from drought treatment.

Seedlings derived from illegitimate seeds of seven clones (PB 86, RRIC 100, RRISL 201, RRISL 217, RRISL 220, BPM 24 and PB 260) showed no significant difference in growth attributes. Seedlings irrigated with sprinkler system(every other day), followed by drip system (every other day) showed improved growth characteristics as compared to those irrigate with drip system at two day intervals and manual watering on every other day.

An experimental trial was commenced at Vishwamadu and Akkarayankulam in Kilinochchi district to study the growth performance of rubber clones. 1000 new plants from RRIC 121 were established at low density spacing of 16' x 16' at Kandakaduwa, Polonnaruwa. The highest yield per hectare (YPH) was recorded in the highest density (800 trees/ha) due to higher number of trees in tapping. However, the girth and g/t/t of trees in higher densities (700 & 800) were significantly low as compared to those in other densities (500 & 600).Yield measurements of crop estimation experiment at Pitiakande revealed that there was no significant difference in yield (g/t/t) under S/4 d3 and S/3 d3 system with ethrel application at 5% and 2% respectively, as compared to the standard system (S/2 d3 + 2.5% E). Crop estimation experiment at Sapumalkanda revealed that the bark thickens at highest girth class (≥61.0 cm) was significantly higher as compared to those at other two girth classes (51-55.9cm and 56-60.9 cm). However, there was no significant difference in yield (g/t/t) among all three girth classes.

Intercropping rubber with perennial crops revealed that growth and the establishment rates of rambutan and jak were satisfactory and better than that of bud grafted (bg) and seedling (s) durian. Mango, guava and pomegranate showed a rapid growth than rambutan when intercropped with rubber. An intercropping trial of Rubber with Agarwood was established at Dartonfield Estate of RRISL. All nurseries were inspected for quality assurance and reports were submitted. Issuing authentic plants to establish budwood nurseries, issuing technically specified tapping knives and marking plates, testing polythene and conducting programmes sponsored by various institutions were attended/ done by the department staff.

PLANT PATHOLOGY AND MICROBIOLOGY

Incidence of secondary leaf fall diseases, Powdery mildew & Colletotrichum leaf disease was mild to moderate during the refoliation period except for a few disease vulnerable sites. Application of sulphur [liquid & dust] was successfully carried out against the secondary leaf fall disease at the experimental sites. The incidence of abnormal leaf fall caused by Phytophthora spp. was also reported to be mild except for some severely infected sites. Corynespora leaf fall disease (CLFD) was reported on the field plants of RRIC 121 during the year 2015 for the second time. The screening of clones against CLFD revealed that Centennial 3 is susceptible to the disease at a moderate level. A series of experiments on the biology of White Root Disease was completed focusing rubber and alternative hosts. Studies on cell wall degrading enzymes secreted by Rigidoporus were also completed. Projects on the new application technology, tree injection, rehabilitation of WRD patches and effect of antagonistic plants to control the disease were also in progress. Report on the incidence of WRD in Kuruwita sub-station was completed. Around 17% of lands at Kuruwita substation were found to be infected with WRD. Several alternative plant types which can tolerate white root disease infection have been identified to be used in Fomes patches. During the recent past, incidence of Brown root disease became increasingly destructive in the non-traditional rubber growing areas. Collection of pathogen isolates of brown root disease was completed. The studies on morphology, pathogenicity, bio-chemical nature of pathogenesis were progressed. Possibilities to improve the adhesive properties of the repellant were also sought. Three alternative chemicals for mancozeb were tested for the management of Patch canker, the bark cracking disorder. Four new chemicals were tested against cockchafer grub attack under field conditions to introduce a substitutes for Chlorphyrifos. The clone screening programmes against the foliar diseases for the year 2015 was only partially completed due to the lack of transport facilities. Occurrence of Ustulina stem rot has become more and the investigations were initiated. Studies were continued to isolate and identify the beneficial soil micro-flora from the main rubber growing areas and also from non-traditional rubber growing areas. The study revealed that the bacterial colonies were the most abundant followed by the fungal organisms. The largest fungal and bacteria CFUs were observed in Dartonfiled, Kalutara under Pueraria compared to the Mucuna cover crop and the bare lands. Evaluation of eleven native antagonistic fungi strains Trichoderma, Penicillium and Aspergilllus as bio control agents for White Root Disease was undertaken. Compost based medium was formulated to produce Trichoderma inoculum. Large scale production of the inocula is in progress. A serum based liquid medium was also tested for the Trichoderma spp. with the collaboration of the Department of Biochemistry & Physiology. An Economical medium was identified to skeletonize rubber leaves to prepare different handicrafts.

SOILS AND PLANT NUTRITION

Ten research and development activities in relation to improvement of soil fertility, increasing fertilizer use efficiency, soil, water and nutrient conservation and weed control were planned, promoted, implemented and monitored. Isolated bacteria from rubber rhizosphere in red yellow podzolic soils solubilized sparingly soluble calcium hydrogen phosphate (CaHPO4) in liquid medium accompanied by a drop in pH. The medium with higher grade Eppawala rock phosphate (HERP) was showed less relationship compared to $CaHPO_4$ and no correlation was found with Eppawala rock phosphate (ERP). The biofim solubilized significantly high amount of phosphorus in liquid medium containing $CaHPO_4$ compared to their alone cultures and was observed synergistic effect for Acetylene reduction assay (ARA). Production of IAA of biofilm was higher than that of bacteria alone cultures. Thus the biofilm formation of rhizosphere microbes seems to be very important for improved soil fertility. The field experiment results seems to suggest that it may have a possibility of improving soil fertility and plant growth of immature Hevea by combine use of biofilm biofertilizers (BFBF) with inorganic fertilizers. Studies on weed control suggested that combination of new weedicide Gluphosinate ammonium with Diuron was more effective than their alone applications. Application of slow release fertilizers gave comparable growth assessments compared to conventional fertilizer application for rubber nursery plants dealing with a number of management problems associated with repeated application.

Site specific fertilizer recommendations programme provided data for 2215 hectares of mature rubber in the estate sector and 30 fertilizer recommendation reports were issued. Six land suitability reports were issued and approximately 300 ha were surveyed for suitability of planting rubber under land selection programme. The department also analyzed approximately 1000 samples (7500 parameters) for outside organizations including 80 fertilizer samples for rubber growers to assure application of good quality fertilizers to their rubber lands.

BIOCHEMISTRY AND PHYSIOLOGY

Commercial scale testing of S/2 d4 and S/4 d3 systems in the Wet Zone was continued in Kuruwita Substation of RRISL. A new tapping field from Galewatta division of Dartonfield estate was also selected to investigate the adaptability of S/2 d4 and S/4 d3 systems in commercial plantations. In addition a weekend harvesting system was also being tested in commercial plantations of Kuruwita RRISL substation. Testing of S/2 d4 harvesting system in the Intermediate Zone was continued with smallholdings in Padiyathalawa and RRISL Substation, Polgahawela.

Experiments were conducted to investigate the changes in biochemical and physiological parameters in rubber plants of three Hevea genotypes under drier climatic conditions in Northern and Eastern Provinces. In order to identify best genotypes for the suboptimal climatic conditions in non-traditional rubber growing areas, new experiments were established at Vauniya, and Kandakaduwa with two control plots in the Wet zone (Pasyala and Dartonfield). Five different genotypes i.e. RRIC 100, RRIC 121, RRISL 203, RRISL 2001 and PB 260 were planted to investigate their sustainability in different agro climates.

Investigations on different commercial ethephon mixtures on latex physiology and yield of trees harvested with different harvesting systems have been continued. Testing of physical properties and biochemical composition of rubber wood of RRIC 100 and PB 86 genotypes was done.

Postgraduate research work conducted by Dr (Mrs) K V V S Kudaligama leading to her PhD degree has won the GRC Postgraduate award 2015 awarded by the Sri Lanka Association for the Advancement of Science.

ADVISORY SERVICES

Nineteen Group extension programmes called "Vihidum Sathkara" were effectively conducted providing advisory and extension services for 931 rubber smallholdings. 72 medium scale rubber lands were inspected and advised for improvements needed under this programme. In total, 5019 advisory visits were carried out to solve problems in technology adoption in the rubber smallholder sector. Two thousand three hundred and one (2301) rubber smallholdings were inspected in the Monaragala district by REOo and necessary advice were given for improvements under the Smallholders Plantation Entrepreneurship Development Programme (SPEnDP). Under this 60 awareness programmes were also conducted for the benefit of 2346 rubber farmers in Monaragala district. Special awareness programmes were conducted in Ampara and Baticoloa districts (Nuwaragalatenna, Warapitiya and Mangalagama) for the benefit of new rubber cultivators. The research study funded by the National Research council (NRC) on the feasibility of expanding rubber cultivation into non-traditional areas was conducted successfully. Eight on farm trials set up in Uva, Eastern, North- central and Northern provinces were maintained and farmers were educated on recommendations of immature up keep.

The extension strategy focused on farmer participatory development of selected rubber units in each REO divisions was continued with the upgrading of 249 rubber lands as model rubber holdings. Status of 245 immature substandard rubber holdings and 233 mature substandard rubber holdings were rehabilitated successfully. Sixty four rubber processing centers were developed as models and construction of 33 new RSS processing centers and rehabilitation of 21 substandard centres were attended. Sixty four and twenty eight model holdings were set up to demonstrate the value of using rainguards and intercropping systems respectively. Conducted 25 training programmes on quality improvement of RSS production for the benefit of 371 RSS producers. As a solution to the tapper shortage, 317 new harvesting assistants were introduced through 18 Tapping Training Schools (TTS) and 734 semi skilled harvesting assistants were trained on tapping quality improvement in 55 skills development programmes. Under the special programme called, "Nipunatha Saviya", 17 training programmes were conducted for the benefit of 659 selected rubber harvesting assistants. Forty six training programmes on the adoption of control measures of the white root disease were conducted for the benefit of 690 rubber farmers.

Forty four farmer training programmes were conducted to educate 1054 rubber growers on general cultivation and processing aspects of rubber. Data collection and GIS based mapping was carried-out in relation to all field training and advisory programmes for effective planning of extension programme.

RUBBER TECHNOLOGY AND DEVELOPMENT

Properties such as micro-organism growth in the low ammonia centrifuged latex prepared with a readily available, non-toxic, low cost chemical was evaluated. Also, ageing resistance, protein content and release of nitrosamines from cast films produced with this newly developed latex were assessed and all these properties were in accordance with the requirements for infant items and toys. Cast films were produced with compounded natural rubber latex containing citronella oil, with the aim of manufacturing rubberized-coir based fenders to protect immature plants against animal attack and properties of the films were tested. NR latex foam with antioxidant as well as antimicrobial effects was produced successfully at laboratory scale as well as factory scale using aloe vera.

Calcium carbonate filled NR/LDPE/waste PE composites were produced using a titanate coupling agent and a peroxide. Pyrogenic carbon filled 80:20 NR/SBR composites suitable for tyre treads were developed. NR/SBR composites were prepared with palmyra fibres coated with different latices or chemical substances and physico-mechanical properties were evaluated. Compounded nitrile rubber (NBR) latex waste based reclaimed rubber was produced mechanochemically using an amino based chemical with the aim of partially replacing virgin NBR with modified waste in oil seal compounds. Carbon black as well as calcium carbonate filled NR/LDPE/recycled PE composites were produced and properties were evaluated. A paving material was developed with ground rubber tyre (GRT) and bitumen. Experiments were conducted to develop NR based solid tyre compounds with coconut shell powder at the request of a coir processing company.

NR/EPDM stopper band compound, required for an agricultural purpose was developed at the request of a rubber band producing company. Trials were conducted to produce low resilient and high abrasion resistant rubber balls for cricket practicing purpose, at the request of a cricket coach. Initial trials on the development of a NR based all-purpose basket were conducted. Work on development of NR latex based moulds suitable to produce herbal soap pieces was initiated. A NR latex compound was developed using a combination of non-toxic fungicides to eliminate mould growth in infant items.

Conducted twenty six training programs/workshops on rubber based products manufacture. Also, the staff was actively involved in transferring the technology of rubber based products manufacture to SME's via five "Krushi FM" live, web radio programs. Further, the staff was involved in transferring knowledge on rubber based products manufacture to the public at five exhibitions and to postgraduate students by conducting practical classes. 238 tests on dry rubber compounds and 166 tests on products were conducted. 207 crepe rubber samples were also tested for hardness.

POLYMER CHEMISTRY

A tyre paint was developed for inner heal of the solid tyre using synthetic resins and natural rubber. Several thermal and mechanical properties were achieved such as heat resistance, crack resistance, and high peel strength to tolerate pressure developed during the rim mounting process. Technology was transferred to the industry and patent was applied for this new product. Introduction of plant based preservative system to eliminate TMTD from latex preservation was continued. New screen printing inks were developed for Natural rubber and Nitrile rubber surfaces. Industrial trails with newly developed inks are being in progress. More than thousand samples of polymer materials and compounding ingredients were tested to analyze of their constituents using FTIR. Analysis of thermal properties of polymers using DSC and material properties using DMA was carried out throughout the year. One workshop on manufacture of natural and synthetic rubber based adhesives was conducted for 15 numbers of SME's in collaboration with Industrial Development Board.

RAW RUBBER AND CHEMICAL ANALYSIS

The department mainly offered the testing, analytical and certification services on raw natural rubber and rubber chemicals to all sectors of the rubber industry including raw rubber processing industries. These services were also extended to rubber traders, researchers from fellow departments of the institute and various local institutions such as Universities, other research institutes as well as individuals including postgraduate students, consultants and inventors etc. A total number of thousand one hundred and eighteen samples of natural rubber latex, dry rubber, rubber processing chemicals and polythene samples were tested for their quality during the year. This included five hundred and eighty three dry rubber samples, three hundred and sixty five natural rubber latex samples, thirty eight rubber processing chemicals, thirty three bleaching agent samples, thirty eight polythene samples and twenty one glove samples. Forty raw rubber analysis certificates for Technically Specified Rubber (TSR) were also issued on requests received from the respective parties for their quality assessment and marketing purposes. In addition, the department carried out miscellaneous analytical tests, trouble shooting activities and four research projects during the year.

Effect of ethephon stimulation on rubber yield, physiological and natural rubber latex quality parameters was studied. Serum sucrose level and magnesium concentration were the main concerned parameters. Visco-elastic properties of yellow fraction crepe rubber and fractioned bleached crepe rubber were investigated under accelerated storage conditions with respect to four parameters namely un-aged plasticity, Mooney Viscosity, Mooney relaxation time and Gel content. Two short term projects on 'Effect of processing conditions on storage hardening and Gel content of raw natural rubber' and 'Raw rubber property variation of RRISL 200 series' were completed during the year.

The department staff continued to provide training on raw rubber and natural rubber latex testing for laboratory personnel, industrialists, research students and university undergraduates.

RAW RUBBER PROCESS DEVELOPMENT AND CHEMICAL ENGINEERING

A novel prosthetic foot with high performance and a light weight was developed based on hybrid nanomaterial filled natural rubber nanocomposite under the technology grant awarded by National Science Foundation (NSF). The new prosthetic foot developed is an alternative for the prosthetic foot fabricated presently by Ranaviru Sevena, Army Rehabilitation Center, Ragama. Hybrid nanomaterial filled natural rubber nanocomposite provides the required stiffness, strength and wear and tear properties of the foot while nanostructured cellular natural rubber compound makes the prosthetic foot less weight with an appropriate resilience. A patent application was filled based on this novel prosthetic foot at Sri Lanka patent office.

A novel process developed to prepare natural rubber/layered silicate nanocomposites has shown an effective interaction between clay platelets and NR molecules resulting in higher physico-mechanical properties compared to that of NR/layered silicate nanocomposites prepared using conventional techniques.

A comparative study carried out on the physical and vulcanized properties of unfractionated unbleached crepe rubber (UFUB) and Air Dried Sheets (ADS) indicated that former could be substituted by later with a slight modification to the present recipe.

Skim natural rubber (SNR), a by-product of centrifuged latex manufacturing process, was up- uplifted as a value added raw natural rubber through nano-technology approach and hence usage of skim natural rubber in different applications would be increased. Application of nano-technology has enhanced the resistance to thermo-oxidative aging properties which is one of the major draw backs of conventional skim rubber.

Skim rubber/polyethylene (50/50) blends were prepared through melt-mixing and dynamic vulcanization of skim phase. Formation of crosslinks in the skim phase is demonstrated by the evidence from the Hakke torque rheometer curves obtained during the blending.

The staff of the department continued to provide routine technical assistance/advisory, analytical services and conducting training programs to large scale raw rubber producers, small and medium scale sheet rubber producers and various government institutions and non-government organizations.

ADAPTIVE RESEARCH

A study was conducted in Padiyathalawa area to assess the microclimatic conditions in a mature rubber field with compared to natural forest and chena cultivated land. Data of this study reveals that conditions in mature rubber field are more or less similar to the natural forest. In the Eastern Province a study was conducted to assess the benefits of anti-transpirant application in sustaining leaf physiology of rubber plant under dry climatic condition. Results of the study show that the application of anti-transpirant with a concentration of 0.6 ml/l at 2 weeks interval contributes better results in growth and physiological parameters of rubber plants. Annual girth increment rate of 8.0 cm was achieved in adaptive research plots established in the Northern Province.

BIOMETRY

Biometry section conducts research and development activities based on three aspects; viz. statistical methods, research support and meteorology and climatology. On statistical methods, the Biometry section was involved in research, focusing on Biometrical aspects especially on development, modification and application of statistical methodologies to suit the needs of the rubber sector. Applications on using logit models for binary responses and spatial modeling were among the areas focused during this year. The research studies carried on climatology were mainly focused on drought analysis and rainfall anomalies. These include application of Standardized Precipitation Index (SPI) and Markov chain models to identify rainfall anomalies in the Low Country Wet Zone of Sri Lanka.

During the year under review, research support provided to other departments included data analysis, interpretation of results and database management. Databases on meteorological data collected in the stations at Dartonfield, Moneragala and and Kuruwita and rainfall data collected in stations at Nivitigalakele, Galewatta, Polgahawela, and Kuruwita were updated and provided the data for scientific purposes on request.

AGRICULTURAL ECONOMICS

Agricultural Economics Unit is mainly involved in various economic analyses on economic viability of rubber planting during the year. The studies conducted during the year were focused on Survey and Analysis cost of production of Natural Rubber (NR) in the estate sector and smallholder sector in Sri Lanka. Analysis of productivity in the Kalutara district was conducted using Geographic Information System (GIS) based on survey data. Databases on Local and International rubber prices, growth performance indicators of NR and Rubber finished products were updated. Agricultural Economics unit was engaged in a variety of outreach activities during this year in collaboration with the Biometry Section and Advisory Services Department. Agricultural Economics Unit conducted a research on multi criteria decision approach on land suitability evaluation in the Vavuniya district using GIS in collaboration with the Biometry Section.

LIBRARY AND PUBLICATIONS

One hundred and two (102) books were added to the reference section of the library bringing the total collection up to 6034.For the benefit of Administration and Accounts Departments, the Library purchased the entire set of Legislative Enactments of Democratic Socialist Republic of Sri Lanka, Establishment Code: Vol.1 & 2 and Financial Regulations. While, eight journals were purchased, thirty titles were received on exchange basis.

During the year, the current contents page service was changed to on-line system using e-mail facilities to make this service more effectively and efficiently. Meanwhile, the initial stage of the Library automation project at Ratmalana library was completed.

DARTONFIELD GROUP

A total crop of 161,670 kg has been harvested during this year which is only 81% of the estimated crop. When comparing with the previous year 9% crop decrease is recorded. The crop harvested from the rainguarded area was 27,852 kg which amount to 17% of total harvested crop. The YPH for the year was 892 kg, 72 kg less than the YPH for last year.

The average intake per tapper recorded during the year was 6.9 kg from an average tapping task of 242 trees. Highest intake per tapper (IPT) of 8.01 kg was recorded from the 1998 field with a tapping of 298 trees of clone RRIC 121 tapped at $^{1}/_{2}$S d3 without etheral in Gallewatta division.

The total number of Normal, Late, Rainguard and No tapping days recorded during the year were 204, 12, 70 and 79 days respectively.

Rainfall recorded in three divisions were Dartonfield 4,168 mm, Gallewatta 4,224 mm, Nivitigalakale 3,651 mm, and the number of wet days were 248, 224 and 159 respectively.

The COP and NSA achieved for the year were Rs.270.57 and Rs.255.26 respectively giving a loss margin of Rs.15.31 per kg and a total loss of Rs. 2.4 million. Loss per hectare recorded for the year was Rs.13,653.84.

Out of total Latex crepe manufactured during the year 73% was graded as No. 01.

KURUWITA SUB - STATION

The mature and immature extent of the Kuruwita Sub Station were 73.26 and 8.9 hectares respectively for the year under review.

A total crop of 100,170 kg has been harvested during the year. The actual crop harvested was 99% of the estimated crop. When comparing with the previous year 1% crop increase is recorded.

The actual yield per hectare (YPH) and the average intake per tapper were 1,367 kg and 8.9 kg respectively.

The total number of Normal, Late, Rainguard, Rain interfered and No tapping days recorded for the year were 174, 32, 140, 02 and 17 days respectively.

Total rain fall recorded for the year was 4,002.14 mm with 251 wet days. When compared with the same period last year rainfall is less by 1,090.9 mm but wet days is more by 12 days.

The cost of production (C.O.P.) and the net sale average (N.S.A) for the year were Rs.191.21 and Rs.207.86 respectively, giving a profit margin of Rs.16.65 per kg and a total profit of Rs.1.6 million. Profit per hectare recorded for the year was Rs. 22,765.91.

METEOROLOGICAL REPORT

The total annual rainfall at Dartonfield was 4,168 mm in 2015, which is 64 mm above the long-term average of 4,072 mm. The rainfall distribution at Dartonfield during this year departed from the usual pattern. Below average monthly rainfall values were observed in January, April, May and July while above average values were recorded in September to December. In the rest of the months, the rainfall received was very close to the long term average. The minimum monthly rainfall of 76 mm and the maximum monthly rainfall of 594 mm were recorded in January and October, respectively. Rains during the South West season (May September) decreased by 621 mm. Rainfall during IM1 (March & April) in 2015 is about 137 mm higher than the previous year. During North East and IM2 seasons, 2015 recorded lower values; viz. 95 mm and 112 mm, respectively compared to 2014.

There were 3 rainfall events in 2015 that exceeded the hazardous limits for landslides reported during the year. The observed total number of rainy days of the year was 248, which exceeded the long term average by 26 days. There were only 3 dry spells greater than or equal to 7 days; the longest being 17 days, from 7th to 23rd January. The details of other dry spells are given below.

The minimum temperature dropped below 20^{0}C in 2 days; 1 day each in January and February. The daily average temperature pattern was fairly steady with a mean annual temperature of 27.5^{0}C. The lowest mean minimum temperature of 21^{0}C was observed in January and February while the highest mean maximum temperature of 33^{0}C was observed in March.

A total of 1828 bright sunshine hours was received at an average rate of 5 hours/day which was comparatively higher than the respective figures observed during the last year. Bright sunshine hours exceeded 6 in 43% of the days, while in 37% of the days it was below 4 hours. The mean RH values recorded at 08:30 and 15:30 were 88% and 80%, respectively.

There are three substations maintained by RRISL in Kuruwita (WL_{1a}), Narampola (IL_{1a} bordering WL_{2b}), Moneragala (IL_{1c}) and Nivithigala Kele (WL_{1a}). A total rainfall of 4,161 mm, 2,817 mm, 2151 mm and ,3651 mm were recorded respectively, in Kuruwita, Narampola, Moneragala and Nivithigala Kele stations during 2015. The rainfall received in Kuruwita, Narampola and Nivithigala Kele stations recorded decreases of nearly 17%, 2% and 10% in annual rainfall compared to the previous year, respectively. The annual rainfall in Moneragala recorded an increase of 42% over the last year.