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RUBBER RESEARCH INSTITUTE OF SRI LANKA

Isolation of microbes associated with rubber rhizosphere

Preparation of biofilm biofertilizer under laboratory conditions

Application of biofilm biofertilizer for nursery plants and immature *Hevea*

Annual Review 2016

Cover Story

Biofilm Biofertilizer for rubber

Soil is an excellent niche of microorganisms. Some soil microorganisms capable of colonizing the surrounding of plant roots are considered as rhizosphere microorganisms. They play a significant role in maintaining the dynamic of soil fertility and plant growth. Primarily, the root colonizing bacteria employ favorable effects on growth of host plants *via* direct and indirect mechanisms, and referred to as plant growth promoting bacteria.

In this study, root samples were collected for the isolation of effective microbes. Morphological and cultural features have been successfully employed in the isolation of bacteria and fungi associated with rubber rhizosphere. These microbes support fixation of atmospheric nitrogen, solubilization of minerals like phosphorus and secretion of stimulating hormones auxins such as Indole 3 acetic acid (IAA).

Microorganisms survive in either free living cells or as organized community known as biofilm in the environment. Biofilms are complex community of microorganisms attached to surfaces or interfaces which could be either biotic or abiotic. This is one of the mechanisms that microorganisms stay alive under adverse environmental conditions. In biofilm structure, its associated microbes alter gene expression for maximum survival in the environment and became a unique pattern of gene expression differing from their free living stages. However, the density of biofilm in the nature is generally not adequate to provide sufficient beneficial effects and therefore needs to be produced and multiplied in the laboratory. In the recent developments of biofertilizer research, biofilms have been produced from fungal-bacterial combination under *in-vitro* conditions and termed as biofilm biofertilizers (BFBF). These have showed increased biological nitrogen fixation (BNF), phosphorus release from sparingly soluble phosphates, organic acids and plant growth hormone production *etc*., compared to mono or mixed cultures of the microbes without biofilm formation.

Rubber plants require a number of elements for healthy growth and development. Due to the removal of nutrients as yield and timber in addition to erosion and other losses from a *Hevea* ecosystem, there is a need to replace those nutrients externally. At present, mineral fertilizers are used to compensate the shortages of nutrients and to manage the soil fertility. Loss of applied fertilizers from the soils leads to marked economic losses and negative environmental impacts.

Considerable attention has been focused recently on BFBF in agriculture is considered to be an eco-friendly procedure which is more cost effective than chemical fertilizers.

Several studies conducted so far with the BFBF under nursery and immature *Hevea* have revealed that combined use of BFBF with modified fertilizer levels could enhance plant growth, perhaps up to their optimum levels with improved nutrient availabilities and enhanced soil fertility parameters. Further, this clearly contributes to reverse land degradation with rubber cultivation, a generic issue that has been lasted for decades, and also to sustain soil fertility, which should support to maintain and possibly increase yields in the long run in conventional rubber plantations.

Rubber Research Institute of Sri Lanka

Annual Review – 2016

1st January 2016 to 31st December 2016

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	P D T C Gunatilleke, NDT (Agric)
	J A Sarath Chandrasiri
Technical Officers (Research & Development)	Mrs Eranga de Silva, NDT
	C G Mallawaarachchi, Dip. in Agric. (Hardy)
	Mrs M Kulathunga, BSc (SL)
	Mrs R H N S Alwis, BSc (SL) (up to 30.11.2016)
Management Assistant (Stenography)	Mrs K A D L Rupasinghe Perera
Biochemistry and Physiology	*(at Dartonfield, Agalawatta)*
Senior Research Officer	Mrs K V V S Kudaligama, BSc (SL), MPhil (SL), PhD (SL)
Research Officer	Miss N P S N Karunaratne, BSc (SL) (from 09.05.2016)
Experimental Officers	M K P Perera, BSc (SL)
Technical Officers (Research & Development)	R P S Randunu, BSc (SL) (up to 10.09.2016)
	Miss P A D T L Madushani, Diploma in Agric.
	Miss A A Amila Nadeeshani, BSc (SL) (up to 31.10.2016)
Management Assistant (Clerical)	Mrs H A Manoji Erandika
Advisory Services	*(at Telewela Road, Ratmalana)*
Head of Department	D M A P Dissanayake, BSc Agric (SL) PhD (Aberdeen)
Advisory Officers	P K K S Gunaratne, BSc Agric (SL)
	R A D Ranawaka
Assistant Training Officer	Miss K G P Manahari, BSc (SL)
Rubber Extension Officers	D Weerasekera
	W D T C Muniratne, Dip. Plant Ex. Mangt.
	D R A M G Abeydissanayake (up to 30.05. 2016)
	R M S Ratnayake, NDT Agric (Hardy)
	D E P M Nanayakkara, Dip. Agric. (Aquinas)

Rubber Extension Officers	W D Chandrasiri (up to 01.03.2016)
	M Dharmadasa, BSc (SL), MSc (SL)
	J A J Perera (up to 09.04.2016)
	E G U Dhanawardena
	Nihal Gamage, Dip. Agric. (Angunakolapelessa)
	U N Jayasuriya
	G D N Seneviratne
	S G G Wijesinghe
	N G Yasaratne
	I P L Kithsiri
	W M A S L Wanigasuriya, Dip. Agric (Aquinas)
	N L Dharmasena
	W P G D C P K Senanayake, NDT Agric (Hardy)
	T L Ramanayake, BSc (SL)
	A R Kulathunga, BSc (SL)
Experimental Officer	S M A Samarakoon, Dip. Agric. (Kundasale)
Management Assistants (Clerical)	Mrs M K Wijetilleke
	Miss S V Shirani Madurika, BA (SL)
	Mrs C Gunatilleke
	Mrs J N R Jayasinghe
	Mrs S M Kaluarachchi
	T R C Silva
	R G A S Dharmaratne
	Mrs K Y G M P Kumari, BA (SL)

Polymer Chemistry	*(at Telewela Road, Ratmalana)*
Head of Department	Mrs A H L R Nilmini, BSc (SL), PhD (Cardiff) (up to 01.03.2016)
Research Officer	Mrs I H K Samarasinghe, BSc (SL)
Experimental Officer	Mrs N Jayawardane, Dip. Agric. (Bibile)
Technical Officers (Research & Development)	Mrs H M H Dhanukamalee, BSc (SL)
	Miss E A K E Edirisinghe, BSc (SL) (up to 06.08.2016)
	M T D C Perera, BSc (SL) (up to 02.12.2016)
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)
	A M K S P Adikari, BSc (SL), MPhil (SL)

Experimental Officers	Mrs L Wanigatunga (up to 12.04.2016)
	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 J A Jayamuthu, BSc (SL) (up to 11.07. 2016)
Management Assistants (Clerical)	Miss W D D Samanmali

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

Head of Department	Mrs D G Edirisinghe, BSc (SL), MSc (SL) MPhil (UK), PhD (SL)
Research Officer	W D M Sampath, BSc (SL)
Experimental Officers	Mrs M K Mahanama, Dip. Rubber Tech. (PRI) (up to 29.01.2016)
	Mrs S I Yapa, Dip. Rubber Tech. (PRI)
	Mrs P C Wettasinghe, Dip. in Science (up to 27.11.2016)
	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)
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) (up to 20.02.2016)
Experimental Officers	Mrs W K C Nalinie, Dip. Rubber Tech. (PRI)
	Mrs U M S Priyanka, BSc (SL), MSc (SL)
	Mrs V C Rohanadeepa
	A K D W Prasad
Technical Officers (Research & Development)	Miss K G P M Dharmatilleke, BSc (SL) (up to 11.03.2016)
	A S Ghouse, Graduate Chemist (up to 11.03. 2016)
	Miss B P Kannangara, BSc (SL) (up to 15.09.2016)

Technical Officers (Research & Development)	B D J H Wijewardana, BSc (SL) (up to 08.02.2016)
	Dinesh Balasooriya, BSc (SL) (up to 28.07.2016)
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.)
Management Assistant (Clerical)	Mrs M A Randima Srimalee
Agricultural Economics Unit	*(at Dartonfield, Agalawatta)*
Research Officers	J K S Sankalpa, BSc (SL), MSc (SL)
	Miss P G N Ishani, BSc Agric. (SL) (from 09.05.2016)
Management Assistant (Clerical)	Miss W W L S Shashikala, BA (SL)
Polgahawela Sub-Station	*(at Narampola Estate, Nungamuwa,Yatigaloluwa)*
Management Assistant (Accounting)	W A C Weeramanthree
Moneragala Sub-Station	(*at Kumbukkana, Moneragala*)
Field Officers	V G D Nishantha Gunaseela
	N V U S Vijitha Kumara
Management Assistants (Clerical)	Mrs D M P Sandun Kumari
	M M Chamath Kumara

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)*
Senior Administrative Officer	D M S Dissanayake, BSc (Mgt.) (SL), MHRM (SL)
Assistant Medical Practitioner	M Subasinghe
Administrative Officers	L P K W Weliwatta, BA (SL), Dip. in HRM (up to 22.02.2016)
	Mrs P Mandalawatta, (Dip. in HRM)
Management Assistants (Clerical)	Mrs P W Neelamanie
	Mrs J A D Wijayanthi
	Mrs B D Niranjala
	Mrs O W D Namali Udayanthi
	Mrs P C Athukorala
	Mrs Thamosha Munasinghe
	Mrs O W D Nilusha Udayanthi
	Mrs M N D Perera
	Mrs B Chandralatha, BA (SL)
	Miss M G L Niroshani
Management Assistant (Stenography)	Mrs J A H S Kumari
Translator	Mrs D N Senevirathna, Dip. Agric. (Kundasale), BSc (SL) (up to 31.03.2016)
Telephone Operator	Mrs J A D C Preethika
Pharmacist	S Lankeshwara (up to 30.03.2016)
Administration Unit (Ratmalana)	*(at Telewela Road, Ratmalana)*
Management Assistant (Clerical)	Mr A T Senaratne
	D P N P Dissanayke
	Harith Kalutharawithana, BSc (SL)
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

Works Section	*(at Dartonfield, Agalawatta)*
Engineering Assistant	Mrs W D D Prasadani, NDES (from 01.06. 2016)
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)
	Udaya Smantha Munindradasa, BA (SL)
Work Supervisor (Electrical)	T M R P Tennakoon
Accounts Section	*(at Dartonfield, Agalawatta)*
Senior Accountant	S S Hewage, CPFA (UK), CBA, FPFA (from 20.05.2016)
Accountant	Mrs A M Lasanthi, BSc (SL)
Accounting Assistant	D D R Lankatilaka, BCom (SL)
Management Assistants (Accounting)	Mrs Irene Perera (up to 29.10.2016)
	Mrs M Gunawardene (up to 08.12.2016)
	Mrs R Handungoda
	Mrs G P Kukulewithana
Management Assistants (Clerical)	A V Nandasena (up to 27.11.2016)
	Mrs K J M C R Fernando
	Mrs C Dissanayake
	A K D A Wickremasinghe
	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
	Miss R P Thilini
	J A J R Lakmal, BA (SL)
	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 Lukshaman, BSc (SL)
Management Assistants	K K P Gunawardena (up to 27.02.2016)
	H D D Achinda
	M A N Sachith Pawinda
	T D Harsha
Field Officer (Nivitigalakele)	B M Siriwardena
Kuruwita Sub-Station	*(at Kuruwita)*
Manager	S A R Samarasekera
Management Assistants (Clerical)	D S Jayasinghe
	K D P Senaratne

* On study leave overseas

Awards

- The prosthetic foot developed by Dr Upul Ratnayake, Dr (Mrs) D G Edirisinghe, Mr W.D. Sampath and Mr Mahesh Abeywardena of RRISL in collaboration with Ranaviru Sevana, Army Rehabilitation Centre, Ragama, received a "Technology Award of Excellence" of the National Science Foundation (NSF), Sri Lanka. This development was made with a technology grant received from NSF, under the category of "Support for Technology Development".

- Dr N.M.C. Nayanakantha, Head, Plant Science Department of RRISL, received the Award for the "Best oral presenter" for the rubber sector at the 6th Symposium on Plantation Crop Research held from 3rd – 5th November 2016, at BMICH, Colombo. He also received an award for the "Contribution made to rubber industry during 2014 – 2015" at the above Symposium.

RUBBER RESEARCH INSTITUTE OF SRI LANKA

DIRECTOR'S REVIEW

R A D S Ranatunge

This review consists of an overview of the rubber industry in the country and in the global scale, Research and Development activities of each Department/Unit of RRISL are given separately under the title of "Activities of Research Departments – 2016".

Rubber industry of Sri Lanka

Rubber production

The natural rubber (NR) production in the country in the year 2016 (up to September) has decreased by 8.5 % from corresponding values of the previous year, *i.e.* from 69,800 tonnes to 63,890 tonnes. Continuous decline of the rubber price since year 2011 would have resulted in neglecting rubber lands which ultimately reflects on overall production in the country. Two largest contributors to the total rubber production in the country, Rubber Smoked Sheet (RSS) rubber declined from 35,022 tonnes to 32,150 tonnes, a reduction of 8.2% and however, Crepe rubber has increased by 26% from 8,563 tonnes to 10,860 tonnes. Concentrated latex production in the country was only 18,168 tonnes with a decline of 28.8% from previous year. Average price of RSS Grade 1 was around Rs.248.55 per kg at the end of 2015 reduced further to Rs.239. 42 per kg at the end of 2016, which is a 3.6% decrease. A kilo of Latex Crepe 1X price dropped by 13% from Rs.301.15 in 2015 to Rs.261 in this period.

Rubber extent

Total rubber extent in the country at the end of 2016 was around 135.4 thousand hectares while the extent under tapping was around 108.7 thousand hectares. The increase in rubber extent was due to the extent of new planting which accounted for 2800 ha.

NR consumption exports and imports

NR consumption in the country in 2016, reduced to 64,000 tonnes from 72,000 tonnes in 2015 up to September. Sri Lanka has exported around 10,300 and 16,000 tonnes of natural raw rubber during the same period in the years of 2015 and 2016, respectively.

Rubber manufacturing sector

Earnings through raw rubber exports was Rs.3,316 million in year 2016 against the Rs.2,671 million in year 2015 up to September period. Export earnings from finished products was recorded as Rs. billion 82 in 2016, with an increase of about 7% against the previous year.

Global rubber industry review

Natural rubber supply:

Total world NR production increased up to 7,569 thousand tonnes in 2016 from the value of 7,504 thousand tones in previous year up to second quarter. World NR production has increased by 0.8% according to International Rubber Study Group (IRSG) statistics. The provisional data received from the member countries of ANRPC indicated an increase of 0.1% year-on-year. This is mainly due to the price improvement in the major markets in Asia Pacific region during the end of the year. While production rose by 1.3% in Thailand, 4.8% in Vietnam, 7.4% in India, it fell 4.0% in china, 9.0% in Malaysia and 0.4% in Indonesia, as per actual figures up to September and preliminary estimates for October and November 2016.

Table 1 gives the annual average yield and mature area in the Association of Natural Rubber Producing Countries (ANRPC) group in years 2016 and 2015. While the average yield declines, the mature area expands in all the countries during 2016. 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. However, these have not been translated into improvement in average yield. The sharp fall in rubber prices especially during the year 2016 would have attributed to the decline in productivity.

Table 1. *The annual average yield per hectare in ANRPC member countries and extents under tapping (up to November)*

Country	Total area ('000 ha)		Tapped area ('000ha)		Yield (kg/ha/year)	
	2015	2016	2015	2016	2015	2016
Cambodia	389	400	111	132	1,140	1,122
China	1,159	1,159	711	720	1,117	1,069
India	811	827	391	436	1,471	1,454
Indonesia	3,621	3,639	3,016	3,021	1,036	1,045
Malaysia	1,079	1,092	650	630	1,410	1,500
Philippines	223	234	-	142	815	_
Sri Lanka	135	135	108	108	819	855
Thailand	_	_	3015	3,130	1,483	_
Vietnam	981	972	600	972	1,695	1,680

***Total rubber demand*:**

Total rubber consumption was 15,599 thousand tonnes in 2016 compared to 15,448 thousand tonnes up to second quarter, in the previous year accounting for 0.9% growth. World NR consumption is being dominated by China with 2,483 thousand tonnes followed by India with 516 thousand tonnes and USA with 474.6 thousand tonnes. China was the highest SR consumer in 2016 followed by USA and European Union countries. China consumed 2,088.4 thousand tonnes of SR and USA consumed 935.8 thousand tonnes in 2016 up to second quarter. According to the international experts, there is a definite hike in the demand for synthetic rubber in the western world, which affects the demand for NR.

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 2 shows the trends in NR consumption and their growth up to Second quarter for major consumers in the world.

Table 2. *Trends in NR demand by major consumers*

	Consumption ('000 tonnes)			Growth (%)*	
	2014	**2015**	**2016**	**2015**	**2016**
China	2,298	2,398	2,483	4.4	3.5
Total EU-28	590	565	609	-4.2	7.8
India	501	500	516	-0.2	3.2
U.S.A.	475	482	475	1.5	-1.5
Japan	350	372	335	6.3	-9.9
Thailand	274	279	310	1.8	11.1
Indonesia	264	262	300	-0.8	14.5
Malaysia	220	232	241	5.5	3.9
Other countries	1,048	1,050	1,004	0.2	-4.4
World	6,020	6,141	6,273	2.0	2.1

(*Up to June)

Based on the statistics up to second quarter, China consumed 39.5% of the total global consumption of natural rubber during 2016. Other major consuming countries are the European Union (9%), India (8%), the US (7%), Japan (5.3%), Indonesia (4.7%), Thailand (4.9%) and Malaysia (3.8%). The growth rate of demand for NR has decreased in USA and Japan. The unsatisfactory performance reflected through continued growth deceleration in emerging and developing economies including China. China has shown a positive growth rate, however, the rate of increase was less than that of previous year.

NR demand and supply gap

Global demand experienced a growth of 2.0% in 2015 while the supply has headed for a 1.9% decrease. The demand supply position for 2016 is also shown in Table 3 in comparison with the previous two years. Global market at the end of second quarter of 2015 was in a deficit of 662 thousand tonnes. Consumption of natural rubber in ANRPC member countries, which account for 65% of the global demand, is anticipated to grow at 4.1% growth during 2016 against the previous year, according to the latest statistics from the association.

Table 3. *Outlook for the demand supply gap*

	Quantity ('000 tonnes)			Growth (%)*	
	2014	**2015**	**2016**	**2015**	**2016**
Production	5,590	5,479	5,553	-1.9	1.3
Consumption	6,020	6,141	6,273	2.0	2.1
Gap	-430	-662	-720		

(* up to Second quarter)

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$ 1.54 a kg in year 2016. Slight recovery of NR prices was observed at the end of year 2016. The average FOB price of RSS3 recorded as US$ 2.39 in Bangkok at the end of year. Average Indian RSS4 has increased to US$2.10 from US$ 1.91per kg against the previous year. According to the ANPRC countries, global natural rubber prices may stay firm due to increasing trend in crude oil prices and as consumption growth outpace production and increase Chinese demand and appreciation of US dollar *etc.*

GENETICS AND PLANT BREEDING

S P Withanage

DETAILED REVIEW

Staff

Dr (Mrs) S P Withanage, Head of the Department, Research Officer Mrs P V A Anushka, Experimental Officers Mr I D M J Sarath Kumara, Mr T B Dissanayaka, Mr H P Peiris, Mr T M S K Gunasekera, Mrs A K Gamage, Technical Officers (Research and Development) Mr B W A N Baddewithana, Miss W A D R Tharanga and Mrs S D P K L Peiris Management Assistant (Clerical) were on duty throughout the year.

Senior Research Officer, Dr P K G S Bandara resigned from the Institute with effect from 30th March 2016. Senior Research Officer, Mr K K Liyanage assumed duties on 04th August after his postgraduate studies, at Kunming Institute of Botany, Chinese Academy of Science China.

Mrs T T D Dhahanayake was assumed duties as a Research Officer with effect from 9th May and K D Piyumi Hasara Kapuge, Management Assistant was transferred to the Accounts Department with effect from 15th October.

Retirement:

Mr L S Kariyawasam, Experimental Officer, retired on 30th January after providing a thirty nine years tremendous service to the RRISL. During his career he worked nearly thirty years at Plant Science Department and the rest at Genetics and Plant Breeding Department. Being an experienced senior officer his guidance has helped young Officers as well his colleagues. His thoughtful steady approach to overcome the problem aroused in the field was remarkable. Especially during establishment of trials in non-traditional area and in managing the smallholder trials his valuable support was significant. Therefore, on behalf of department and RRISL, I wish him and his family good health and happy retirement.

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 PKGSS Bandara	Technical update	10th February, RRI, Dartonfield
	Technical update	6th March RRI, Dartonfield
SP Withanage	Malaysian Rubber Board - IRRDB Workshop on Agronomy and Transfer of Technology	26th - 28th April, Park Avenue Hotel, Kedah Malaysia
	Progress Review Meeting NCPB* Meeting and Progress Review of NARP** Projects	31st May, CARP, Colombo
	NCPB*Meeting and Progress Review of NARP Projects	8th June, CARP, Colombo
	NCPB*Meeting and Progress Review of NARP** Projects	16th June, CARP, Colombo
	NCPB* Meeting and NARP** Projects Evaluation	27th June, CARP, Colombo
	Workshop on Real time PCR	July, University of Colombo, Hemsons (PVT) Ltd.
	Biotechnology Workshop	19th August, HARTI, Colombo, Organized by CARP
	NCPB* Meeting	26th August, CARP, Colombo
	Onsite Research Monitoring	18th November, RRI, Batalagoda
	NCPB* Meeting	21st November, CARP, Colombo
	Awareness Workshop on International Research Grant	13th December, NSF, Colombo
	Seminar on Water Quality and Human Health	4th October, Institute of Chemistry Ceylon, Colombo
SP Withanage PVA Anushka TTD Dahanayake	Scientific Committee Meeting	14th July, RRI, Ratmalana
	Technical Update	11th May, RRI, Dartonfield
	Workshop on Scientific Writing	29th June, RRI, Dartonfield
	Technical Update	20th July, RRI, Ratmalana
TTD Dahanayake	Workshop on organizational results framework	25th July, RRISL, Ratmalana
SP Withanage PVA Anushka	NCPB* Meeting, NARP** Projects Evaluation and Proposal Presentation	29th July, RRI, Batalagoda

Name of the Officer	Seminars/Training Programmes/ Workshops/Exhibitions	Date/Place and Organizer
PVA Anushka TTD Dahanayake	Certificate course on "Plant Breeding Techniques for improvement of Annual food and floricultural Crops"	2nd - 5th August, PGIA, Peradeniya
SP Withanage KK Liyanage TTD Dahanayake	Plant Breeding Workshop	17th -18th RRI, Batalagoda, Organized by CARP
SP Withanage KK Liyanage PVA Anushka TTD Dahanayake	6th Plantation crop Symposium	2nd - 3rd November, BMICH, Colombo. CRI,TRI and RRI jointly organized

***** 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
PVA Anushka	Rubber Breeding and Recommendation - Students of Sabaragamuwa University	02nd February, RRISL, Dartonfield
PVA Anushka	Rubber Breeding and Recommendation - Students of Rajarata University	29th April, RRISL, Dartonfield
PVA Anushka	Rubber Breeding and Recommendation - Students of Uva University	24th December, RRISL, Dartonfield

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

Thirty Microsatellite molecular markers were screened with parents, grandparents and moderately susceptible control clones and found polymorphism in four primers. Polymorphic markers need to be screened with the progeny to find out more molecular markers for develop a marker for early identification of CLF disease resistant genotypes (S P Withanage and W A D R Tharanga).

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

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

Microsatellite molecular markers were screened and three distingue groups were observed (Fig. 1). Other parameters such as girth, bark thickness, bole height, branching pattern and canopy density were also used in genotype screening.

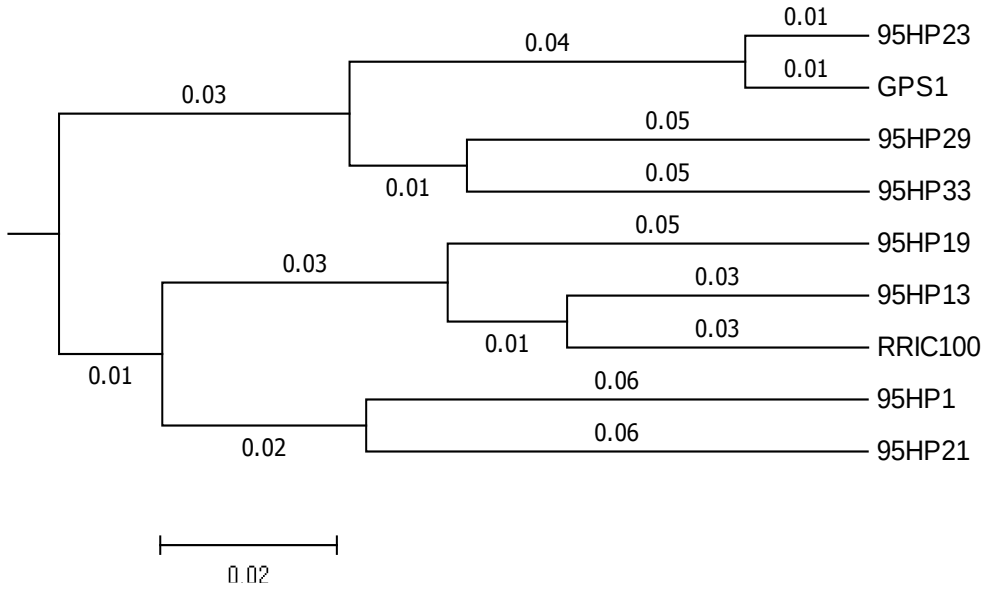


Fig. 1. Genetic distance of selected six genotypes, observed using fifteen Polymorphic Molecular markers
(S P Withanage, L S Kariyawasam, A K Gamage and W A D R Tharanga)

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)

The procedure of total RNA isolation from latex was optimized since latex is a difficult biological material for total RNA isolation. Six methods were tested. Quantity and purity of isolated RNA were analyzed using a spectrophotometer. Integrity of RNA was checked in gel electrophoresis (Fig. 2).

Second and third isolation methods gave good RNA yield and sufficient purity level for cDNA synthesis and qRT PCR (quantitative PCR).

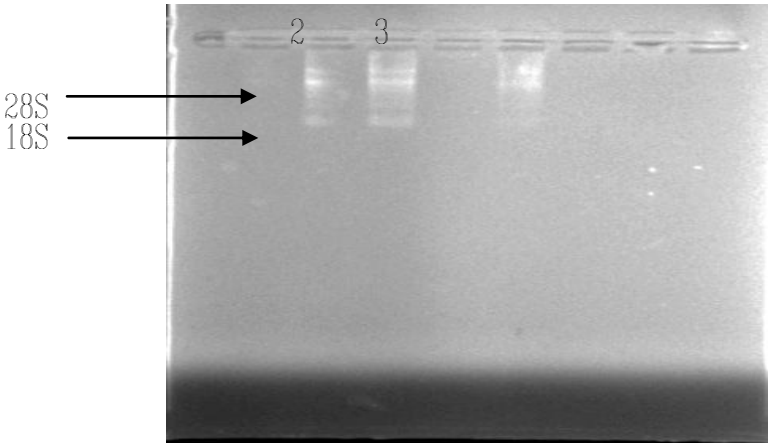


Fig. 2. Integrity of RNA extracted from six methods. Only second and third lanes showed two bands
(P K G S S Bandara, S P Withanage, B W A N Baddewithana and T M S K Gunasekara).

Hand pollination programme

The annual hand pollination programme was done at Neuchatle estate and hundred and twenty one new genotypes were raised. Four 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 2016 hand pollination programme*

Cross	No. of genotypes obtained
RRISL 201x RRISL 2001	17
RRISL 201 x RRISL 2005	08
RRISL 201 x RRISL Cen 2	03
RRISL 208 x IAN 714	07
RRISL 208 x RRISL 2006	09
RRISL 203 x RRISL 2006	07
RRISL 203 x IAN	07
RRISL 211 x IAN	51
RRISL 211 x RRISL 2006	12
Total	121

(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 maintained. 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. Also planting materials were prepared for six clones to be established at the breeding garden (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 could not be possible.

Table 2. *Details of Small Scale Clone Trials*

HP year	Site	Planting season	Current status
1998	N'kele I, II & III	June 2001	8th year of tapping
	Kuruwita Substation I, II & III	July 2001	8th year of tapping
1999	Kuruwita Substation I, II & III	June 2002	6th year of tapping
2000	Delkeith IV & V	June 2003	6th year of tapping
	Elston VIII & IX	July 2003	65th year of tapping
2001	Paiyagala I	June 2006	4th year of tapping
	Kuruwita Substation II	July 2006	4th year of tapping
2002	Pallegoda I	July 2007	2nd Year of tapping
2002	Eladuwa II	May 2009	1st Year of tapping
2004	Eladuwa Trial I	July 2009	1st Year of tapping
2004	Neuchatel Trial II	Nov 2009	1st Year of tapping
2007	Kuruwita Sub station (seedlings)	July 2009	1st Year of tapping
1995	Yatadola I	July 2011	Immature
2006	Payagala	July 2012	Immature
2005	Monaragala	Nov 2014	Immature
2005	Galewatta	May 2016	Immature
2008	Eladuwa	Nov 2016	Immature
2010	Eladuwa	Nov 2016	Immature

Terminations

Five trials as 2000 hand pollination evaluation number I, II, III at Arappalakande and number VI and VII at Nivitigalakele were terminated due to high percentage of tapping panel dryness occurred.

Two trials as 1995 hand pollination evaluation at Katandola and 2008 HP evaluation at Oakwell were terminated due to poor support given by the estate management and unavoidable management circumstances (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)

Girth measurements for thirteen years and eight years yield data were analyzed. The HP entry 90-7 and 90-16 showed the highest mean yield of first eight years next to the control clone RRIC 121 (Fig. 3).

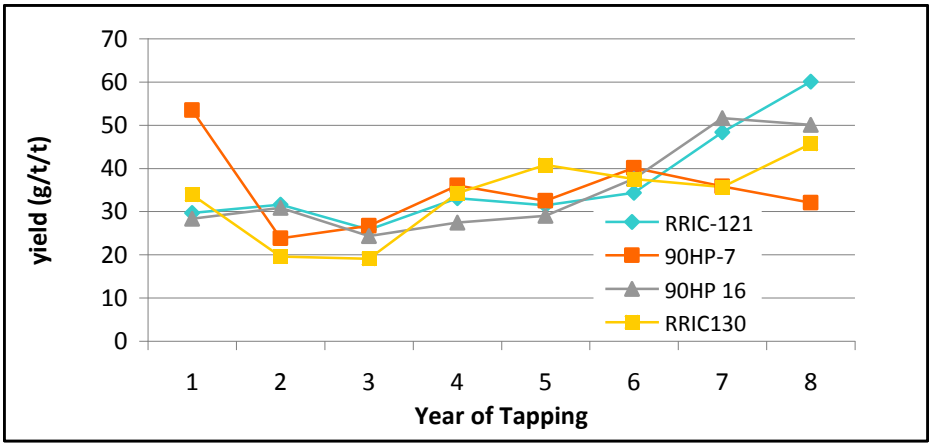


Fig. 3. Mean yield of top most HP entries of the 1990 HP progeny planted at the Kuruwita Substation in 2002
(S P Withanage, P V A Anushka, I D M J Sarath Kumara and H P Peiris)

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

1991 HP clones at Pallegoda estate (GPB/BST/HPS/91/1)

According to the evaluation of girth for thirteen years and seven years yield, found that the control clone RRISL 205 was recorded highest girth but post tapping girth increment was high in RRIC 121. Selections as HP 91-4, HP 91-13 and HP 91-

19 reached to tappable girth by five years along with control clones whereas selections HP91-1 and HP91-21 have taken seven years (Fig. 4). All selections were given higher yield compared to control clones (Fig. 5). Selections were taken into bud wood nursery for multiplication.

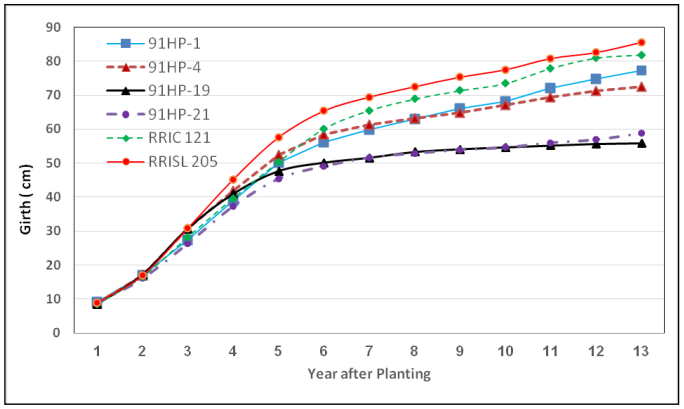


Fig. 4. Girth expansion for thirteen years in selected five HP entries with control clones

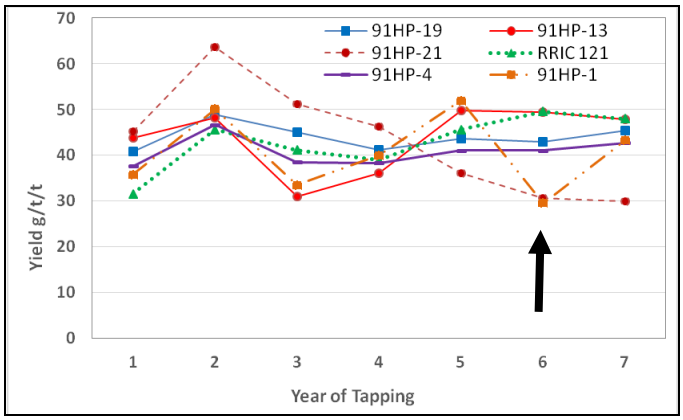


Fig. 5. Yield variation for seven years of five selections and control clones. Black arrow showed the starting of "B" panel

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

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

Two HP entries years as 91- 57 and 91-58 are selected after evaluating girth for sixteen years (Fig. 6), yield and other secondary characters. Selections were established in budwood nursery to taken into large scale evaluation in next year.

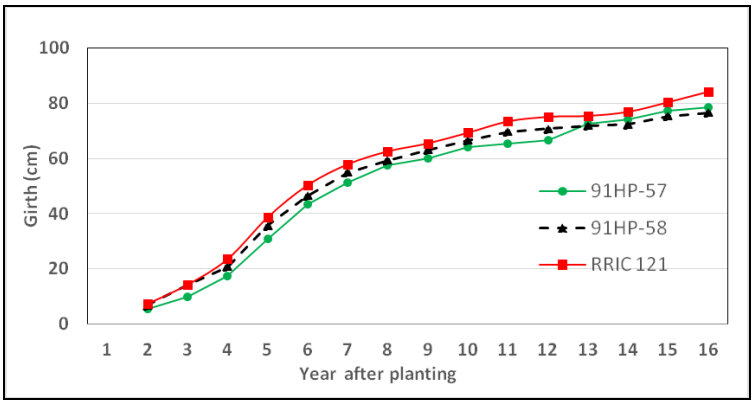


Fig. 6. *Mean girth for sixteen years of best performing HP entries of the 1991 HP progeny planted at Vogan estate*

(S P Withanage, P V A Anushka, K K Liyanage, 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, girth measurements for sixteen years and yield data for seven (for trial 01) and nine (for trial 02) years analyzed. In trial 01, only the selection HP 96 - 14 was recorded yield above to control clones RRIC 121, PB 260 and RRISL 205 (Fig. 7). In trial 02, also only single clone 96 HP - 40 was recorded highest yield compared to control clones. However, three sections were made (Fig. 8).

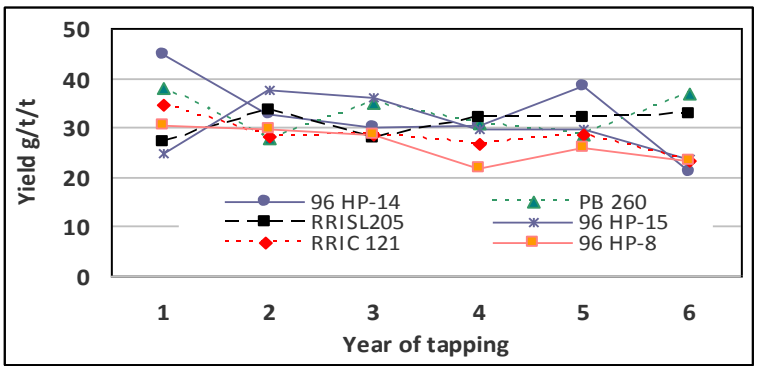


Fig. 7. Mean yield of three selections made from 1996-01 HP trial planted in 1999 with control clones

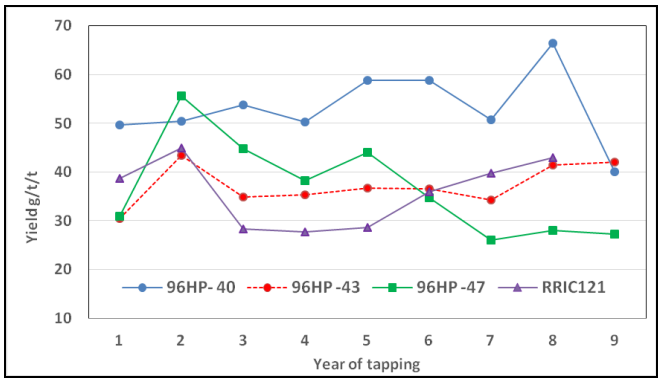


Fig. 8. *Mean yield of three selections made from 1996-02 HP trial planted in 1999 with control clones*

(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 for sixteen years were analyzed for both trials. HP entry 97- 9 was ranked at top in term of girth whereas HP entry 97-67 was the highest in trial 2.

Yield for first six years were analyzed. In trial 01, three HP entries were recorded 36 - 43 g/t/t whereas control clone RRIC 121 was given around 36 g/t/t (Fig. 9). In Trial 02, twelve HP entries were given yield around 40 - 62 g/t/t while control clone was recorded 35 g/t/t (Fig. 10). However, it is need to evaluate their performances further as one third of population, around twenty genotypes were selected for estate RRI collaborative trials to evaluate their commercial level performances.

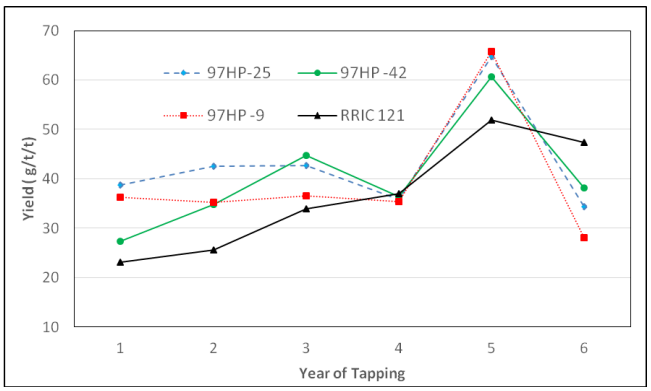


Fig. 9. Six years mean yield of top most HP entries of the 97 HP progeny planted at Clyde estate in 2000 (Trial 01)

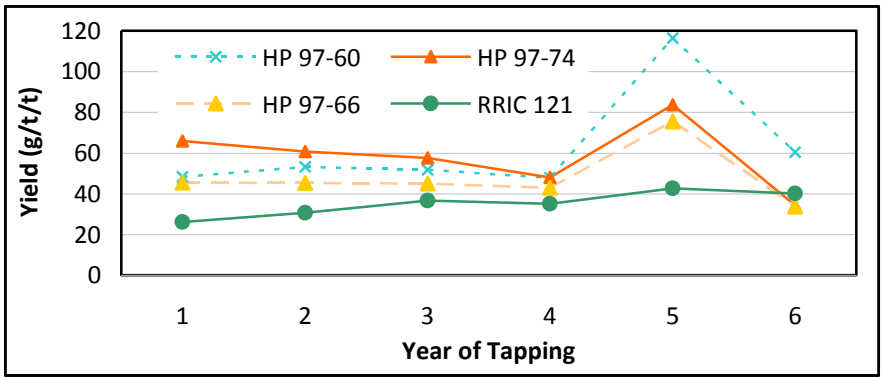


Fig. 10. Six years mean yield of top most HP entries of the 97 HP progeny planted at Clyde estate in 2000 (Trial 02)
(S P Withanage, P V A Anushka, P K G S S Bandara and T M S K Gunasekara)

Evaluation of 1998 HP entries

Girth measurements for sixteen years 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)

Six HP entries as 98 HP – 138, 98 HP- 228, 98 HP- 225, 98 HP- 281, 98 HP-133 and 98 HP 269 have selected based on their yield, girth and bark thickness and considering the brown bast incidences occurred. All these selections were taken into further evaluation of early selectable parameters to shorten the *Hevea* breeding and selection cycle (S P Withanage, T T D Dhanayake, 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)

Genotypes 98-219, 98-105, 98-124, 98-143, 98-236, 98-98, 98-80, 98-68, 98-73 and 98-223 were given more than 40 g/t/t yield in average of six years. 98-80 and 98-219 were recorded highest mean yield of 53.7 g/t/t and 52 g/t/t respectively (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 for fifteenth year were taken for each trial. However, yield data for eighth years was not taken and analyzed seventh year data. 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 3a). With considering the vigour, three HP

entries where have good yield also were selected as Latex-timber clones (Table 03b) (S P Withanage, K K Liyanage, P V A Anushka, P K G S S Bandara and H P Peiris).

Table 3a. *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

Table 3b. *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	85.5[a]	99-157	100.69[a]	99-230	88.37[a]
99-74	82.5[ab]	99-159	81.06[b]	99-156	87.14[ab]
99-73	82.25[ab]	99-167	79.9[bc]	99-216	77.75[abc]
99-67	80.06[abc]	99-47	78.38[bcd]	99-64	76.65[bcd]
99-81	70.9[bcd]	99-236	73.9[bcde]	99-92	76.31[bcd]
99-54	70.68[bcd]	99-161	72.25[bcdef]	99-166	73.56[bcde]
99-55	70.00[bcde]	99-272	71.86[bcdef]	99-63	72.5[cdef]
99-61	69.75[bcde]	99-178	71.63[bcdef]	RRIC 121	72.0[cdefg]
99-52	69.9[bcde]	99-194	70.0[bcdefg]	99-138	71.0[cdefgh]
99-83	69.33[bcde]	RRISL 205	69.67[bcdefg]	99-78	70.75[cdefghi]

(S P Withanage, K K Liyanage, 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 fourteenth year girth measurements are given in Table 4. There was a significant difference between two families in term of girth but not enough data were collected for analysis of the yield.

Table 4. *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	62.13[b]	67.3[a]
Minimum	42.5	45
Maximum	88	115
Variance	148.8	196.84

(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 fourteenth year girth (Table 5) measurements of two families are given below. There is no significant difference observed between two families.

Table 5. *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	58.01[a]	62.25[a]
Minimum	39.5	41.5
Maximum	87	100
Variance	132.82	181.3

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

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. Top most HP

entries were shown (Fig. 11). In Trial IX, 52 genotypes are derived from 11 families with six single tree plots per genotype in a completely randomized design. Eleven genotypes were recorded above 40 g/t/t mean yields of first five years and top most genotypes are given in Figure 12.

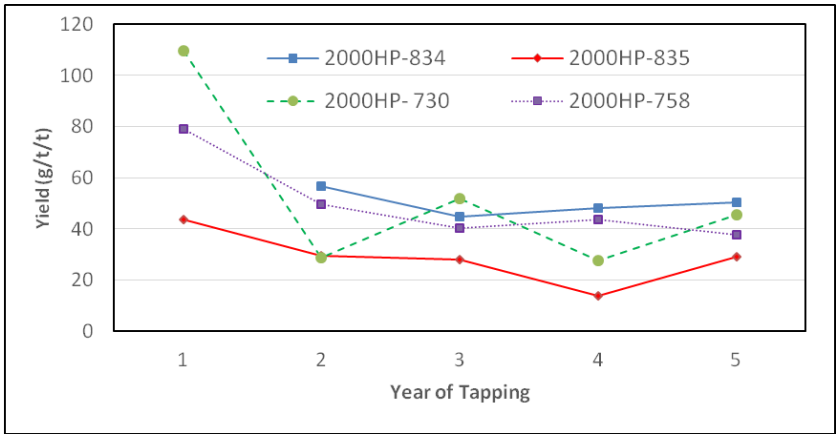


Fig. 11. Top most genotypes out of which recorded high mean yield in first five years of taping of trial VIII at Elston estate, planted in 2003

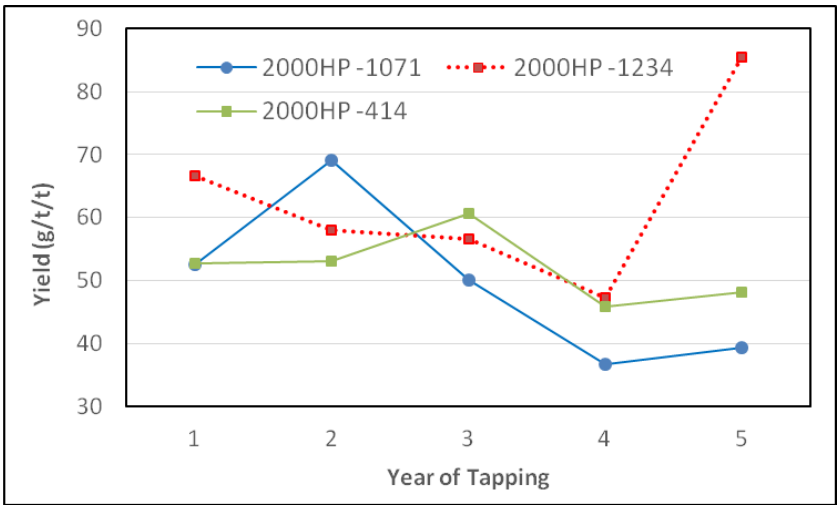


Fig. 12. Top most genotypes out of which recorded above 40 g/t/t/ mean yield in first five years of taping at trial IX planted in 2003

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 ninth year were grouped using the Duncan's multiple range test and top most promising HP entries are given in Table 6. 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. With compared to control clone RRIC 121, six genotypes were performed well.

Table 6. *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 HP-110	66.52^{a}	2001 HP-220	65.35^{a}
2001 HP-249	65.47^{ab}	2001 121	63.9^{ab}
2001 HP-199	65.18^{abc}	2001 HP-185	63.23^{ab}
2001 HP-257	64.37^{abcd}	2001 HP-179	60.78^{abc}
2001 HP-224	62.65^{abcd}	RRISL 203	60.0^{abcd}
RRIC 121	61.0^{bcde}	RRISL 205	58.7^{abcde}
2001-112	60.23^{cdef}	2001 HP-207	57.40^{abcdef}
2001-92	59.43^{cdefg}		
2001-294	59.39^{defg}		

(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)

Ninth 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 7. Around two HP entries performed well compared to control clone RRISL 203. But five HP entries were performed above to clone RRIC 121.

Table 7. *Mean girth of top most HP entries of the 2002 HP progeny planted in 2007*

Clone	Mean girth (cm)
2002-17	67.22[a]
2002-96	66.62[ab]
RRISL 203	66.12[ab]
2002-18	65.89[ab]
2002-11	65.23[ab]
2002-14	64.62[abc]
RRIC 121	63.19[abc]
2002-24	62.97[abc]
2002-67	61.59[abcd]
2002-77	61.47[abcd]

(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. Seventh year girth is shown in Table 8. Yield data collection was started.

Table 8. *Mean girth of top most HP entries of the 2000 HP progeny planted in 2009 at Eladuwa*

Clone	Mean girth (cm)
2002 HP-138	71.8[a]
2002 HP-30	63.07[b]
2002 HP-20	63.0[b]
2002 HP-66	61.67[bc]
2002 HP-93	58.73[bc]
2002 HP-9	58.35[bc]
RRIC 121	56.98[cd]

(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)

Seventh 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 09). 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, six HP entries were ranked above control clone PB 260.

Table 9. *Mean girth of top most HP-entries of the 2004 HP-progeny planted in 2009 at Neuchatle*

Clone	Mean girth (cm)
2004-298	54.13^{a}
2004-115	53.45^{ab}
2004-332	51.71^{abc}
2004-228	51.62^{abc}
2004-10	50.56^{abcd}
2004-15	50.35^{abcd}
PB260	49.16^{abcde}
2004-341	48.71^{abcdef}
2004-346	$48.36^{abcdefg}$
2004-268	$48.05^{abcdefg}$

(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)

Seventh year girth was taken. The HP entry 2004 - 347 showed significantly higher girth and seven entries ranked above the RRIC 121 (Table 10).

Table 10. *Mean girth of top most HP-entries of the 2004 HP- progeny planted in 2009 at Eladuwa estate*

Clone	Girth (cm)
2004-347	55.9^{a}
2004-107	55.9^{a}
2004-48	55.09^{ab}
2004-190	54.19^{abc}
2004-228	54.1^{abc}
RRIC 121	53.82^{abcd}
2004-320	53.27^{abcde}
2004-50	51.81^{abcde}
2004-164	50.87^{bcde}
2004-456	49.5^{cdef}

(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)

Eighth year girth data were collected for the seedling progeny and family means are given in Table 11. Family **RRIC 130 × GP 22-137** was recorded the highest girth.

Table 11. *Family means of 2007 HP - progeny at the Kuruwita Substation planted in 2008*

Family	Girth (cm)
RRIC 130 × GP 22-137	60.68[a]
RRIC 130 × GP 1-2	60.00[a]
RRIC130 × GP 21-163	59.60[a]
RRIC130 × GP 10-154	57.75[a]
45/710 × PB 260	56.98[a]
PB 260 × 45/710	56.74[a]
47/717 × PB 260	52.67[a]
RRIC130 × GP 44-24	50.50[a]
PB 260 × 45/717	49.00[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 GPB/BST/HPS/2008/01

Forty two genotypes from 2008 hand pollination progeny were established at Oakwell estate to evaluate their adaptability for higher evaluations. Average girth of these three year old plants was between 9 - 11 cm (Table 12). However, the field was severely damaged by mammalian pests. Hence, it has taken a decision to terminate this trial due to poor performances and maintenance difficulties,

Table 12. *Mean girth of top most HP-entries of the 2007 HP- progeny planted in 2013 and 2014 at Oakwell estate*

Clone	Mean girth (cm)	
2008-133	11.25[a]	
2008-297	10.69[a]	
2008-209	10.67[a]	
2008-145	10.56[a]	
2008-192	10.43[a]	
2008-203	10.33[a]	
2008-244	10.00[a]	
2008-273	9.75[a]	
2008-127	9.12[a]	
RRISL Cen1	9.65[a]	Replanted in 2014
RRISL 203	8[ab]	
RRIC 121	5.25[b]	

(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 GPB/BST/HPS/2005/01

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.

New planting

Evaluation of 2005 HP progeny planted in 2016 at Galewatta GPB/BST/HPS/2005/02

Thirty five genotypes from 2005 hand pollination progeny which was raised by double selfing of Corynespora susceptible clone RRIC 103, were established at Galewatta division 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 (S P Withanage, P V A Anushka and W A D R Tharanga).

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

Sixteen genotypes selected from 2010 were planted in Eladuwa estate in complete randomized block design with control clones, RRIC 121 and RRISL 2001 (S P Withanage, P V A Anushka and A K Gamage).

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

Eighteen genotypes selected from 2008 were planted in Eladuwa estate in complete randomized block design with control clones PB28/59, RRIC 121 and RRIC 100 (S P Withanage, P V A Anushka and W A D R Tharanga).

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

Annual girth measurements were taken from all the trials. Table 13a (registered clones) and 18b (unregistered clones) show the girth measurements for the year under review and for the previous two years and the planting sites (S P Withanage, L S Kariyawasam, T M S K Gunasekara and W A D R Tharanga).

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

Clone	Site	Year of planting	Girth in cm		
			2014	2015	2016
RRISL 201	Dammeria B	2010	-	26.54	33.2
RRISL 203	Monaragala	2009	32.7	41.6	44.56
	Wewassa	2011	17.1	24.54	32.64
	Lagos	2011	28.1	39.3	47.06
	Muwankanda	2010	26.9	38.27	43.41
	Dammeria B	2010	-	29.21	34.2
	Kamburupitiya* (University)	2011	35.15	45.9	
RRISL 207	Dosert division	2004	-	62.5	
RRISL 208	Dartonfield	1994	74.8	76.17	77.19
	Lagos	2013	-	20.52	31.76
	Moralioya	2010	37.75	42.35	49.06
	Dammeria B	2010	-	25.2	30.0
RRISL 210	Payagala	2006	59.8	62.14	63.51
RRISL 211	Dartonfield	1994	73.1	73.29	75.43
RRISL 212	Kuruwita	2006	52.6	54.92	56.7
RRISL 214	Dosert division	2004	-	52.36	-
	Kuruwita	2006	48.6	49.97	51.7
RRISL 216	Dartonfield	1994	-	79.29	79.56
RRISL 217	Kuruwita	1995			
RRISL 219	Dartonfield	1994	79.6	83.62	85.86
	Kuruwita	2008	45	47.46	49.09
RRISL 2000	Dosert division	2004	64.5	66.45	
	Kuruwita	2005	61.7	65.09	66.9

Clone	Site	Year of planting	Girth in cm		
			2014	2015	2016
RRISL 2001	Dammeria B	2010	-	39.1	46.6
	Muwankanda	2010	25.78	38.38	45.46
	Dammeria B (Hanipe Dev.)	2011	-	26.9	34.6
	Lagos	2013	-	19.03	30.08
	Dosert division*	2004	60.45	61.65	-
RRISL 2002	Dosert division*	2004	60.97	62.02	-
RRISL 2003	Dosert division*	2004	57.5	58.83	-
	Lagos	2013	-	21.39	35.15
RRISL 2004	Dosert division	2004	55	55.63	-
RRISL 2006	Dosert division	2004	-	67.1	-
	Lagos	2013	-	17.21	25.26
	Monaragala*	2009	37.8	47.15	50.28
	Eladuwa*	2009	39.8	45.62	-
	Moralioya*	2010	40.4	44.65	51.3
RRISL 2100	Payagala*	2006	59.4	61.28	62.41
	Monaragala*	2009	41.9	50.47	52.1
	Edalla*	2010	34.1	42.08	51.5
	Kuruwita	2011	20.51	31.96	41.77
RRISL Centennial 3	Kuruwita*	2009	46.2	52.42	57.58
	Monaragala*	2009	34.3	44.78	47.2
	Eladuwa*	2010	53.69		59.86
	We-oya	2010	41.58	48.75	52.66
	Edalla*	2010	36.06	46.62	55.55
	Kuruwita*	2010	22.29	36.23	46.41
	Siriniwasa	2011	38.5	45.89	-
	Lagos	2013	-	23.63	33.3
RRISL Centennial 4	Pallegoda	2007	54.3	64.9	-
	Kuruwita	2007	53	53.95	55.1
	Eladuwa*	2009	41.2	46.96	52.02
	Monaragala*	2009	40.5	49.48	51.0
	Lagos	2011	20	36.72	46.06
RRISL Centennial 5	Pallegoda	2007		63.5	67.6
	Eladuwa	2009		45.46	52.8
	Kuruwita	2007	52.93	54.8	57.66

Table 13b. *Mean annual girth measurements of un-registered 2004- entries selected to ECTs (Estate/ RRISL Collaborative Trials)*

Clone	Site	Year of planting	Girth in cm		
			2014	2015	2016
78-140	Eladuwa	2006	51.4	53.25	53.38
78-198	Eladuwa	2006	60.1	63.5	64.38
78-150	Nivitigalakele	2006	69.2	73.50	79.43
78-260	Eladuwa	2006	54.3	56.23	57.24
78-278	Kuruwita	2006	55.6	57.9	60.26
78-334	Eladuwa	2006	60.7	63.19	63.71
78-341	Eladuwa	2006	-	58.09	58.69
78-510	Kuruwita	2006	56.6	58.64	60.58
78-534	Kuruwita	2006	52.5	54.65	57.37
78-689	Eladuwa	2006	53.3	56.24	56.71
78-759	Kuruwita	2006	53.2	54.93	56.47
78-770	Kuruwita	2006	54.7	56	57.78
78-873	Kuruwita	2006	53.8	56.16	57.89
86-10	Kuruwita	2009	37.1	42.82	46.65
86-87	Kuruwita	2009	39.5	45.13	49.89
87-139	Eladuwa	2009	45.1	42.82	56.94
87-235	Kuruwita	2008	39.9	42.76	46.97
92-129	Pallegoda	2007	59.0	60.9	64.8
	Kuruwita	2007	52.2	53.41	55.91
92-250	Pallegoda	2007	59.2	66.6	74.76
92-279	Pallegoda	2007	60.5	63.38	72.76
95-33	Kuruwita	2004	-	53.27	-
95-55	Kuruwita	2004	-	56.16	-
95-55	Lagos	2013		19.96	30.63
GP 12-93	Kuruwita	2006	50.9	53.27	55.12
GP 22-137	Payagala	2006	60.3	65.35	68.46
GP 44-24	Payagala	2006	55.3	56.84	58.6
RRIC 100 seedlings	Kuruwita	2005	60.5	64.6	66.5

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 14.

Table 14. *Clone, year of tapping and average yield (g/t/t) of ECT (Galewatta) trials*

Clone/Selected HP- entry	Year of tapping	Average (g/t/t)
RRISL 208	13	66.69
RRISL 211 (S2/d 2) *	13	53.72
RRISL 211 (S2/d 3) *	13	50.66
RRISL 216	13	40.68

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

(S P Withanage, K K Liyanage, 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 values of the five clones obtained from three sites planted in year 2001, 2003 and 2009 are given in Table 15a and some of their mean yields are given in Table 15b.

Table 15a. *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	65.7
	RRISL 205	2003	69.7
	RRISL 121	2003	65.7
	RRISL 206	2003	59.0
Kegalle	RRISL 201	2001	85.3
	RRISL 203	2001	73
Godagama	RRISL 205	2001	77.7
	RRISL 201	2001	74.5
	RRISL 203	2001	69.3

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

Table 15b. *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)		
		2014	**2015**	**2016**
RRISL 201	Kegalle (SRT/01/01)	48,1	41.73	Tapping was not done properly due to low rubber prices and tapper scarcity
	Homagama (SRT/01/03)	64.7	70.34	
RRISL 203	Kegalle (SRT/01/01)	34.5	46.22	
	Homagama (SRT/01/03)	47.2	40.51	
RRISL 205	Kegalle (SRT/01/01)	-	-	
	Homagama (SRT/01/02)	24.3	-	

(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.

Thousand eight hundred and thirty number of accessions were selected for this year multiplication and establishment. All these accessions were preliminary characterized under different categories such as early and late wintering, high girth, dwarf, tall, smooth bark *etc*. Then they were pollarded and established the seedling nursery for bud grafting. Completed the planting in Nivitigalakele Substation (S P Withanage, K K Liyanage, 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. However, some trials were abandoned due to poor support of smallholders.

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 16.

Table 16. *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	Fourth year girth (cm)
SRT-EP 12/1	SM Wirawardana Marawa Padiyathalawa	IL2	> 1600	RRISL 2001	30.29
				RRISL 203	27.73
				RRISL 2005	28.22
				RRISL 2006	27.08
SRT-EP 12/2	Indrani Kusumalatha Marawa Padiyathalawa	IL2	>1600	RRISL 203	41.27
				RRIC 121	36.57
				RRISL 2001	37.44
				RRISL 2006	32.96
SRT-EP 12/3	AM Sumanawathi Helakomana Padiyathalawa	IL2	> 1600	RRISL 203	31.56
				RRIC 100	31.07
				RRISL 2005	30.29
				RRISL 208	25.5
SRT- EP12/4	HM Wimalasena Kudaharasgala Mahaoya	IL2	> 1600	RRISL 208	24.31
				RRISL 2005	25.78
				RRIC 100	24.33
				RRISL 203	24.22
SRT-EP 12/5	YB Thilakarathna Harasgala, Mahaoya	IL2	>1600	RRISL 203	18.68
				RRIC 121	16.12
SRT-EP 12/6	Sakyas Farm Padiyathalawa	IL2	>1600	RRISL 2001	Fire damaged
				RRISL 2006	
				RRISL 203	28.5
				RRIC 121	28.7
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	41.1
				RRISL CEN 3	41.2
				RRISL 2001	42.1
				95-55	43.3
				RRISL 203	38.5

(S P Withanage, K K Liyanage, 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 17).

Table 17. *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	Third year girth (cm)
SRT-EP 13/1	HM Jayarathna 17-1 C Lathugala Warankatagoda	DL2a	> 1300	RRIC 121 (210)	21.4
SRT-EP 13/3	HM Shantha Kumara 51 C Lathugala Warankatagoda	DL2a	> 1300	RRIC 121 (210)	15.00
SRT-EP 13/4	HM Saman Kumara 17/1 B Lathugala Warankatagoda	DL2a	> 1300	RRISL 203 (210)	17.9
SRT-EP 13/5	M Chandrani Ranasingha 51 B – 2 Lathugala Warankatagoda	DL2a	> 1300	RRISL 203 (210)	13.8

(S P Withanage, K K Liyanage, T T D Dahanayake, 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 18 with their first year girth.

Table 18. *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**	**Second year Girth (cm)**
SRT-EP 14/1	G Senevirathne Mahaoya	IL2	>1600	RRIC 121 (210)	13.3
SRT-EP 14/2	M Senevirathne Mahaoya	IL2	> 1600	RRISL 2001 (210)	10.99
SRT-EP 14/3	A M Jayasekara Mahaoya	IL2	>1600	RRISL 2006 (210)	12.92
SRT-EP 14/4	T M Amarasena Mahaoya	IL2	>1600	RRISL 2005 (210)	13.21

(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 19.

Table 19. *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	Second year girth (cm)
SRT-UP 14/1	DM Arunashantha Siyabalanduwa	DL 1b	>900	RRISL 203 (260)	Abandoned
SRT-UP 14/2	UAH Kumara Buttala	IL1c	>1300	RRIC 121 (210)	Abandoned
SRT-UP 14/3	PTG Newton Etiliwewa	DL 1a	>1100	RRIC 121 (210) RRISL 2100 (210) RRISL 203 (210) RRISL 2001 (210)	8.15 6.1 8.6 8.75
SRT-UP 14/4	SM Ruwansiri Monaragala	IL 1c	>1300	RRISL 2001 (210)	Abandoned
SRT-UP 14/5	MT Kumarage Sellakataragama	DL5	>600	RRIC 121 (210)	Abandoned

(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 20. Girth measurements were not taken due to poor growth.

Table 20. *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	First year girth (cm)
Bibile (collaborate with World Vision)					
SRT-UP 15/1-WV	HM Punchibanda Ilukpathana	IL1c	>1300	RRISL 2001-(215)	Not taken
SRT-UP 15/2-WV	AM Karunawathie Ilukpathana	IL1c	>1300	RRISL 2001 (215)	Not taken
SRT-UP 15/3-WV	HMW Wijekumara Kudumirisketiya Ilukpathana	IL1c	>1300	RRISL 2001 (430)	Not taken
SRT-UP 15/4-WV	Chandana Kumara Radaliyagoda Ilukpathana	IL1c	>1300	RRISL 2001- (115)	Not taken
Kataragama					
SRT-UP 15/5	GKChaminda Diyawaragmmana Junction, Sella Rd	DL 5	>650	RRISL2001 RRISL 203 (215)	Not taken

(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 21.

Table 21. *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	First year Girth (cm)
SRT–CP 15/1	W Wekunagoda Palapaththla Seelan Estate Koongahamulla Palapathwala			RRISL 2001 (125) RRISL2005 (125) RRISL 2006 (125) RRISL 2100 (125)	Not taken
SRT – CP 15/2	PM Gunasekera Palapaththla Madawalaulpotha	IM3B	>1200	RRISL 2001(125) RRISL 2005 (125) RRISL 2006 (125) RRISL 2100 (125)	Not taken due to heavy weeds
SRT – CP 15/3	Willium Bogstoa Hathamunagala Est (A divi) Madawalaulpotha			RRISL 2001 (125) RRISL 2005 (125) RRISL 2006 (125) RRISL 2100 (125)	Abandoned

(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 22.

Table 22. *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	First year girth (cm)
SRT-NCP 15/1	Army camp Kandakaduwa Polonnaruwa	DL1c	>900	RRISL 2001 (500) RRISL 2006 (500)	6.51

(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 23.

Table 23. *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**	**First year girth (cm)**
SRT –NWP15/1	LA Karunawathie, Uriyawa Anamaduwa	DL3	>800	RRISL2001 (75) RRISL2005 (75) RRISL2006 (75) RRISL2100 (75)	Not Taken
SRT -NWP 15/2	HM Somalatha Uriyawa Anamaduwa	DL3	>800	RRISL2001 (75) RRISL2005 (75) RRISL2006 (75) RRISL2100 (75)	Not Taken

Trial	Smallholder and Location	Agro climatic Region	75% expectancy value of Annual rainfall (mm)	Clone and no: of plants	First year girth (cm)
SRT-NWP 15/3	Ven; Dhammananda Tero, Kelegama, Anamaduwa	DL3	>800	RRISL2001 (125) RRISL2005 (125) RRISL2006 (125) RRISL2100 (125)	Abandoned
SRT-EP 14/4	Ananada Madawila Kotawehera Nikawaratiya	DL3	>800	RRISL2001 (90) RRISL2005 (90) RRISL2006 (90) RRISL2100 (90)	Abandoned

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

PLANT SCIENCE

N M C Nayanakantha

DETAILED REVIEW

Staff

Dr N M C Nayanakantha, Principal Research Officer, was appointed as the Head of the Department with effect from 1st June 2016. 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, Mrs E U M de Z Dissanayake and Mr H A U Deshapriya, Technical Officers, Mrs D E Jayawardena and Mrs P D A H M A de Almeida, Management Assistants were on duty throughout the year.

Miss B M S S Panditharathna and Miss K S D N Senanayake were appointed as Research Officers with effect from 9th May 2016.

Miss N C Jayawanthi, Mrs B V H Madhushani and Miss L A R Amarathunga, Technical Officers, resigned from RRISL with effect from 13th July, 11th November and 14th November 2016 respectively.

Resignations & Retirements:

Dr A M W K Senevirathna resigned from the RRISL with effect from 31.12.2015, after 19 years of service at the RRISL, to join the Uva Wellassa University as a Senior Lecturer (Grade I). He was the Head of the Plant Science Department at the time of his resignation. His contribution to rubber industry in the capacity of a physiologist is remarkable. Also, he made a valuable contribution in developing rubber nurseries in the country through monitoring and certifying them for quality improvement. He is a Presidential Award winner in 2003 and 2008 for outstanding international publications, and has made a number of intimation publications on his research mainly on Rubber x Banana intercropping systems, plant physiology and Tapping Panel Dryness of rubber. He has served in number of International (IRRDB) and National Committees and Task Forces and was an active member in several professional bodies.

Research students

- Miss P S S Rodrigo, University of Ruhuna, conducted her final year project on "Effect of different sowing media on germination and growth of rubber (*Hevea brasiliensis*) seedlings" under the supervision of Dr N M C Nayanakantha and Dr (Mrs) P Seneviratne.

- Miss S A M Kavindi, University of Ruhuna conducted her final year project on "Effect of nitric oxide donor sodium nitroprusside on growth and physiological parameters of budded rubber (*Hevea brasiliensis)* plants" under the supervision of Dr N M C Nayanakantha.
- Miss S P P Silva, University of Wayamba, conducted her final year project on "Influence of selected clonal seedling rootstocks on growth of young-budded rubber (*Hevea brasiliensis)*" under the supervision of Dr N M C Nayanakantha and Dr (Mrs) P Seneviratne.
- Miss P M P S Vijithasiri, University of Ruhuna, conducted her final year project on "Effect of exogenous application of salicylic acid on physiological and morphological changes of rubber (*Hevea brasiliensis*) seedlings under water stress" under the supervision of Mrs S A Nakandala.
- Miss D L D Amarasinghe, University of Ruhuna, conducted her final year project on "Growth and yield performance of Cinnamon (*Cinnamomum verum*) under four spatial arrangements of rubber (*Hevea brasiliensis* Muell Arg*.)"* under the supervision of Mr T U K Silva.
- Miss I D H N Weerawansha of Aquinas University College of Sri Lanka completed her final year project on "Growth performance of Cinnamon under four spatial arrangements of rubber in Kuruwita" under the supervision of Mr T U K Silva.

Seminars/Training Programmes/Workshops/Exhibitions conducted

Subject/Theme	Number of programmes	Beneficiary/Client	Officers involved
Nursery management	15	University students NIPM students Agricultural Diploma students Rubber Development Officers Smallholders (SPEnDP)	NMC Nayanakantha
Tapping	09	CEO & Managers of Kotagala Plantation University students NIPM students Agricultural Diploma students	NMC Nayanakantha
Field Establishment and immature upkeep	03	NIPM students Rubber Development Officers	SA Nakandala

Subject/Theme	Number of programmes	Beneficiary/Client	Officers involved
Tapping	07	University students NIPM students Agricultural Diploma students Rubber Development Officers	TUK Silva
Intercropping	12	University students NIPM students Agricultural Diploma students Rubber Development Officers Smallholders (SPEnDP)	TUK Silva
Bud grafting	02	CEO & Managers of Kotagala Plantation RDD Nursery workers	LN de Zoysa MN de Alwis
Nursery management	02	Smallholders	LN de Zoysa
Field Establishment & Immature Upkeep	02	Rubber Development Officers Smallholders (SPEnDP)	LN de Zoysa
Tapping	01	Smallholders (SPEnDP)	PD Pathirana
Tapping	10	Smallholders (SPEnDP) Field staff & Tappers of RPCs NIPM Students University students Agricultural Diploma Students	P KW Karunatilaka

Seminars/Conferences/Meetings/Workshops attended

Officer	Subject	Organization
NMC Nayanakantha SA Nakandala TUK Silva KSDN Senanayake BMSS Panditharathna	Scientific Committee Meeting	Rubber Research Institute of Sri Lanka

Officer	Subject	Organization
NMC Nayanakantha SA Nakandala TUK Silva KSDN Senanayake BMSS Panditharathna GAS Wijesekera RK Samarasekara MN de Alwis DLN de Zoysa PD Pathirana PKW Karunatilaka R Handapangoda EUM de Z Dissanayake HAU Deshappriya BVH Madushani LAR Amarathunga	6th Symposium on Plantation Crop Research	Jointly organized by Coconut Research Institute, Rubber Research Institute, Tea Research Institute & Sugarcane Research Institute
NMC Nayanakantha TUK Silva	International Symposium on Agriculture and Extension	University of Ruhuna
NMC Nayanakantha SA Nakandala KSDN Senanayake BMSS Panditharathna	Workshop on Effective Proposal Writing	Sri Lanka Institute of Development Administration (SLIDA), Colombo
NMC Nayanakantha SA Nakandala TUK Silva KSDN Senanayake BMSS Panditharathna	Workshop on Organizational Research Framework	Rubber Research Institute of Sri Lanka
NMC Nayanakantha	27th Annual Congress of Post Graduate Institute of Agriculture	University of Peradeniya
	Agricultural Extension National Conference	University of Peradeniya
	6th Research Symposium	Uva Wellassa University
	District Committee Meeting, Kilinochchi	Divisional Secretariat Office, Kilinochchi
	Technical Evaluation Committee meeting for purchasing of polybags for government rubber nurseries	Rubber Development Department (RDD)
	Progress Meeting	Ministry of Plantation Industries (MPI)

Officer	Subject	Organization
NMC Nayanakantha	Biotechnology Workshop	Sri Lanka Council for Agricultural Research Policy (SLCARP)
	International Workshop on Coping Mechanisms for Low Rubber Price	Rubber Research Institute of Sri Lanka (RRISL) and International Rubber Research and Development Board (IRRDB)
	Workshop on Effective Proposal Writing	National Science and Technology Commission (NASTEC)
	Workshop on Introduction of New Subject Areas for A/L Programme	National Institute of Education (NIE), Maharagama
TUK Silva	Progress Meeting	Post Graduate Institute of Agriculture, University of Peradeniya
	Bark Anatomy and Physiology	RRI, CATAS, China
BMSS Panditharathna KSDN Senanayake	28th Annual Congress of Post Graduate Institute of Agriculture	University of Peradeniya
PKW Karunatilaka	Short Course on Rubber	Rubber Authority of Thailand

Services

Testing the quality of polythene

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

Supplying the technically specified tapping knives and marking plates

About 2800 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. 157 marking plates were supplied to stakeholders (N M C Nayanakantha, P Seneviratne, W Karunathilaka and D E Jayawardana).

Issuing authentic budwood and budded plants

Budwood and budded plants were not issued for the year under review (N M C Nayanakantha, P Seneviratne and R Handapangoda).

Nursery inspection

Government, RPC and Private nurseries were inspected and details are given in Tables 14, 15 & 16 (N M C Nayanakantha, P Seneviratne, M N de Alwis, L N de Zoysa and R Handapangoda).

Visits

Advisory	-	141
Experimental	-	420
Nursery inspection	-	83
Other	-	54
Total	-	**698**

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)

Wintering and flowering were observed for 20 clones at five estates and one small holder field (Dompe) during January-February. The time period of completion of wintering is depicted in Table 1. Individuals of RRIC 130 also showed a complete wintering at Millewa estate although this clone is known to show a partial wintering in early occasions in other estates. Majority of the clones completed wintering during 3-4th week of February. However, RRISL 206 and RRISL 220 at Salawa estate showed early wintering (1st week of January) (N M C Nayanakantha, P D Pathirana and P Seneviratne).

Seed production (CC/2003/1/b)

Seeds were collected from 20 clones from five estates and one small holder field (Dompe) as depicted in Fig. 1. A drastic reduction in seed production was recorded for 2016 than for 2015 irrespective of clones and sites. Nevertheless, a satisfactory seed production was recorded from RRIC 100 at Pallegoda and RRISL 201at Kuruwita. However, seed production of RRIC 100 was not satisfactory in other estates and the small holder field, mainly due to *Phytophthora* leaf and pod disease causing premature fall of infected pods. Interestingly RRIC 121 recorded a comparatively higher seed production for 2016 than for 2015 at the small holder field at Dompe. Although BPM 24, RRISL 217, RRISL 220 and RRISL 226 showed a satisfactory seed production for 2015, none of them yielded a satisfactory seed production for 2016. Unfortunately the clones such as RRISL 203 and RRISL 2001 recommended for the small holders have recorded a low seed yield in current year similar to that in previous years (N M C Nayanakantha, P D Pathirana and P Seneviratne).

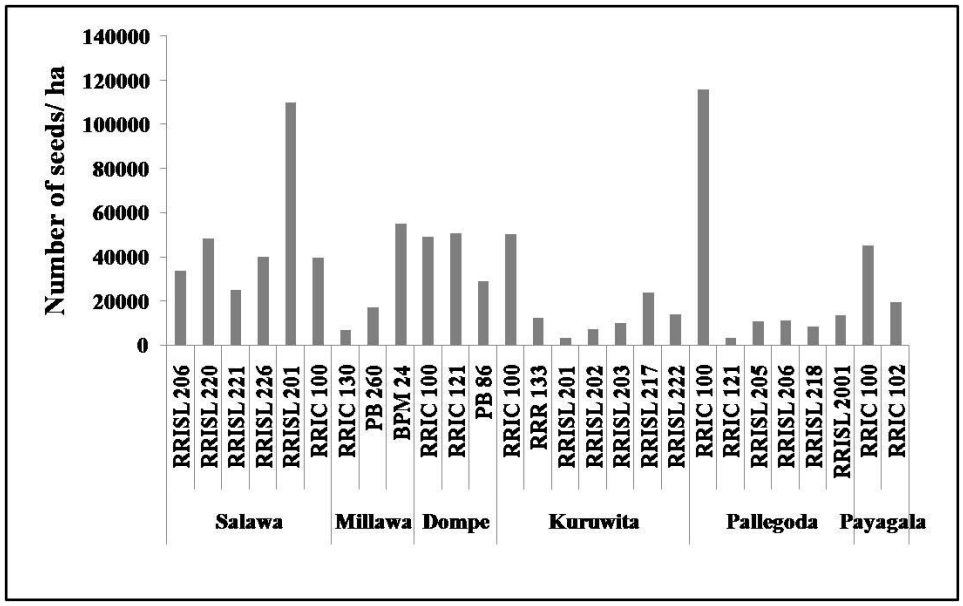


Fig. 1. Total seed production in each clone in different estates

Investigation on cost effective sowing media for germination of rubber seeds (SM/ 2016/Dartonfield)

An experiment was commenced to see the effect of different sowing media on germination dynamics of rubber seeds. Fresh rubber seeds were sown in different sowing media, as depicted below, in a net house according to a RCBD design.

Control : River sand
Treatment 1 : Coir dust
Treatment 2 : Sea sand (reclaimed/purified)
Treatment 3 : Quarry dust (fine)
Treatment 4 : Quarry dust (coarse)
Treatment 5 : Sea sand + River sand (1:1)
Treatment 6 : Sea sand + Coir dust (1:1)

All sowing media were effective for germination of rubber seeds, although the medium containing sea sand: river sand showed significantly a low germination percentage as compared to control (Fig. 2).

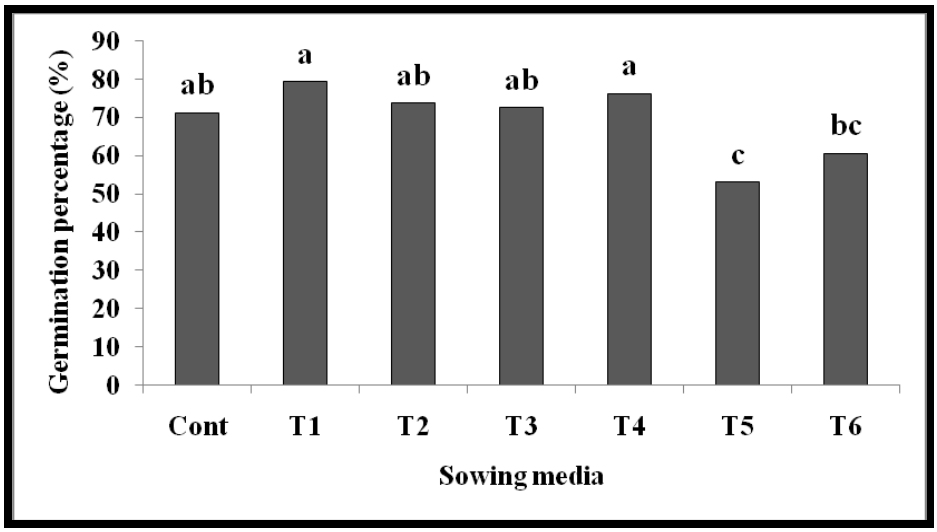


Fig. 2. Effect of sowing media on germination of rubber seeds after 14 days of sowing

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

Growth attributes of seedlings raised from seeds sown in all sowing media were satisfactory after three months from transplanting into poybags (Table 2 & 3).

Table 2. *Growth attributes of seedlings raised from seeds sown in different sowing media after three months from transplanting into polybags*

Treatment	Plant height	Stem diameter	Chlorophyll content	Leaf area	Dry weight of shoot
Cont.	58.9±3.07^{b}	6.8±0.17^{ab}	57.5±0.86^{a}	624.6± 48.06^{b}	10.1±0.3^{bcd}
T1	55.4±2.52^{b}	7.6±0.26^{a}	57.6±3.05^{a}	682.6± 66.81^{b}	10.4±1.2^{bc}
T2	71.0±4.05^{a}	7.6±0.27^{a}	54.3±26^{a}	1191.3± 210.34^{a}	14.8±1.1^{a}
T3	55.8±2.31^{b}	6.9±0.21^{ab}	57.5±1.29^{a}	572.4 ± 83.24^{b}	9.8±0.6^{bcd}
T4	56.7±2.39^{b}	7.3±0.18^{ab}	58.9±.17^{a}	614.8± 108.22^{b}	11.2±1^{b}
T5	57.7±2.98^{b}	6.6±0.22^{b}	58.4±0.77^{a}	418.7± 38.05^{b}	7.5±0.3^{d}
T6	57.6±3.96^{b}	6.9±0.39^{ab}	58.8±2.24^{a}	472.6± 59.74^{b}	8.1±0.6^{cd}

Table 3. *Root attributes of seedlings raised from seeds sown in different sowing media after three months from transplanting into polybags*

Treatments	Length of tap root	Dry weight of ESR+SR	Dry weight of tap root	Dry weight of total roots
Cont.	41.16±4.6[a]	1.79±0.1[ab]	2.30±0.2[ab]	4.10±0.2[abc]
T1	44.10±3.6[a]	2.28±0.3[a]	3.05±0.1[a]	5.33±0.2[a]
T2	42.42±4.1[a]	1.63±0.7[ab]	2.98±0.5[a]	4.61±0.4[ab]
T3	41.70±3.1[a]	1.67±0.2[ab]	2.22±0.1[ab]	3.89±0.1[bc]
T4	43.88±2.2[a]	1.45±0.1[b]	2.30±0.2[ab]	3.76±0.3[bc]
T5	38.96±4.8[a]	1.41±0.2[b]	1.85±0.0[b]	3.27±0.2[c]
T6	41.46±3.5[a]	1.57±0.3[ab]	1.84±0.1[b]	3.42±0.2[bc]

ESR: Early Secondary Roots; SR: Secondary Roots

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

Priming of rubber seeds for improved germination dynamics, seedling and budded plant attributes and tolerance to abiotic stresses (ST/2013/DF)

There was no effect of sodium nitroprusside (SNP) or seed coat treatment on budgrafting performance. The budgrafting success was 80-85% in all cases, including control. Interactive effects were not observed for any of the parameters *viz.*, diameter of the scion shoot, length of the scion shoot, leaf area and chlorophyll content of the leaves between seed coat treatment and SNP treatment (Table 4 & 5). Nevertheless, growth characteristics of the scion shoots of stock plants derived from seeds with SNP treatment, especially at 20µM, were relatively better though statistically not significant.

Table 4. *Effect of seed treatment with NO donor SNP on scion shoot characteristics of budded rubber plants*

Treatment	Shoot diameter (mm/plant)	Shoot length (cm/plant)	Leaf area (cm^2 /plant)	Chlorophyll content (SPAD value)
Control	5.13 ± 0.18[a]	21.08 ± 0.73[a]	204.48 ± 19.59[a]	40.73 ± 2.03[b]
Water soaked	5.69 ± 0.28[a]	26.75 ± 1.84[a]	157.37 ± 23.72[a]	44.55 ± 1.68[ab]
Soaked in 20µM SNP	5.84 ± 0.31[a]	27.36 ± 2.74[a]	229.68 ± 48.67[a]	45.23 ± 1.61[ab]

Treatment	Shoot diameter (mm/plant)	Shoot length (cm/plant)	Leaf area (cm^2 /plant)	Chlorophyll content (SPAD value)
Soaked in 50µM SNP	5.74 ± 0.25^{a}	24.73 ± 2.53^{a}	164.11 ± 28.65^{a}	40.81 ± 1.59^{b}
Soaked in 100µM SNP	5.44 ± 0.25^{a}	21.47 ± 1.61^{a}	209.33 ± 42.15^{a}	42.61 ± 1.65^{ab}
Soaked in 200µM SNP	5.62 ± 0.35^{a}	22.23 ± 1.68^{a}	183.13 ± 32.93^{a}	46.27 ± 1.05^{a}

(N M C Nayanakantha, K D Madushani and L A R Amarathunga)

Table 5. *Effect of seed coat treatment on scion shoot characteristics of budded rubber plants*

Treatment	Shoot diameter (mm)	Shoot length (cm)	Leaf area (cm^2)	Chlorophyll content (SPAD value)
Intact seeds	5.54 ± 0.16^{a}	24.77 ± 1.31^{a}	172.43 ± 17.80^{a}	42.74 ± 0.91^{a}
Decoated seeds	5.62 ± 0.16^{a}	23.14 ± 1.05^{a}	210.27 ± 20.46^{a}	43.99 ± 1.07^{a}

(N M C Nayanakantha, K D Madushani and L A R Amarathunga)

Priming of rubber seedlings/budded plants for improved growth attributes and tolerance to abiotic stresses (PR/2013/DF)

1. Effect of sodium nitroprusside (nitric oxide donor) as a priming agent for growth improvement and abiotic stress alleviation in rubber plants

i. Glass house experiment at Dartonfield

Budded plants from PB 260 at two leaf whorl stage were treated with SNP at four concentrations as mentioned below in a glass house.

Control : No water/ SNP treatment
Treatment 1 : Mock treatment (spray with water)
Treatment 2 : Spray with SNP 20 µM
Treatment 3 : Spray with SNP 50 µM
Treatment 4 : Spray with SNP 100 µM
Treatment 5 : Spray with SNP 200 µM

Physiological attributes *viz.,* leaf chlorophyll content, net photosynthesis rate (*A*) and stomatal conductance (*gs*) were measured before imposing the treatments and one month after the treatments. Since the day time temperature was very high in the glass house ($37\text{-}43C^{0}$), plants had already been subjected to heat stress and that could be attributed to poor physiological performances of the plants. These could not be improved significantly by a single application of SNP as a spray treatment (Table 6).

ii. Open nursery experiment at Padiyathalawa

A new experimental trial was commenced in the government rubber nursery at Padiyathalawa on application of SNP on budded plants. Budded plants from RRIC 121 at two leaf whorl stage were spray treated with SNP as shown below;

Control : No SNP/water treatment
Treatment 1 : Mock treatment (spray with water)
Treatment 2 : SNP 50 µM
Treatment 3 : SNP 100 µM
Treatment 4 : SNP 150 µM
Treatment 5 : SNP 200 µM

Before imposing the treatments, diameter of the shoots were recorded. One month after the treatments, diameter of the shoots and chlorophyll content of leaves were recorded. There was no significant difference in shoot diameter and chlorophyll content of budded plants treated with SNP as compared to control or mock treatment (Table 7). Single application of SNP was not very much effective for growth improvement in rubber plants under stress conditions. Therefore, application of SNP at different time intervals should be tested.

Table 7. *Effect of NO donor SNP on growth parameters of nursery-grown rubber plants under abiotic stress conditions*

Treatments	**Diameter (mm)**		**Chlorophyll content (SPAD value)**
	Initial	**After 1 month**	**After 1 month**
Control	5.40 ± 0.06^{a}	6.58 ± 0.45^{ab}	56.16 ± 0.52^{ab}
T1	5.18 ± 0.19^{a}	6.49 ± 0.33^{ab}	59.13 ± 0.47^{a}
T2	5.26 ± 0.21^{a}	6.38 ± 0.53^{b}	55.56 ± 1.16^{b}
T3	5.40 ± 0.14^{a}	6.88 ± 0.38^{a}	57.58 ± 0.82^{ab}
T4	5.35 ± 0.013^{a}	6.59 ± 0.36^{ab}	58.00 ± 1.56^{ab}

(N M C Nayanakantha, B M S S Panditharathna and L N de Zoysa)

iii. Field experiment at Nottinghill Estate, Mawathagama

SNP was applied as a foliar spray on one year old rubber plants. There was slight increase in girth on SNP treated plants, especially at 100 µM concentration as compared to control. Chlorophyll contents also increased with SNP treatment under stress condition (high temperature and low soil moisture status) (Table 8).

Table 8. *Effect of NO donor SNP on growth of field grown rubber plants under abiotic stress (high temperature and low soil moisture status) conditions*

Treatments	Girth at 120cm height	Chlorophyll content (SPAD value)
Control	14.6±0.53	46±0.42
SNP 50 µM	14.8±0.58	48±0.52
SNP 100 µM	15.2±0.54	50±0.58

(N M C Nayanakantha)

2. Effect of Moringa (Moringa oleiifera) leaf extract (MLE) as a biostimulant/ botanical and a priming agent for growth improvement and abiotic stress alleviation in rubber plants

An experiment was set to see the effect of Moringa leaf extract (MLE) as a biostimulant/botanical and a priming agent for growth improvement and abiotic stress alleviation in rubber plants. Glass house grown seedlings were budgrafted with RRIC 121. After one month from grafting, *i.e.* after the cut back of stock plants, budded plants were treated with MLE at two concentrations (3% & 5%). Growth and physiological data were recorded at two leaf whorl stage. Results revealed no significant difference in growth and physiological parameters in response to MLE treatment (Table 9). Application of MLE at different time intervals should be tested.

Table 9. *Effect of Moringa leaf extract (MLE) on growth and physiological parameters of rubber plants*

Treatments	Shoot height (cm)	Shoot diameter (mm)	Chlorophyll content (SPAD value)	Stomatal conductance (mmol $m^{-2}s^{-1}$)
Control	52.14±6.63[a]	9.02±0.76[a]	58.99 ±0.23[b]	1.10±0.06[a]
Mock treatment (water)	62.81±7.45[a]	10.58±0.49[a]	59.12 ±1.46[a]	0.94 ±0.32[a]
3% Moringa leaf extract	70.42 ±4.94[a]	9.90±0.34[a]	59.73±0.97[a]	1.25±0.17[a]
5% Moringa leaf extract	49.36 ±17.70[a]	8.94±0.63[a]	55.52±0.44[a]	1.03±0.09[a]

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

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

Seedlings raised from seeds of different clones were budgrafted with PB 260. Budgrafting success was 85-90% with all rootstocks and hence they all can

successfully be utilized to raise rootstock nurseries to be budgrafted with scions of PB 260. There was no significant difference in scion diameter, number of leaves, leaf area, chlorophyll content and dry weight of budded plants raised from rootstocks of different clones (Table 10.)

Table 10. *Effect of rootstock on growth of scion of young-budded rubber*

Treatment	Stem diameter (mm/plant)	No. of leaves (per plant)	Leaf area (cm^2 /plant)	Chlorophyll content	Shoot dry weight
RRIC 100	6.57± 0.19	11.21± 0.69	751.99±82.08	52.61± 1.37	6.02± 0.74
PB 86	6.77± 0.30	11.73± 0.38	789.28±43.26	53.26± 1.3	6.53± 0.33
RRISL 201	6.16± 0.25	10.71± 0.78	667.48±39.31	53.06± 1.61	5.63± 0.66
RRISL 206	7.16± 0.16	12.00± 0.46	872.39±39.78	52.82± 1.33	7.22± 0.30
RRISL 217	6.83± 0.35	13.50± 2.01	973.19±183.18	56.73± 0.93	10.90± 2.30
RRISL220	6.92± 0.24	12.57± 0.64	781.56±103.18	51.95± 1.65	6.73± 0.73
PB 260	6.61± 0.15	11.97± 0.58	777.21± 96.88	49.20± 2.17	5.97± 0.66

(N M C Nayanakantha, S P P Silva, P Seneviratne and L A R Amarathunga)

A new seedling population was raised from seeds derived from different clones as depicted in Table 11 and their stem diameter values were recorded after 4 months from transplanting into polybags. Growth of seedlings raised from all clonal seeds was satisfactory (Table 11).

Table 11. *Effect of clone on stem diameter of seedlings after 4 months from transplanting into polybags*

Ttreatments	Diameter (mm)
RRIC 100	9.31 ± 0.26^{ab}
RRISL 201	9.30 ± 0.42^{ab}
RRISL 206	$9.11\pm.19^{b}$
RRISL 220	8.71 ± 0.53^{b}
RRISL 221	9.45 ± 0.50^{ab}
RRISL 226	9.86 ± 0.35^{a}
PB 260	8.76 ± 0.23^{b}

(N M C Nayanakantha, B M S S Panditharathna, P Seneviratne, L A R Amarathunga and E U M de Z Dissanayake)

Effect of transplanting stage on growth of seedlings

An experiment was commenced to study the effect of various transplanting stages on growth of the seedlings. Although RRISL has recommended to transplant the germinated seeds at the radicle immergence stage, this is not practiced at government rubber nurseries. They generally transplant seedlings at leaf emergence/ expansion stage. Therefore, seedlings were transplanted into polybags at different developmental stages as shown below in the government rubber nursery at Egaloya;

Control : At radicle emergence stage
Treatment 1: Stem elongation up to 1"
Treatment 2: Stem elongation up to 2"
Treatment 3: Growth of seedling up to leaf emergence stage
Treatment 4: Growth of seedling up to leaf expansion stage

There was a significant difference in growth attributes among treatments as compared to control. A significantly low stem height and stem diameter was recorded from seedlings transplanted at the full leaf expansion stage as compared to control and the other treatments. However, those seedlings showed the highest chlorophyll content as compared to control (Table 12).

Table 12. *Effect of transplanting stage on growth of seedlings after 3 months from transplanting into polybags*

Treatments	Stem height	Stem diameter	Number of leaves	Chlorophyll content (SPAD value)
Control	63.57 ± 0.2^{ab}	7.89 ± 0.3^{a}	9.14 ± 0.4^{a}	55.59 ± 0.4^{b}
T1	61.38 ± 0.4^{b}	7.73 ± 0.2^{a}	9.50 ± 0.1^{a}	56.10 ± 0.2^{b}
T2	67.04 ± 0.2^{a}	8.04 ± 0.2^{a}	9.00 ± 0.2^{a}	56.81 ± 0.1^{ab}
T3	65.69 ± 0.5^{ab}	7.93 ± 0.4^{a}	8.16 ± 0.1^{a}	56.72 ± 0.2^{ab}
T4	56.19 ± 0.6^{c}	6.78 ± 0.5^{b}	7.50 ± 0.3^{a}	60.65 ± 0.2^{a}

(N M C Nayanakatha, P Seneviratne, G A S Wijesekera, B V H Madushani and E U M de Z Dissanayake)

Clonal propagation

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

The plant of the elite tree of clone 28/59 (Udabage) showed a satisfactory girth increment (19.8 cm) at a height of 120cm. Nevertheless, plants of both elite seedlings of Nahalla and Dapiligoda did not show a satisfactory girth increment (P Seneviratne and G A S Wijesekera).

Bud grafting

Rejuvenation of budwood plants - Egaloya Rubber Nursery

Plants produced from all 19 successive grafting passages were field planted at Galewatta (P Seneviratne and G A S Wijesekera).

Root trainer experiment (RT/2015/Galewatta)

No root trainer experiments were conducted during the year under review (N M C Nayanakantha, P Seneviratne, G A S Wijesekera and E U M de Z Dissanayaka).

Irrigation systems for rubber nurseries

Drip and Sprinkler irrigation systems were designed for the government rubber nursery at Padiyathalawa in Ampara District. A drip irrigation system was designed for a 4 ha field and a sprinkler irrigation system was designed for the nursery covering about 6 ha (S A Nakandala).

Effect of exogenous application of salicylic acid on physiological and morphological attributes of nursery-gown rubber plants under water stress

Experiments were conducted under protected house (in Dartonfield) and nursery conditions (in Padiyathalawa) to confirm the efficacy of salicylic acid (SA) under water stress (drought) condition. The experimental design was Complete Randomized Block Design (RCBD) with six replicates. The following treatments were imposed;

Control : No stress treatment/SA application
Treatment 1 : Water stress (Drought), DR
Treatment 2 : Drought + SA 0.5mM
Treatment 3 : Drought + SA 0.3mM
Treatment 4 : Drought + SA 0.1 mm

A stock nursery was established under protected house condition at Dartonfield and SA treatments were imposed as a soil drench using 100 ml solution from each concentration. Same treatments were imposed on budded plants from RRIC 121 at two leaf whorl stage at Padiyathalawa nursery. Application of SA was repeated after three months from the first application. Growth and physiological parameters were recorded at 2, 4, 6 and 8 weeks after application.

Drought treatment significantly reduced the chlorophyll content in rubber seedlings. However, a significantly higher chlorophyll content was recorded from seedlings treated with 0.3 mM and 0.5 mM concentrations of SA as compared to control (Fig. 3).

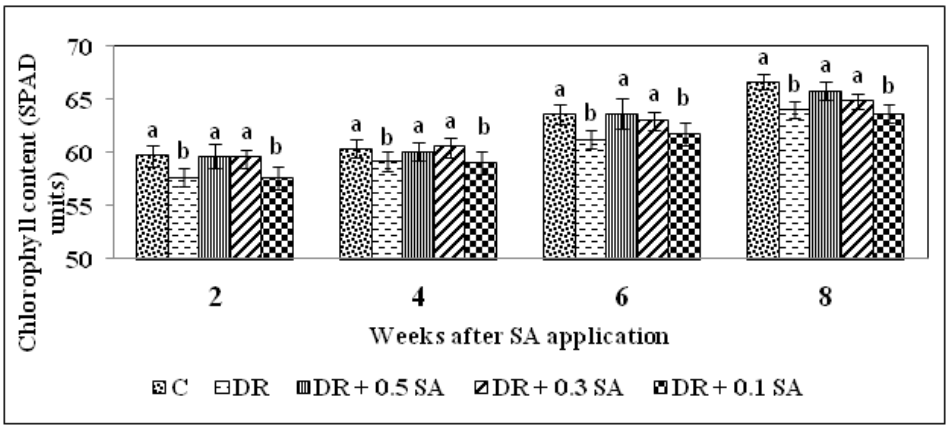


Fig. 3. Effect of salicylic acid on chlorophyll content of rubber seedlings under normal and stress condition

Drought treatment drastically reduced the stomatal conductance. However, SA treatment was able to maintain the stomatal conductance at a significantly higher level as compared to control (Fig. 4).

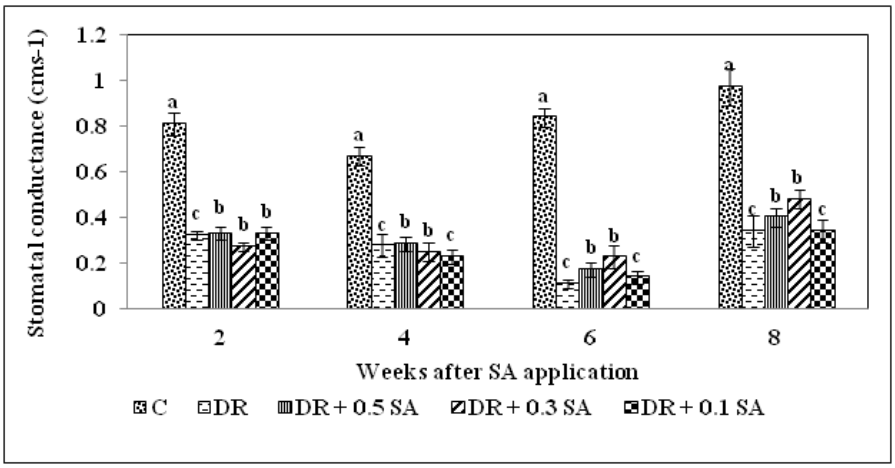


Fig. 4. Effect of SA on stomatal conductance of rubber seedlings under normal and stress condition

Plants irrigated at regular intervals recorded a low leaf temperature throughout the study period. However, in response to drought treatment, an increase in leaf temperature was recorded and that could be mainly due to decrease in

transpiration rate (Table 13). When the stressed treatment coupled with SA application, growth and root attributes improved to a great extent irrespective of the concentration. Similar results were recorded from budded plants treated with SA at same concentrations at Padiyathalawa nursery. Therefore, SA can be effectively used as a potential growth enhancer under drought condition in alleviating the negative effect exerted due to stress.

Table 13. *Effect of SA on growth attributes of rubber seedlings under normal and stress condition 8 week after the treatments*

Treatments	Stem diameter (mm)	leaf area (cm^2)	Length of root (cm)		Total dry weight (g /plant)	Total (MC %)	root: shoot ratio
			Tap root	Secondary roots			
C	7.84	1098.57	43.0	427.6	15.65	69.34	2.61
DR	6.99	830.04	52.7	619.2	13.80	67.15	1.96
DR + 0.1mM	7.02	933.82	47.0	441.6	13.99	67.2	2.23
DR + 0.3 mM	7.50	952.66	48.5	404.3	14.99	62.2	2.21
DR + 0.5 mM	7.06	1052.36	49.2	527.7	14.00	66.49	2.14

(S A Nakandala, P Seneviratne, B M S S Panditharatna and E U M de Z Dissanayake)

Crown budding

Results of the crown budding experiments revealed that several trunk-crown combinations were effective for girth and yield as compared to control. As far as both yield and girth were concerned, successful trunk-crown combinations were RRIC 130 + RRIC 133 and RRIC 110 + RRIC 130, which recorded a higher girth and yield as compared to control, RRIC 130 alone. The growth of the trunk-crown combinations of RRIC 130 + BPM 24 and RRIC 110 + *Hevea spruciana* were poor as compared to other treatments and controls. Hence crown budding can effectively be employed for replacing some troublesome or unproductive crowns of certain clones with effective crowns for growth and yield improvement. The above experiments were terminated after analyzing the results.

Budwood nurseries

BN/2000/Olikanda, BN/2001/Olikanda, BN/2008/Dolahena, BN/2012/DF and BN/2014/Gallewatta

Bud wood nurseries at Dolehena, Dartonfield and Gallewatta were regularly visited. Weeding, manuaring, pollarding and application of fungicide were done. Growth and morphological data were recorded at all three nurseries after pollarding. Although attempts were made to uproot the nurseries at Olikanda, it could not be done as planned. Authentic budwood were not issued (N M C Nayanakantha, P Seneviratne and R Handapangoda).

Budwood nursery for clone identification purposes (2010/DF)

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

Moneragala Substation

Management of nurseries, distribution of plants, upkeep of fields and training programmes were done successfully (P Seneviratne, T U K Silva and V G D N Gunaseela).

Young budding nursery at Monaragala

Nurseries were not established during the year under review. About 2500 plants produced from 2015 August nursery were issued (P Seneviratne, T U K Silva and V G D N Gunaseela).

Budwood nursery

Budwood nurseries with 1603 plants were maintained properly (P Seneviratne, T U K Silva 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 14, 15 & 16.

Table 14. *Details of RPC nurseries established in August 2015, January 2016 and August 2016*

Regional plantation company	No. of estates	No. of nurseries	No. of plants 2016	Plants certified Y.B. 2015 Aug.	Total
Balangoda	02	02	47,000	3,300	*50,300*
Elpitiya	02	03	10,000	-	*10,000*
Kegalle	01	01	73,000	-	*73,000*
Keleni velly	08	08	240,000	127,500	*367,500*
Kotagala	06	06	127,000	39,125	*166,125*
Malwatta Valley	01	01	-	-	-
Namunukula	02	02	-	-	-
Pussella	06	06	72,500	43,300	*115,800*
Total	**28**	**29**	**569,500**	**213,225**	**782,725**

Table 15. *Details of government nurseries established in August 2015, January 2016 and August 2016*

Name of the nursery	Season	No. of plants established
Egaloya	2015 Aug.	171,000
	2016 Jan.	160,000
	2016 Aug.	203,000
Gurugoda	2015 Aug.	142,220
	2016 Jan.	73,000
	2016 Aug.	88600
Karapincha	2015 Aug.	100,000
	2016 Jan.	12,500
	2016 Aug.	150,000
Meerigama	2015 Aug.	175,000
	2016 Jan.	90,000
	2016 Aug.	150,000
Welikadamulla	2015 Aug.	250,000
	2016 Jan.	165,000
	2016 Aug.	218,000
Middeniya	2015 Aug.	166,000
	2016 Jan.	55,000
	2016 Aug.	60,700
Moneragala	2015 Aug.	346,000
	2016 Jan.	130,000
	2016 Aug.	151,000
Grand total		**3,057,020**

Table 16. *Details of private nurseries established in August 2015, January 2016 and August 2016*

Region	Season	No. of plants established	No. of plants certified
Kegalle	2015 Aug.(18)	270,500	110,600
	2016 Jan.(03)	55,000	-
	2016 Aug.(18)	388,000	-
Rathnapura	2015 Aug.(04)	48,000	27,000
	2016 Jan.(03)	55,000	-
	2016 Aug.(05)	62,000	-
Kalutara	2015 Aug.(01)	30,000	10,000
	2016 Jan.	-	-
	2016 Aug.	-	-
Galle	2015 Aug.(01)	4,000	-
	2016 Jan.	-	-
	2016 Aug.	-	-

Region	Season	No. of plants established	No. of plants certified
Moneragala	2015 Aug.	-	-
	2016 Jan.	-	-
	2016 Aug.	-	-
Total		**912,500**	**147,600**

(N M C Nayanakantha, P Seneviratne, M N de Alwis, D L N de Zoysa, R Handapangoda and B V H Madhushani)

Planting techniques

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

The girth, girth increment and yield are given in Tables 17, 18 & 19.

Table 17. *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)	0.32	0.44	0.14	0.23	0.18	0.26
P value	0.02	0.02	0.13	0.06	0.29	0.01
Sample size (n)	44	29	126	68	36	99
STDEV of girth	8.95	12.04	9.16	10.13	9.13	10.81

Table 18. *Correlation among the yield (mean latex volume) and the initial girth of the plants*

Correlation among the volume and the initial girth of the plants						
	Opened in 2008			Opened in 2013		
	Bad	**Moderate**	**Good**	**Bad**	**Moderate**	**Good**
Correlation coefficient (r)	0.02	0.10	0.19	0.38	0.17	0.21
P value	0.93	0.62	0.07	0.01	0.37	0.09
Sample size (n)	30	26	90	55	28	64
STDEV of girth	61.08	52.59	64.03	50.11	57.74	47.33

Table 19. *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 Girth (cm)	Opened in 2013 Girth (cm)
Bad	65.36 ± (1.35)	65.40 ± (1.21
Moderate	66.53 ± (2.24)	69.37± (1.52)
Good	64.92 ± (0.82)	66.16 ± (1.09)

The growth of the plants was better in holes identified as moderate right from the beginning. This is evident in trees opened for tapping in 2008 and 2013. Also, this experiment was affected with drought prevailed during the inception. As the correlation co-efficiency is decreased it was decided to terminate the trial with data up to 2017 (P Seneviratne, G A S Wijesekara and L N de Zoysa).

Stumped budding experiment (SB/ 2016/Moneragala)

An experiment was commenced to study the effect of clone on stumped buddings and planting of stumped budded plants under sub optimal conditions in non traditional rubber growing areas.

Two hundred budded plants from RRIC 121 were field planted at Moneragala Sub Station in November 2016 at a distance of 2.5m x 7.75m. Additionally 30 plants were established in trenches for replacing week or dead plants in the future (S A Nakandala, N M C Nayanakantha and L N de Zoysa).

Comparison of planting materials-PT/Gallewatta/2007

Growth and yield of young budded plants of both clones were better than bare root plants (Table 20).

Table 20. *Mean growth and yield values of different planting materials after second year of tapping*

Planting material	Yield (g/t/t)	Yield (kg/ha/yr)	Girth (cm)
RRIC121, Young budding	28.07	2105.19	69.77±1. 80
RRIC 121, Bare root	26.72	2003.94	61.15±1.72
RRISL 201,Young budding	32.41	2430.56	70.60±1.25
PB 260, Bare root	22.32	1683.85	62.59±1.36

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

Performances of clones PB 86 and RRIC 100

About 100 plants had been damaged by porcupines. Girth values of two clones are given in Table 21.

Table 21. *Mean girth values of two clones after three years*

Clone	Girth at 120cm above ground
PB 86	19.35 ± 1.8
RRIC 100	22.07 ± 2.8

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

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

Morphological characteristics of rubber clones in budwood nurseries established in different areas under different agro climatic conditions were different (Table 22).

Table 22. *Morphological characteristics of rubber clones in budwood nurseries (before pollarding) located in different areas*

Clone	No. of shoots		No. of leaf whorls/plant	
	Egaloya	**Ampara**	**Egaloya**	**Ampara**
PB 86	3.53[c]	0.84[d]	7.65[a]	8.45[a]
PB 260	5.10[c]	3.21b[c]	6.58[b]	6.48[c]
RRIC 100	7.73[b]	3.37b[c]	5.28[c]	6.45[c]
RRIC 102	10.60[a]	8.59[a]	5.28[c]	6.50[c]
RRIC 121	7.83[b]	4.08[b]	7.35[a]	8.31[a]
RRISL 203	7.08[b]	4.85[b]	6.15[b]	7.43[b]
RRISL 217	7.45[b]	3.83[b]	7.65[a]	7.50[b]
RRISL 2001	4.25[c]	1.79[cd]	7.20[a]	7.69[b]

RRIC 102 showed a significantly higher number of shoots in budwood nurseries in both Egaloya and Ampara. RRIC 121 showed a significantly higher number of leaf whorls per plant in Ampara while PB 86, RRIC 121, RRISL 217 and RRISL 2001 showed significantly higher number of leaf whorls per plant as compared to other clones (Table 22). Shoot diameter was better in PB 260, RRIC 100, RRIC 121, RRISL 203 and RRISL 2001in Egaloya while in Ampara, RRIC 100, RRIC 102, RRIC 121 and RRISL 203 showed a better shoot diameter (Table 23). A significantly higher shoot height was recorded from PB 260, RRIC 121 and RRISL 2001 for Egaloya while PB 86 and RRIC 121 showed a significantly higher shoot height for Ampara (Table 23). Diameter increment was significantly better in almost all the clones in Egaloya except RRISL 217 (Table 24). However in Ampara, RRIC 100, RRIC 121, RRISL 203 and RRISL 2001 showed a significantly higher diameter increment as compared to other clones (Table 24). A significantly higher height increment was recorded from PB 86, RRIC 121 and RRISL 217 in Egaloya as compared to other clones while in Ampara PB 86, RRIC 100, RRIC 102, RRIC 121, RRISL 203 and RRISL 2001 all showed a significantly higher height increment as compared to other clones (Table 24).

Table 23. *Mean growth values for clones in budwood nurseries located in different areas before pollarding*

Clone	Diameter (mm)		Height (cm)		Length of the second internode (cm)	
	Egaloya	**Ampara**	**Egaloya**	**Ampara**	**Egaloya**	**Ampara**
PB 86	7.43^{b}	7.70^{bc}	84.36^{b}	84.04^{a}	11.59^{bc}	10.45^{cb}
PB 260	8.61^{ab}	7.46^{bc}	100.45^{ab}	59.12^{d}	17.34^{a}	12.25^{b}
RRIC 100	10.22^{a}	8.04^{abc}	38.36^{c}	67.41^{cd}	11.81^{bc}	11.47^{cb}
RRIC 102	7.61^{b}	8.33^{abc}	27.81^{c}	75.97^{cb}	19.09^{a}	17.47^{a}
RRIC 121	9.46^{ab}	9.02^{a}	111.73^{a}	103.62^{a}	13.61^{b}	12.41^{b}
RRISL 203	8.46^{ab}	8.46^{ab}	82.64^{b}	80.46^{bc}	10.18^{cd}	9.36^{cb}
RRISL 217	7.29^{b}	5.50^{d}	80.71^{b}	58.40^{d}	12.10^{cb}	9.66^{cb}
RRISL 2001	8.46^{ab}	7.34^{c}	94.93	77.32^{cb}	8.21d	8.71^{c}

Table 24. *Mean height and diameter increment in rubber clones in budwood nurseries (after pollarding) located in different areas*

Clone	Diameter increment (mm)		Height increment (mm)	
	Egaloya	**Ampara**	**Egaloya**	**Ampara**
PB 86	6.61^{a}	2.41^{cd}	449.11^{a}	317.54^{abc}
PB 260	6.69^{a}	2.10^{de}	359.39^{bc}	282.59^{bc}
RRIC 100	6.90^{a}	2.66^{abcd}	325.75^{cd}	299.03^{abc}
RRIC 102	6.87^{a}	2.49^{bcd}	271.33^{d}	315.06^{abc}
RRIC 121	6.64^{a}	2.86^{abc}	382.79^{abc}	375.42^{a}
RRISL 203	6.96^{a}	3.16^{ab}	318.33^{cd}	339.74^{ab}
RRISL 217	5.68^{b}	1.74^{e}	412.36^{ab}	255.56^{c}
RRISL 2001	6.98^{a}	3.34^{a}	325.72^{cd}	313.74^{abc}

Interestingly the budgrafting success in all clones, except PB 86, RRIC 102 and PB 260, was higher in Ampara than in Egaloya (Table 25). Although a low budgrafting success was expected from Ampara due to dry weather condition prevailed in most of the months, it didn't occur. This increase in budgrafting percentage could be directly attributed to the fact that the budgrafting was performed during a rainy period (February). On the other hand, the low budgrafting success in Egaloya could be due to dry weather prevailed during February when the budgrafting was carried out (N M C Nayanakantha, P Seneviratne and R Handapangoda).

Table 25. *Budgrafting performance of rubber clones in stock nurseries established in different areas*

Clone	Budgrafting percentage (%)		
	Egaloya	**Monaragala**	**Ampara**
PB 86	92.59	90.91	84.78
PB 260	89.83	89.36	88.89
RRIC 100	25.53	86.02	53.90
RRIC 102	97.87	82.47	85.34
RRIC 121	80.39	95.65	86.05
RRISL 203	60.00	60.32	77.69
RRISL 217	74.07	80.41	85.61
RRISL 2001	62.79	84.21	77.04

Northern Province planting

Experimental field at Vavuniya south was visited by the officers of Plant Science Department and Adaptive Research Unit (N M C Nayanakantha, P Seneviratne and M N de Alwis).

Kilinochchi

Growth and physiological data were recorded. Tallest plants were observed from RRISL 2001 followed by RRIC 121 and RRISL 203 (Fig. 5). Highest girth was recorded from RRISL 203 (Fig. 6).

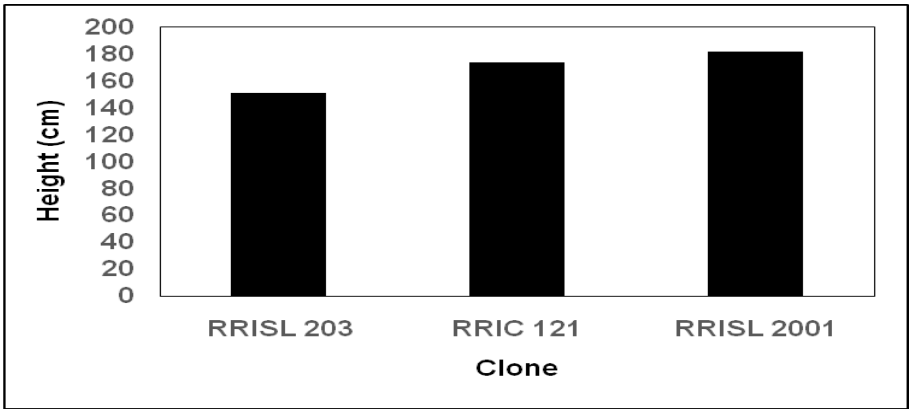


Fig. 5. Effect of clone on mean height of rubber plants after 8 months from planting

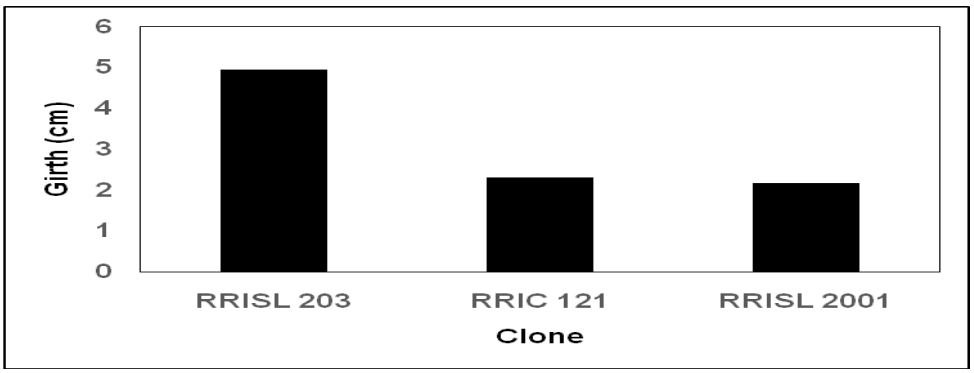


Fig. 6. Effect of clone on mean girth of rubber plants after 8 months from planting

Rate of photosynthesis at different light levels was higher in RRISL 203 followed by RRIC 121 and RRISL 2001 (Fig. 7).

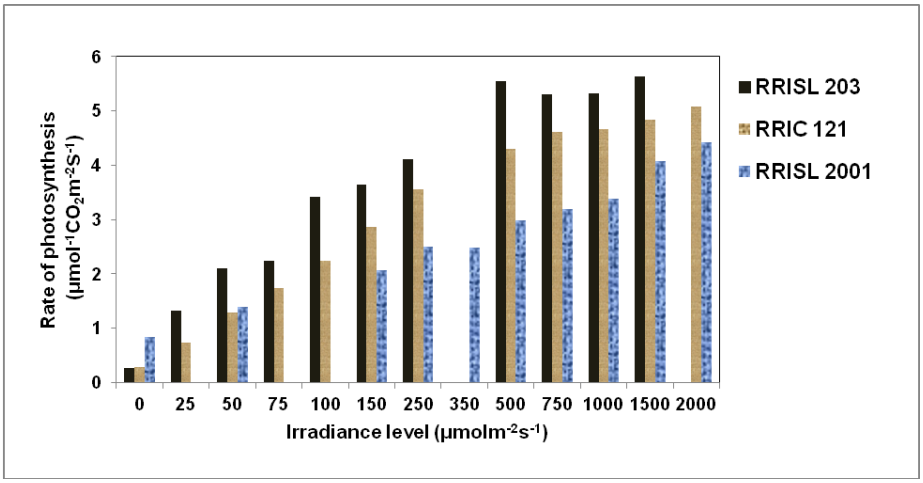


Fig. 7. Rate of photosynthesis at different light levels for different clones

Stomatal conductance was low in RRISL 203 as compared to RRIC 121 and RRISL 2001 both in the morning and day time (Table 26). Low stomatal conductance along with high photosynthesis rate could have been the reason for better growth in RRISL 203 as compared to other two clones under stress conditions (N M C Nayanakantha and M N de Alwis).

Table 26. *Effect of clone on stomatal conductance of rubber plants*

Clone	Stomatal conductance ($mmolm^{-2}s^{-1}$) at different time intervals	
	9:00 am	**12.00 pm**
RRISL 203	0.654	0.595
RRIC 121	0.678	0.649
RRISL 2001	0.687	0.697

Cultural practices during immature phase

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

Tree girth and bark thickness decreased with the increase in planting density. Also, a similar decrease was recorded in individual tree yield (g/t/t) as shown in Table 27. Due to the reason mentioned above and low rubber price prevailed, the tapping system of the entire field has been converted from S/2 d2 to S/2 d3 +2.5% ET (5/y) system from mid - 2016. Therefore, the increase of yield per tree was high during last five months. The percentage of trees in tapping was more or less same to that in last year due to upper cuts on TPD trees. YPH values were not statistically significant among the densities. However, higher values for YPH were recorded for higher densities due to more number of trees could be tapped per hectare overcoming the decrease of g/t/t for higher densities.

Table 27. *Effect of planting density on growth and yield parameters of rubber. In (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	76.53	11.78	65.47	327	90.05	10.81	66.46	332
600	76.48	11.44	63.75	383	83.94	10.13	67.22	403
700	68.17	10.08	61.85	433	79.61	10.08	62.27	436
800	68.94	10.08	61.76	494	77.08	10.09	67.34	539

(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	60.48	1360	71.76	1579
600	48.98	1452	59.14	1622
700	48.42	1439	53.54	1649
800	45.34	1430	53.06	1959

(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 R Handapangoda).

Low density trial at Gallewatta and Nivithigalakele - 2012

The mean girth of RRISL 203 was higher than RRISL 2001 at both spacing and both locations (Galewatta and Nivithigalakele) (Tables 28 & 29).

Table 28. *Mean girth of rubber clones at different densities at Gallewatta*

Clone	No. of plants	Spacing (feet)	Mean girth (cm) ± SEM
RRISL 2001	294	14x15	38.35±0.86
RRISL 203	422	14x15	40.88±1.54
RRISL 2001	314	16x16	33.93±1.33
RRISL 203	391	16x16	40.08±1.89

Table 29. *Mean girth of rubber clones at low density at Nivithigalakelle*

Clone	No. of plants	Spacing (feet)	Mean girth (cm) ± SEM
RRISL 2001	317	16x16	39.26±0.95
RRISL 203	358	16x16	41.82±1.32

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

Low density trail at Kandakadu, Polonnaruwa - 2013

Due to dry weather prevailed in most of the months, plants had been subjected to abiotic stresses. Manuring had also been delayed and hence the growth of the plants was poor.

Mean girth of the plants measured at 120cm above ground level and intercropped with banana was 13.28±1.86 cm (P Seneviratne, N M C Nayanakantha, M N de Alwis and R Handapangoda).

Immature upkeep

Rubber Mini- Clearing (Home garden) concept

Post evaluation programs were conducted in Kalutara, Ampara and Vavuniya districts as depicted in Table 30.

Table 30. *Post evaluation programmes conducted in different districts*

District	No. of home gardens inspected
Kalutara	179
Ampara	189
Vavuniya	36

(P Seneviratne, R K Samarasekara, M N de Alwis, L de Zoysa and R Handapangoda)

Exploitation

Longer tapping cycle through sorter tapping cuts – Pitiyakanda Estate

Yield measurements for the period from January to December 2016 are given in Table 31.

Table 31. *Yield measurements for the period from January to December 2016*

Treatments	No. of trees	No. of tapping days	Average g/t/t	BB %
T1 : S/4 d3 + 5% E 12/y	42	10	29.2[a]	4
T2 : S/3 d3 + 2.5% E 12/y	42	10	28.6[a]	4
T3 : S/2 d3 + 2.5% E 5/y (* BUT up to December 2010)	45	10	28.4[a]	8
T4 : S/2 d3 + 2.5% E 5/y	41	10	29.8[a]	-

Same yield could be obtained by consuming less bark in T1 and T2 as compared to control (T4) (N M C Nayanakantha, K S D N Senanayake, R K Samarasekera and C Jayawanthi).

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

Girth, bark thickness, bark consumption and yield measurements were recorded and summaries are given in Table 32.

Table 32. *Mean girth, bark thickness, annual bark consumption and yield measurements for the period from January to December 2016*

Girth class (cm)	Girth (cm)	Bark thickness (mm)	Annual bark consumption (cm)	g/t/t
T1 : 51-55.9	59.69	7.30[b]	14.39	39.2[a]
T2 : 56-60.9	65.66	8.13[a]	13.86	36.1[a]
T3 : ≥61.0	74.51	8.58[a]	13.96	35.1[a]

There was no significant difference in g/t/t among the girth classes tested. The bark thickness was significantly low in the lowest girth class (51-55.9 cm) as compared to other two girth classes (N M C Nayanakantha, P Seneviratne, K S D N Senanayake, R K Samarasekara and L A R Amarathunga).

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

The details of the experiment are given in the Annual Review for 2012. Girth, bark thickness, annual bark consumption and yield measurements were recorded and summaries are given in Tables 33 and 34 for RRIC 121 and RRISL 203 respectively.

Table 33. *Mean girth, bark thickness, annual bark consumption and yield measurements for RRIC 121 for the period from January to December 2016*

Girth class (cm)	Girth (cm)	Bark thickness (mm)	Annual bark consumption (cm)	g/t/t
T1 : 45-50.9	58.58	6.0[b]	22.85	27.45[c]
T2 : 51-55.9	63.29	6.0[b]	22.80	30.39[c]
T3 : 56-60.9	69.55	7.0[a]	25.05	39.02[b]
T4 : ≥61.0	79.35	6.0[b]	24.03	52.99[b]

Table 34. *Mean girth, bark thickness, annual bark consumption and yield measurements for RRISL 203 for the period from January to December 2016*

Girth class (cm)	Girth (cm)	Bark thickness (mm)	Annual bark consumption (cm)	g/t/t
T1 : 45-50.9	55.01	6.33[b]	25.29	21.39[c]
T2 : 51-55.9	59.33	7.00[b]	26.83	22.89[c]
T3 : 56-60.9	65.77	8.00[a]	24.07	24.07[b]
T4 : ≥61.0	72.46	8.00[a]	23.94	36.52[a]

A significantly higher bark thickness was recorded from higher girth classes (56-60.9 and ≥61.0 cm) as compared to low girth classes (45-50.9 and 51- 55.9 cm) for both clones. A significantly higher g/t/t was recorded at higher girth classes, *i.e.*

56-60.9 and ≥61.0 cm for both clones (N M C Nayanakantha, K S D N Senanayake, R K Samarasekera and C Jayawanthi).

A modified stimulation method for rubber – Pitiyakanda Estate

Yield measurements taken during the period from January to December 2016 are summarized in Table 35.

Table 35. *Yield measurements for the period from January to December 2016*

Girth class (cm)	Treatments	No. of trees	Average no. of tapping days	g/t/t
50	Panel	117	10	41.9[a]
	Poi kanu + Middle + Neththi kanu	109	10	43.4[a]
	Poi kanu + Nehthi kanu	106	10	45.4[a]
55	Panel	98	10	48.6[a]
	Poi kanu + Middle + Neththi kanu	114	10	41.8[a]
	Poi kanu + Nehthi kanu	96	10	49.6[a]
60	Panel	97	9	49.9[a]
	Poi kanu + Middle + Neththi kanu	102	9	45.9[a]
	Poi kanu + Nehthi kanu	85	9	54.5[a]

There was no significant difference in g/t/t among the treatments tested (N M C Nayanakantha, P Seneviratne, K S D N Senanayake, R K Samarasekara and N C Jayawanthi).

Novel gaseous stimulation system (GST/2014)

Monthly mean tree yield (GTT) and mean DRC in different stimulation treatments are presented in Figures 8 & 9.

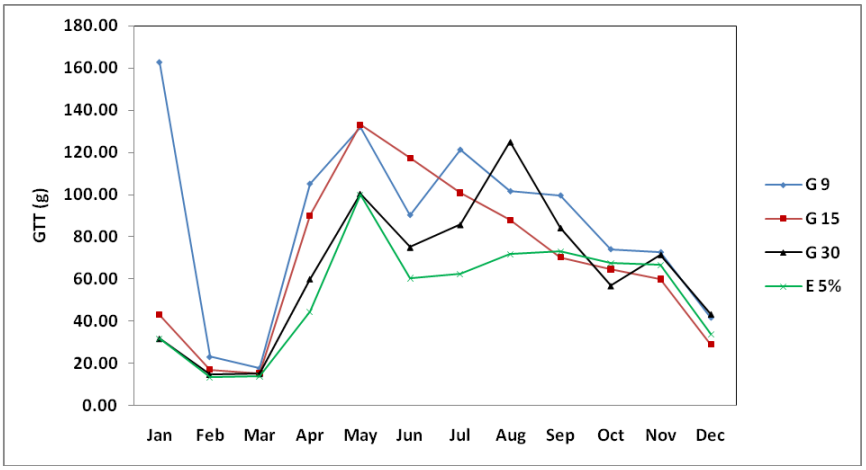


Fig. 8. Monthly mean tree yield (GTT) in response to various treatments: ethylene gassing at 9 day (G 9), 15 day (G 15) and 30 day (G 30) intervals and 5% ethephone application at monthly intervals (E 5%). Data represent mean of 36 trees

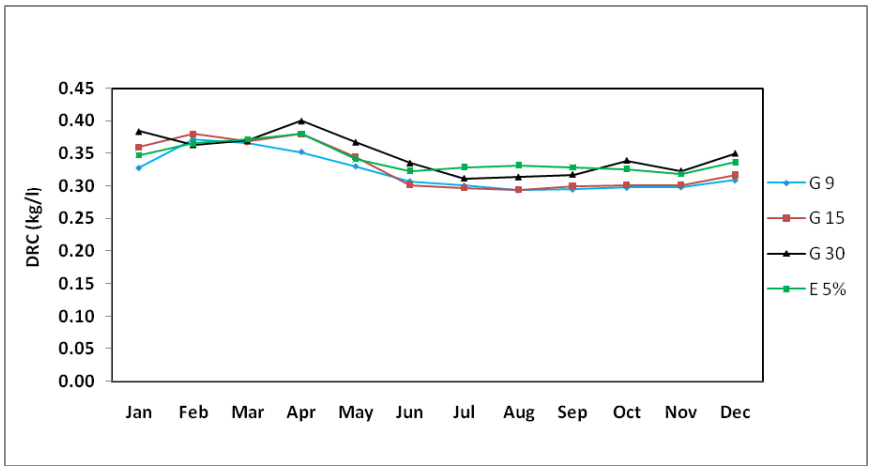


Fig. 9. Monthly mean dry rubber content (% DRC) in response to various treatments: ethylene gassing at 9 day (G 9), 15 day (G 15) and 30 day (G 30) intervals and 5% ethephone application at monthly intervals (E 5%). Data represent mean of 36 trees

Data revealed that ethylene gassing increased the latex yield over the control (E 5%) with the highest at 9 day interval (G 9) in most of the months although the DRC was dropped a little with ethylene gassing, especially at 9 (G9) and 15 (G 15) day

intervals (N M C Nayanakantha, A M W K Senevirathna, P Senevirathna and W Karunathilake).

Tapping Panel Dryness

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

An experiment was commenced to see the effect of different chemicals and natural plant extracts (botanicals) having antioxidant properties to address tapping panel dryness problem of rubber trees to increase the productivity in rubber plantations. Plants were selected from a field at Galewatta established in 1997. TPD percentage of trees such as fully dried, partially dried and likely to dry was recorded (N M C Nayanakantha, K S D N Senanayake, R K Samarasekara and W Karunathilaka).

Early selection of clones by physiology (PH/2007)

Girth and bark thickness measurements taken at the end of the reporting year is given in the Table 36.

Table 36. *Mean girth and bark thickness of different clones measured at 120 cm height*

Clone	No. of trees	Girth	Bark thickness
RRISL 2000	11	72.1 ± 3.2	0.86 ± 0.03
RRISL 2001	09	54.6 ± 2.7	0.79 ± 0.03
RRISL 2002	12	61.3 ± 3.3	0.77 ± 0.03
RRISL 2003	14	51.7 ± 2.2	0.72 ± 0.02
RRISL 2004	14	58.0 ± 2.2	0.79 ± 0.02
RRISL 2005	16	68.1 ± 1.7	0.84 ± 0.03

(N M C Nayanakantha, A M W K Senevirathna and P K W Karunathilake).

Intercropping Agarwood with Rubber (IC/AW/2015)

Growth data was recorded at two months intervals from January-December 2016 and the data after 16 months (December 2016) are presented in Table 38. In the double row system under full sun light condition, the highest stem height was recorded from *A. subintegra* and the lowest was recorded from *G. walla*. Under same conditions the highest stem diameter was recorded from *A. subintegra* and the lowest was recorded from *G. Walla* (Table 37).

Table 37. *Growth attributes of three agarwood species after 16 months from planting:* 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 of plants (cm)	Height increment (cm)	Diameter of plants (cm)	Diameter increment (mm)
Double row	AC	280.3 ± 5.1	20.7 ± 1.87	5.3 ± 1.1	6.35 ± 1.14
	GW	128.1 ± 5.7	4.77 ± 1.29	1.7 ± 0.9	1.75 ± 0.74
	AS	298.1± 7	19.47 ± 2.97	5.2 ± 1.5	6.24 ± 1.83
Single row	AC	311.00 ± 9.02	27.03 ± 2.71	4.8 ± 2.6	6.09 ± 1.04
	GW	107.13 ± 5.7	1.32 ± 1.27	1.1 ± 0.81	0.99 ± 0.36
	AS	294.33 ± 10.41	21.12 ± 3.15	4.3 ± 2.87	5.24± 0.45

Physiological parameters indicated that the highest net photosynthesis rate was recorded from *A. subintegra* and the lowest was recorded from *G. Walla* under full sun light condition (Table 38). However, under 50% artificial shade and natural shade (under rubber) conditions, the highest photosynthesis rate was recorded from *A. crassna* and the lowest was recorded from *A. subintegra* (Table 38).

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

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

(a) 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

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) and census of tapping panel dryness were recorded. Initial flow rates were measured and plugging indices were calculated based on the initial flow rates. Latex sucrose levels were also recorded. Rainfall and the distribution of tapped and wet days were also recorded. Assessments on wounds and bark deformation on tapping panel were done as visual observations.

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)

Treatment four was stimulated using 2.5% Etheral (1.6g per tree) at three months interval.

A clear relationship between phloem turgor pressure (PTP) and the initial flow rate (IFR) was noticed because the clones which possess high PTP (Fig. 10), *i.e.* RRIC 133 and RRIC 121 recorded significantly the highest IFR (Fig. 11). However, there were no clear differences among treatments tested during the normal time of tapping. Nevertheless, a significantly low PI was recorded in T4 as ethephone stimulation could have delayed the latex vessels plugging (Fig.12). Treatments subjected to different levels of recovery tapping, *i.e.* T2 and T3 recorded a significantly low yield per tree and that was highest in T4 (Fig. 13). Therefore, the ultimate yield, *i.e.* yield per tree per annum was comparable among the treatments (Fig. 14).

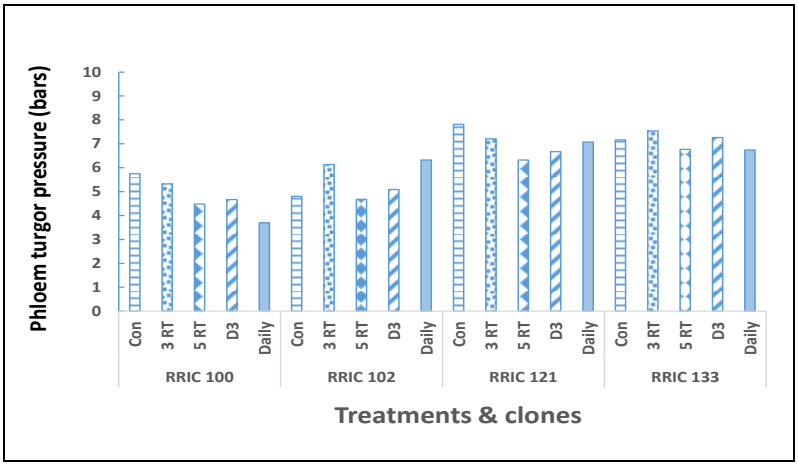


Fig. 10. Phloem turgor pressure (bars) measured just below the tapping cut at normal time of tapping in different treatments and clones

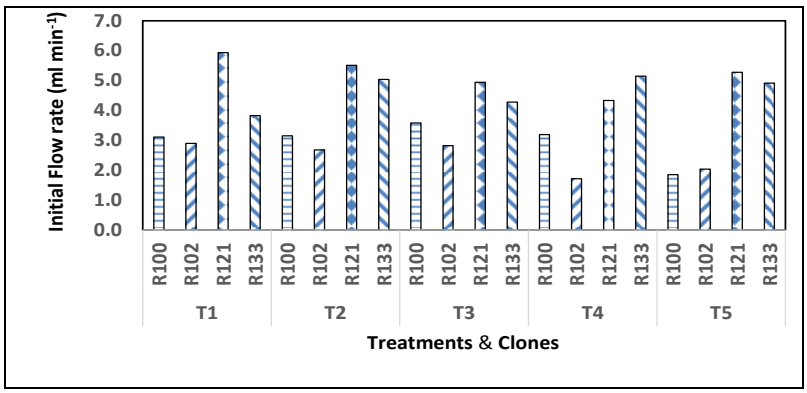


Fig. 11. Initial flow rates (ml min^{-1}) measured while tapping at normal time of tapping in different treatments and clones

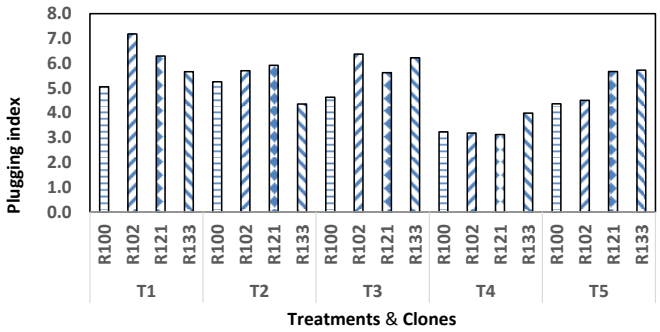


Fig. 12. Plugging index at normal time of tapping in different treatments and clones

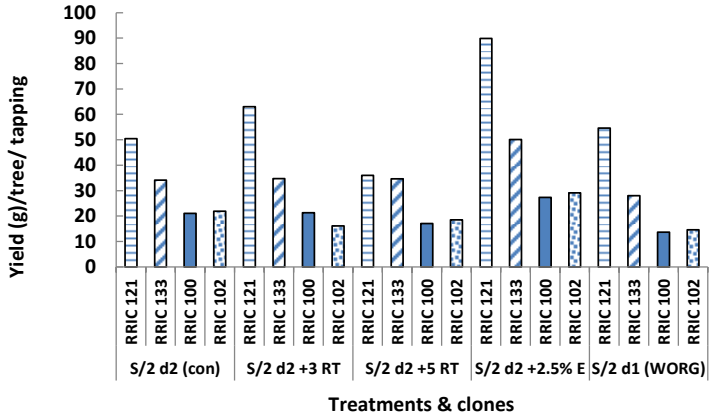


Fig. 13. Dry rubber yield (g) per tree per tapping in five treatments and four clones tested

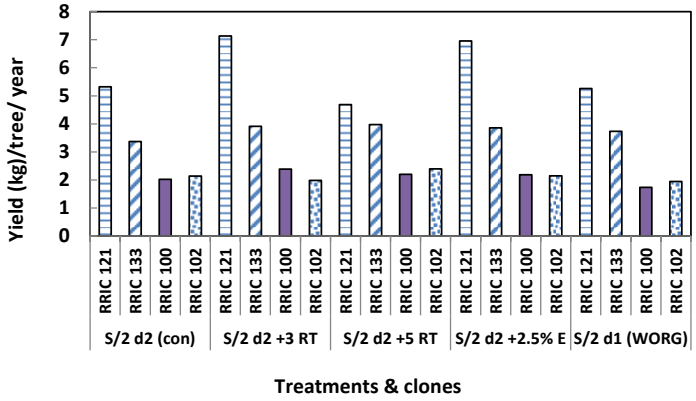


Fig. 14. Dry rubber yield (kg) per tree per annum in different treatments and clones

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

Five sites from Regional Plantation Companies (RPCs) and five smallholdings were selected for this assessment. Three from Kalutara, Ratnapura and Kegalle representing major rubber growing districts and another two from Kurunegala and Moneragala districts representing low country intermediate zone where the rainfall is comparatively low (higher number of tapping days) were selected. The survey conducted clearly showed that in most of the rubber fields in the plantation companies, the rate of the utilization of rubber bark had been increased at an alarming rate. In most of the rubber fields, actual panel duration to finish each panel was higher than the estimated panel durations (Fig. 15a). However, some fields diverted to the low frequency harvesting showed some kind of recovery and extended panel durations (Fig. 15b).

The higher rates of bark consumption resulted in shifting to other panels earlier and therefore harvesting being continued on comparatively smaller trees and on partially renewed bark. Due to insufficient time given for the bark to renew after tapping, comparatively lesser number of latex vessels were observed in different fields of the estate as shown in Figure 16.

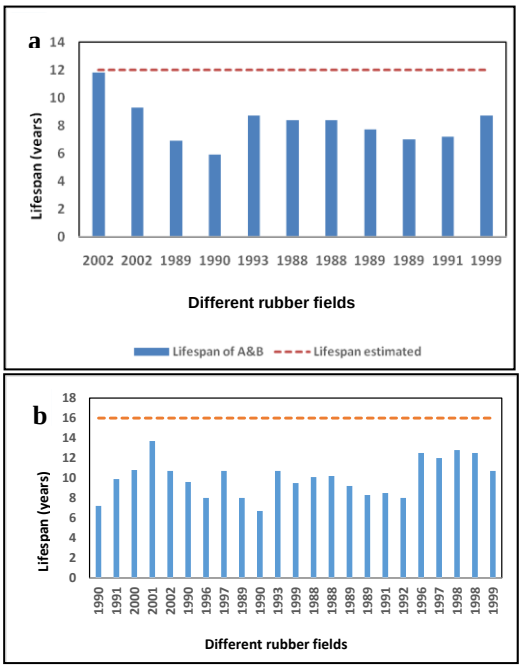
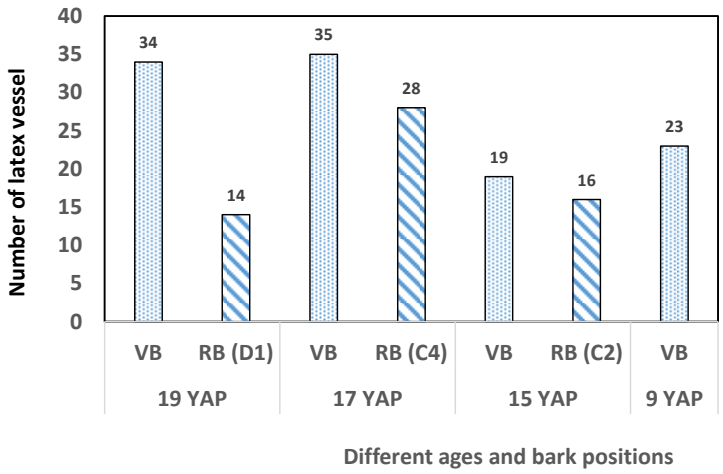


Fig. 15. Different rubber fields tapped under S/2 d3 above **(a)** and S/2 d2 below **(b)** in the same estate in Kegalle District and their lifespan (years) to consume tapping panel A and B. Dash-line indicates their estimated lifespan



VB = Virgin bark at 150 cm, RB = renewed bark and Panel positions at the time of assessments are given in brackets

Fig. 16. Number of latex vessel rings recorded in cross sections of rubber bark of clone RRIC 121 at different ages and bark positions in selected fields
(T U K Silva, P Seneviratne, and H A U Deshapriya)

Intercropping

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

Growth of rubber with respect to the girth and thickness of virgin bark measured at 150 cm height were measured (Tables 39 and 40) and those were higher in wider within row systems, *i.e.* T3 and T4. A percentage trees in tapping was comparable among treatments (Table 41). Daily latex yields were monitored for latex volume and % dry rubber content by using a metrolac. Wider within row systems, *i.e.*, T3 and T4 recorded higher g/t/t values than the other two systems, *i.e.*, T1 and T2 (Table 42). Yield of tea in terms of Kg per hectare per year was higher in both rehabilitated and un-rehabilitated tea plots after pruning both areas during 2015 (Table 43). There were no marked differences of growth and yield of cinnamon under four spatial arrangements of rubber at 15 years after planting (Table 44). Although, the growth and the establishment rates of rambutan and jak were satisfactory and better than that of bud grafted (bg) and seedling (s) durian (Table 46) there were no commercial yields from fruit crops during the year under review.

Table 39. *Mean girth (cm tree^{-1}) of rubber in different treatments. Measurements were made at 150 cm height*

Main trts.	Sub treatments				
	Tea	**Cinnamon**	**Durian/Jak**	**Rambutan**	**Sole rubber**
T1 (3m×3m)-15m	74.88	70.72	73.04	70.73	74.82
T2 (3m×3m)-18m	78.46	70.63	69.66	68.67	71.85
T3 (3.5m×3.5m)-15m	79.70	78.31	77.06	75.15	77.12
T4 (3.5m×3.5m)-18m	81.75	77.03	80.77	79.03	80.01

Table 40. *Summary of the bark thickness of rubber (mm tree^{-1}). Measurements were made at 150 cm height*

Main trts.	Sub treatments				
	Tea	**Cinnamon**	**Durian**	**Rambutan**	**Sole rubber**
T_1	9.59	9.19	9.58	8.96	9.37
T_2	9.63	9.68	9.37	9.44	10.18
T_3	9.90	10.03	10.68	10.20	10.25
T_4	10.55	10.17	10.05	9.93	9.88

Table 41. *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	316
T4	88.13	234	84.16	224	87.46	233	88.33	235	89.06	237

Table 42. *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	38.85	1265	39.79	1248	37.58	1329	35.32	1185	50.05	1505
T2	31.76	926	39.94	1211	44.04	1411	41.79	1376	42.07	953
T3	42.40	1328	56.51	1462	57.65	1591	46.52	1431	40.66	1439
T4	65.15	1676	54.35	1349	66.51	1689	50.15	1294	44.06	1126

Table 43. *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	23.40	22.21	257	1336	364	2037
T2	23.70	23.50	239	1616	239	1474
T3	23.17	23.65	323	1817	344	1653
T4	23.62	24.41	224	1062	323	1614

Table 44. *Summary of the growth and yield performance of cinnamon under different planting arrangements of rubber*

Different measurements of cinnamon	Treatments				P (Probability)
	T1	T2	T3	T4	
Stem diameter (mm)/bush	17[a]	19.38[a]	18.70[a]	18.63[a]	0.5284
Height (m)/bush	2.13[a]	2.32[a]	2.29[a]	2.35[a]	0.1323
Yield (g)/stem	91.1[a]	75.51[a]	105.26[a]	85.51[a]	0.4614

(Means with the same letter along the row are not significantly different at 5% probability level)

Table 45. *Summary of the growth performance of Rambutan, Jak, budgrafted 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	80.37	65.40	36.16	28.67*
T2	83.04	94.40	69.22	43.80
T3	77.42	63.00	66.75	44.28
T4	77.62	80.20	13.00*	71.25

*****Plants were re-established in 2007 due to the damage of rabbits

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

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

The objective of this experiment are 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 46. Cinnamon showed better performance and was harvested third

time this year. Reasonable amount of cut leaves can also be harvested from messengiana as well.

Table 46. *Crops planted along the rubber fence, spacing (m), girth (cm) and their overall plant height (m) at the sixth 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	10.53	2.14
Rattan (*Calamus rotang*)	2.5	Nm	0.97
Messengiana (*Dracaena messengiana*)	0.9	21.93	1.80
Cane palm (*Dypsis lutescens*)	0.9	13.75	1.43
Arecanut palm (*Areca catechu*)	2.0	35.06	3.60
Main crop	**Spacing (m)**	**Girth at 120 cm**	
Rubber	2.5m x 7.75m	48.06	Not measured

(T U K Silva and H A U Deshapriya)

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

The objective of the experiment together with treatment layout are given in the Annual Review for 2011. Out of the four species tested teak has recorded better growth and 100% survival and seems to be more suitable for the boundary of rubber with reasonable gap in between rubber and teak (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 47. Plant basal girth and heights of different intercrops with two spatial arrangements of rubber are given in the Table 48. A satisfactory plant height was recorded in each crop at the five years after planting (Table 48). Mango, guava and pomegranate showed very higher growth rate whilst reasonable yield of guava could be harvested. Flowering and fruit setting of mango and pomegranate were observed in some trees.

Table 47. *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	38.43
Rubber x Banana	2.5m x 7.75m	39.50
Rubber x Pomegrenate/Guava	Single row system	24.17
Rubber x Pomegrenate/Guava*	2.5m x 12m	18.15
Rubber x Cinnamon	Paired row system	39.75
Rubber x Mango/Rambutan	(3m x 3m) – 18m	38.56

Table 48. *Plant basal girth and height (cm) of different intercrops planted under two different rubber spatial arrangements*

Intercropping system	Year established	Intercrop spacing (m)	Basal girth (cm)	Tree height (m)
Pomegrenate	2010	3m x 3m	24.30	2.02
Guava			40.75	3.96
Pomegrenate	2012		26.52	2.37
Guava			28.00	3.48
Cinnamon	2010	0.6m x 1.2m	9.38	3.39
Mango		10m	55.87	4.35
Rambutan*		10m	-	-

***Plants were resupplied**

(T U K Silva and H A U Deshapriya)

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

Data was not collected during the year under review and also the data collected so far are being analysed (P Seneviratne).

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

Data was not collected during the year under review and also the data collected so far are being analysed (P Seneviratne).

Table 1. *Date of completion of wintering in each clone in each estate/smallholder field*

	Completion of wintering					
Clone	**Payagala**	**Pallegoda**	**Milewa**	**Kuruwita**	**Salawa**	**Dompe**
RRIC 100	3rd wk of Feb	1st wk of Feb		3rd wk of Feb	2nd wk of Feb	2nd wk of Feb
RRIC 102	1st wk of Feb	-	-	-	-	-
RRIC 121	-	3rd wk of Feb	-	-	-	3rd wk of Feb
RRIC 130	-	-	4th wk of Feb.	-	-	-
RRIC 133	-	-	-	3rd wk of Feb	-	-
RRISL 201	-	-	-	3rd wk of Feb	2nd wk of Feb	-
RRISL 202	-	-	-	3rd wk of Feb	-	-
RRISL 203	-	-	-	3rd wk of Feb	-	-
RRISL 205	-	1st wk of Feb	100	-	-	-
RRISL 206	-	3rd wk of Feb	100	-	1st wk of Jan.	-
RRISL 217	-	-	-	3rd wk of Feb	-	-
RRISL 218	-	3rd wk of Feb	100	-	-	-
RRISL 220					1st wk of Jan.	
RRISL 221					4th wk of Feb	
RRISL 222	-	-	-	3rd wk of Feb	-	-
RRISL 226					2nd wk of Feb	
RRISL 2001	-	1st wk of Feb	-	-	-	-
PB 86						2nd wk of Feb
PB 260	-	-	4th wk of Feb.	-	-	-
BPM 24	-	-	4th wk of Feb.	-	-	-

WK: Week

(N M C Nayanakantha, P D Pathirana and P Seneviratna)

Table 6. *Effect of NO donor SNP on physiological parameters of rubber plants under abiotic stress conditions*

Treatments	Chlorophyll content (SPAD value)		Net photosynthesis rate (µmol $^{-1}CO_2m^{-2}s^{-1}$)		Stomatal conductance (mmol m^{-2} s^{-1})	
	Before	After	Before	After	Before	After
Control	56.81±0.91[a]	52.5±11.79[a]	2.85±0.83[a]	1.59±0.29 [a]	0.09±0.05 [a]	0.07±0.04 [a]
T1	54.88±0.68[a]	53.1±2.77 [a]	2.58±0.51[a]	2.86±0.67 [a]	0.05±0.01 [a]	0.04±0.02 [a]
T2	53.05±2.10[a]	54.9±2.16 [a]	1.47±0.57 [a]	3.39±0.14 [a]	0.06±0.03 [a]	0.03±0.03 [a]
T3	54.4±1.02[a]	53.63±2.66 [a]	3.11±0.86 [a]	2.68±0.41 [a]	0.05±0.01 [a]	0.03±0.02 [a]
T4	54.86±0.98[a]	55.35±1.19 [a]	3.67±0.99 [a]	2.58±0.37 [a]	0.05±0.01 [a]	0.04±0.01 [a]
T5	53.41±2.07[a]	53.91±2.44 [a]	2.94±0.56 [a]	3.32±0.24 [a]	0.09±0.02 [a]	0.05±0.01 [a]

(N M C Nayanakantha, S A M Kavindi, S S Panditharathna, W Karunathilake, E U M de Z Dissanayake and L A R Amarathunga).

Table 38. *Physiological parameters of three agarwood species after 16 months from planting:* Gyrinops walla *(GW)* Aquilaria crassna *(AC) and* Aquilaria subintegra *(AS) grown as intercrops with rubber under two spacing systems*

Growth Radiation	Species	Upper asymptote (A_{max}), ($molm^{-2}s^{-1}$)	Light saturation point, ($molm^{-2}s^{-1}$)	Dark respiration ($molm^{-2}s^{-1}$)	Light compensation point, ($molm^{-2}s^{-1}$)	Quantum yield	Convexity
Full sun	AC	10.6 (±0.334)	140	-0.988 (±0.206)	12	0.083 (±0.012)	0.395
	AS	12.3 (±0.189)	145	-0.641 (±0.117)	7.18	0.089 (±0.006)	0.544
	GW	11.2 (±0.121)	146	-1.30 (±0.091)	15.1	0.086 (±0.004)	0.051
50% artificial shade	AC	10.1 (±0.353)	134	-0.962 (±0.207)	11.6	0.083 (±0.014)	0.196
	AS	7.62 (±0.164)	84.7	-0.852 (±0.123)	8.52	0.100 (±0.011)	0.413
	GW	8.93 (±0.205)	123	-1.38 (±0.132)	16.5	0.084 (±0.010)	0.323
Natural shade under young rubber	AC	8.55 (±0.285)	118	-1.650 (±0.194)	19.1	0.087 (±0.014)	0.450
	AS	6.20 (±0.228)	102	-2.47 (±0.177)	29.1	0.085 (±0.016)	0.487
	GW	6.37 (±0.183)	109	-1.89 (±0.150)	24.9	0.076 (±0.009)	0.767

(N M C Nayanakantha, A M W K Senevirathna, M P D Lanka, A Deshapriya, E U M de Z Dissanayake and P K W Karunatillake in collaboration with University of Sri Jayawardhanapura and Sadaharitha Plantations Ltd.)

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 & Microbiology Department. Mrs M K R Silva, Research Officer was on duty throughout the year. Miss L H S N Gunerathne assumed duties as a Research Officer of the department with effect from 09th May 2016. Experimental Officers, Mrs B I Tennakoon, Mrs E A D D Siriwardene and Mr S C P Wijayaratne continued to work in the department. Mr E A D N Nishantha was on no-pay leave from the 1st of November 2016. Mr S R D P C Peiris was promoted as the Network Administrator and covered up all the duties and responsibilities of the Audio Visual & IT Unit. Miss W M S P Wijekoon and Mrs A N Wijevardhana resigned with effect from 21st July & 31st October 2016, respectively. Mrs K A D Y Madushani Lanka, Management Assistant was on duty throughout the year. Mrs H K I Madushani and Mr P S Sandaruwan worked as Temporary Research Assistants under the Development Project – 23/1/15 and Mr P W Balasooriya assumed duties as a Research Assistant under the NSF Project RG/2016/AG/01. Mrs H K I Madushani resigned on 15th December 2016.

Research grants received

Source and Grant No.	Duration	Title of the project	Allocation	Status
National Science Foundation [NSF]	Dec. 2015	Support for Research Equipment for a Gradient PCR Machine	Rs.825,000	Received Gradient PCR machine Complete -
Ministry of Plantation Industries **Development Project – 23/1/15**	May 2016 - 2021	Identification of the potential pest and disease problems of rubber in non-Traditional areas to develop improved management strategies	20 Rs. Mn.	In progress
National Science Foundation **NSF Project: RG/2016/AG/01**	May 2016 - 2019	Investigations on biological control measures for WRD of rubber to improve integrated disease management strategies	2.071 Rs.Mn.	In progress

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
PMSM Premajayantha	October 2015 - Feb 2016	Aquinas University College	Optimization of diffèrent media for *Trichoderma* spp.
DYL Wijesinghe	December 2015 - December 2016	University of Sri Jayawardenapura	Variability study of *Corynespora cassiicola* from traditional and non-traditional rubber growing areas
SV Withanage	March 2016 - December 2016	University of Sri Jayawardenapura	Inducement of agarwood using toxins of *Aspergillus niger* and *Fusarium soloni*
NR Aberathne	July 2016 - December 2016	University of Sri Jayawardenapura	*In vitro* comparision of *Rigidoporus microporus* the cause of white root disease of *Hevea brasiliensis* with the associated decaying fungi

Committees attended

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

Training programmes attended

Officers	Training programme	Duration
THPS Fernando	Workshop on mitigation of South American Leaf Blight (SALB) of rubber in the Asia-pacific region - present and future in Kuala Lumpur, Malaysia	15th Oct - 22nd Oct 2016

Training programmes conducted

Dr (Mrs) T H P S Fernando and Mrs M K R Silva served as the resource personnel in training Estate Managers, Assistant Superintendents and Field Officers. Mrs B I Tennakoon, Mrs E A D D Siriwardene, Mr S C P Wijayaratne and Mr E A D

N Nishantha covered the practical aspects of the above programmes while all the staff members extended their fullest cooperation in educating students from Universities and Technical Colleges on departmental activities. Mr S R D P C Peiris covered all audio visual aspects of the training programmes organized by the institution.

Trainings provided

Name	Duration	University	Project Title
SW Fernando	April 2016 - October 2016	School of Agriculture, Bibile	Agriculture production Technology - Job training
AKDS Niranjala	May 2016 - June 2016	Higher National Diploma in Agriculture	Agriculture production Technology - Job training
PS Dharmasiri	May 2016 - June 2016	Higher National Diploma in Agriculture	Agriculture production Technology - Job training

Experimental/Advisory visits

Purpose	No of visits
Experimental	245
Advisory	65
Other	91
Total	401

LABORATORY AND FIELD INVESTIGATIONS

Chemical control of *Hevea d*iseases (23/P/01)

Chemical control of white root disease to revise the present recommendation

A field trial was initiated to investigate the need of revising the present chemical recommendation against the white root disease. This was conducted in a 3½ years old immature rubber field. tebuconazole (250 EW) at the concentrations of 1% and 0.5% (4 litres per each tree) and hexaconazole (50g/l) at the concentrations of 1%, 2%, 2.5% and 5% (4 litres per each tree) were tested for the efficacy having an initial disease index of each tree (T H P S Fernando and S C P Wijayaratne).

Another trial was started at a smallholding in Baduraliya to test different chemical concentrations as given below. The curative effect is being assessed.

Teboconazole (Folicur 25 EW)

T1 - 40 ml of the chemical dissolved in 4 liters of water

T2 - 20 ml of the chemical dissolved in 4 liters of water

Hexaconazole (Hayleys hexaconazole 50 g/L)

T3 - 40 ml of the chemical dissolved in 4 liters of water
T4 - 80 ml of the chemical dissolved in 4 liters of water
T5 - 100 ml of the chemical dissolved in 4 liters of water
T6 - 200 ml of the chemical dissolved in 4 liters of water
T7 - Control (no fungicide application)
(T H P S Fernando and B I Tennakoon)

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, PVC-coated galvanized square mesh and PVC mesh showed promising results at the effectiveness and durability study under the field conditions. The trials are further evaluated for the durability (M K R Silva, T H P S Fernando and B I Tennakoon).

Tree injection against white root disease 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 (T H P S Fernando and S C P Wijayaratne).

Alternative chemicals for the management of the bark cracking disorder

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

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 was not done (T H P S Fernando, M K R Silva, S C P Wijayaratne and B I Tennakoon).

Chemical control of the* Phytophthora *bark rot disease

In the trial carried out at Galewatta to assess the potential of using lower concentrations of currently-used fungicides for the prevention of black stripe disease, it was found that Brunolinum Planetarium or Ridomyl can be used in reduced concentrations as preventive application against *Phytophthora. i.e.* Brunolinum Planetarium at the concentrations of 7.5% and Ridomyl at the concentrations of 3g/l (Table 1).

The experiment was carried out at Galewatta division of the Dartonfield estate in a rubber clearing of the clone RRISL 102. The clearing was ten years-old and was under the tapping panel A. The disease conditions were provided by artificially inoculating the trees with a spore suspension of *Phytophthora* and the area of the lesion resulted at the each treatment was measured.

Table 1. *The mean infected area under different treatments*

Treatment	Mean area infected (m^2)*
Brunolinum Planetarium 15%	0.3470[a]
Brunolinum Planetarium 7.5%	0.5120[a]
Ridomyl 5g/ml	0.1670[a]
Ridomyl 3g/ml	0.2360[a]
Mancozeb 3g/ml	2.9490[b]
Control	2.8320[b]

*Values followed by a common letter are not significantly different according to DMRT (P= 0.05)

(M K R Silva, T H P S Fernando and B I Tennakoon)

Biology of pests (23/P/02)

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

The fungus *Rigidoporus microporus* is distributed worldwide causing diseases in a number of economically important crops including *Hevea brasiliensis*. Further, the white root disease caused by this fungus, mainly in tropical countries is becoming increasingly important. Currently available literature is limited to assess the information on biology, pathogenicity, genetic variability of *R. microporus* from different host plants. Therefore, the objective of this investigation was to study the requirement of environment factors, biology, pathogenicity and genetic variability of *R. microporus* on different host plants.

Twelve isolates of *R. microporus* were used in this study (Fig. 1). Isolates were obtained from different host plants such as *Hevea brasiliensis*, *Cinnomomum zeylanicum*, *Camellia sinensis*, *Artocarpus nobilis*, *Alstonia macrophylla*, *Artocarpus*

heterophyllus, *Mucuna bractiata*, *Salix babylonica* and *Murraya koenigii* (Table 2). Effect of different media, temperature, pH levels and light intensity were tested against their growth under *in vitro* conditions. The growth of *R. microporus* was maximum in the pH range between 7-8 (Fig. 2) and the temperature range between 25-30^{0}C. The exposure of the fungus to continuous dark conditions resulted in the maximum mycelium growth compared to continuous light condition. Among the different media tested malt extract agar was the best medium.

Under investigation of cell wall degrading enzymes, the *R. microporus* isolate of *Artocarpus nobilis* from the Kalutara district (R6) produced comparatively higher pectin lyase (PL), polygalacturonase (PG), ß-glucosidase and laccase enzyme than the other isolates. The pH of the medium showed correlation with the activity of enzymes during the incubation period. Molecular weight of PL and PG of the isolate R6 was 30.16 ± 2 kDa and 42.83 ± 0.76 kDa respectively (Table 3). The other isolates did not produce sufficient concentration of PG and PL to determine their molecular weights. The molecular weights of laccase ranged from 57 kDa to 69 kDa for all isolates that was eluted as the first peak of the laccase ezyme activity assay.

Pathogenicity level of the isolates was assessed based on the symptoms produced on the *H. brasiliensis* roots. Non parametric results were analysed by Kruskal Wallis analysis and were used to develop cluster by Genestat programme. All the isolates tested were pathogenic on *H. brasiliensis* and re-isolation showed the same cultural and morphological characteristics as those of the initial isolates. The twelve tested isolates were grouped into two main clusters from 0.8 similarity level as high and low virulent. R10 (*Artocarpus heterophyllus*) and R6 (*Artocarpus nobilis*) were grouped alone as a main cluster under low pathogenicty on *H. brasiliensis*. All the other isolates were grouped as more virulent isolates. The R6 isolate was least virulent and

The isolate R 2 (*Mucuna bractiata*) was the most virulent isolate among the twelve isolates. In the pathogenicity test, basidiocarp formation, thick rhizormorphs on infected seedlings, fast degradation of inoculated root pieces and less inoculum viability were observed with R6 inoculated root pieces and *H. brasiliensis* seedlings. Isolate R6 inoculated seedlings and root pieces produced different characters in the pathogenicity test than the other isolates.

The sensitivity of isolates to tebuconazole and hexaconazole fungicides was evaluated by poisoned food technique. The concentration - 50 ppm of tebuconazole was detrimental to the growth of all the tested isolates of *R. microporus*. The hexaconazole fungicide showed tolerance ability within the tested concentrations (5 ppm to 100 ppm).

In RAPD and ISSR analysis, clusters showed a number of sub clusters which indicated the high genetic variation among the investigated isolates. These results indicated that there was 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 was funded by National Research Council, Sri Lanka: Grant No. 11-39).

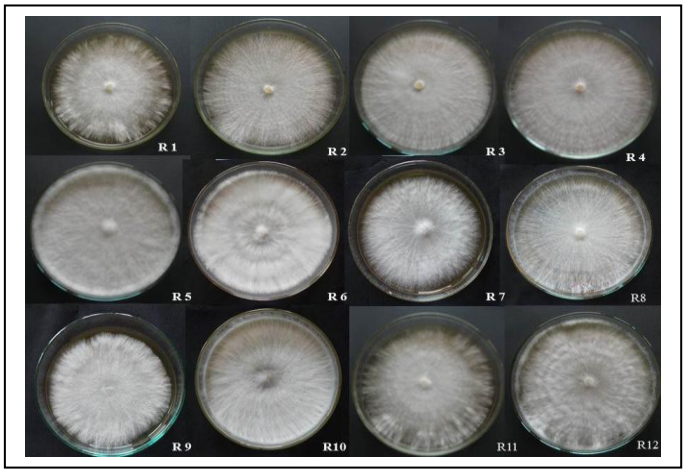


Fig. 1. Colony morphology of different *R. microporus* isolates (12 fungal isolates, details given in Table 3) on MEA after 6 days of incubation at RT (28±2 ºC) under continuous dark

Table 2. *Variations in cultural characteristics of* R. microporus *isolates obtained from different host plants*

Isolate	Host plant	Place of collection	Colony morphology	Growth rate (cm/day)*
R1	*H. brasiliensis*	Kalutara	Flat colony, concentric zone	1.21^{d}
R2	*M. bractiata*	Deraniyagala	Fluffy colony, concentric zone	1.34^{c}
R3	*C. zeylanicum*	Kuruwita	Fluffy colony, concentric zone	1.49^{a}
R4	*H. brasiliensis*	Monaragala	Flat colony, concentric zone	1.52^{a}
R5	*C. sinensis*	Kuruwita	Flat colony, no concentric zone	1.42^{b}
R6	*A. nobilis*	Kalutara	Fluffy colony, concentric zone	1.28^{d}
R7	*M. koenigii*	Kalutara	Flat colony, no concentric zone	1.13^{e}
R8	*S. babylonica*	Kalutara	Flat colony, concentric zone	1.25^{d}
R9	*A. macrophylla*	Padukka	fluffy colony, no concentric zone	1.02^{f}
R10	*A. heterophyllus*	Kegalle	Fluffy colony, anticlockwise turning	1.47^{a}
R11	*H. brasiliensis*	Kegalle	flat colony, concentric zone	1.21^{d}
R12	*H. brasiliensis*	Galle	flat colony, concentric zone	1.11^{e}

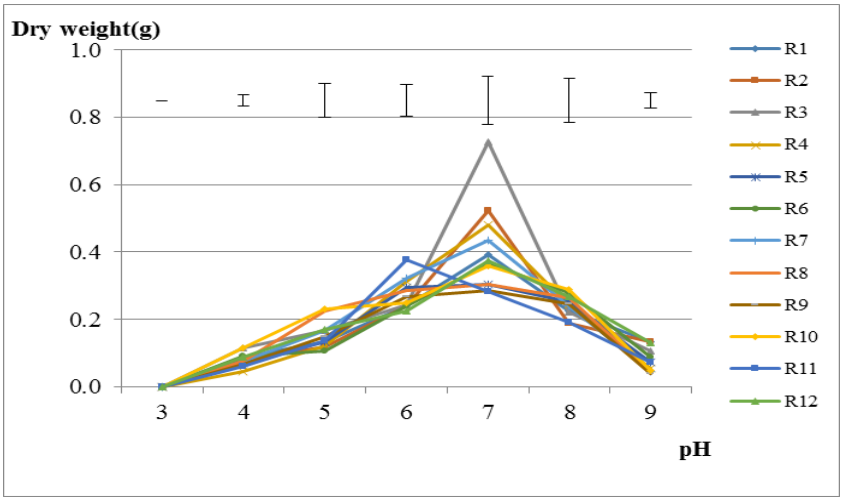


Fig. 2. Effect of pH on the dry weight of the twelve *R. microporus* isolates after 6 days of incubation at RT (28±2 ºC)

Table 3. *Molecular weights of the laccase and pectinolytic enzymes* R. microporus *isolates grown in culture media*

Isolate	Molecular weights (KDa)		
	Laccase	PG	PL
R1	65.5 ± 2.765	-	-
R2	57.167 ± 4.311	-	-
R3	62.167 ± 3.403	-	-
R4	66.5 ± 2.947	-	-
R5	61.167 ± 4.646	-	-
R6	61.333 ± 3.512	42.833 ± 0.764	30.167 ± 2.021
R7	69.0 ± 3.50	-	-

Genetic variability of the *Rigidoporus microporus* pathogen population - ISSR-PCR analysis

Inter-simple sequence repeat (ISSR) markers were used to investigate genetic diversity among 12 isolates of *R. microporus* isolates from different host plants. Among ten primers, seven primers showed multi band patterns for each isolate. The primers amplified a total of 32 bands from 12 isolates tested. The average number of bands per primers was 4.6. Band size ranged from 250 - 2000 bp. In this study the G+C content of the primers ranged from 47.06 - 66.67%. The bands obtained from Rimi 3, Rimi4, Rimi 5, Rimi 6 primers were shown in Figure 32, 33, 34 & 35

respectively. UPGMA analysis based on total ISSR character differences was carried out to group the 12 isolates of *R. microporus*. The dendrogram resulted two main distinct groups, designated as A and B. B main cluster was grouped alone with R6 and other eleven isolates were clustered in to A main cluster. Cluster A was sub clustered into two groups and one of the sub cluster consisted with R1, R4 and R2 (Fig. 3) (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).

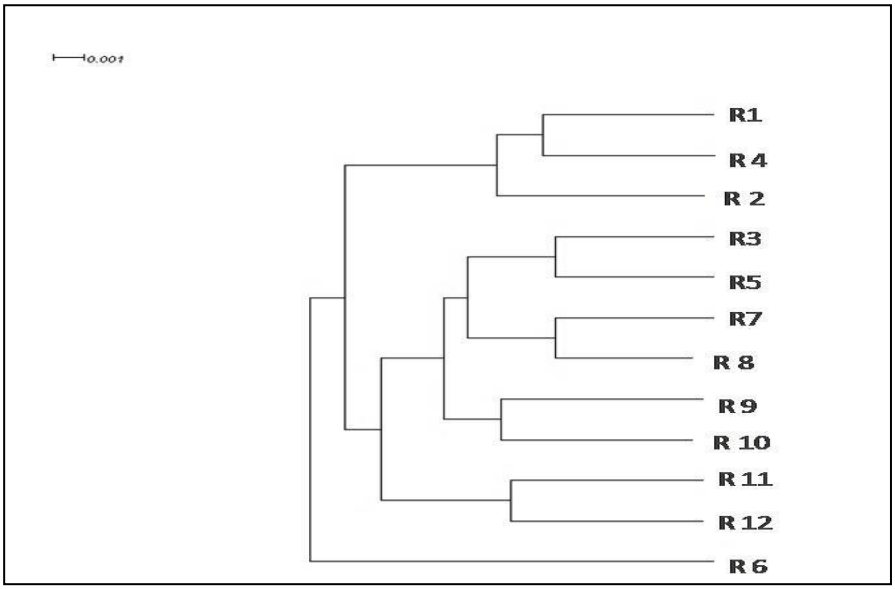


Fig. 3. The dendrogram of twelve isolates in *R. microporus* (R1-R12) constructed using UPGMA method by neighbor programme of Phylip 3.695

***Morphology and physiology of the brown root disease-causing fungus,* Phellinus noxius**

Collection of isolates of *Phellinus noxius:* the pathogen causing brown root rot was continued from various rubber-growing regions of the country. The disease was reported from teak *(Tectona grandis)* and jack *(Artocarpus heterophyllus)* from Bibile and Gampaha areas respectively. The pathogenicity of the isolates obtained from, *Careya arborea* ('kahata'), *Gmelina arborea* ('eth demata') and *Bridelia retusa* ('keta kela') was proved by carrying out Koch's postulates. Moreover, similar to the previous years, it was recorded that the disease occurrence was high in certain agro-ecological regions of the country.

Studies on the morphological characteristics of the pathogen cultures were carried out. The fluffiness and the density of the cultures and the development of coloration with time by different isolates were tested in the petri plate (Fig. 4).

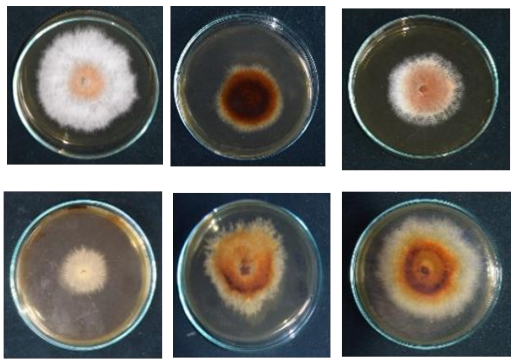


Fig. 4. Morphological features of *Phellinus noxius* isolates under investigation

The growth rates of the isolates in different media *i.e*. Malt extract agar (MEA), Czapec-dox agar (CDA), Lima bean agar (LBA) and Potato dextrose agar (PDA) were investigated (Fig. 5).

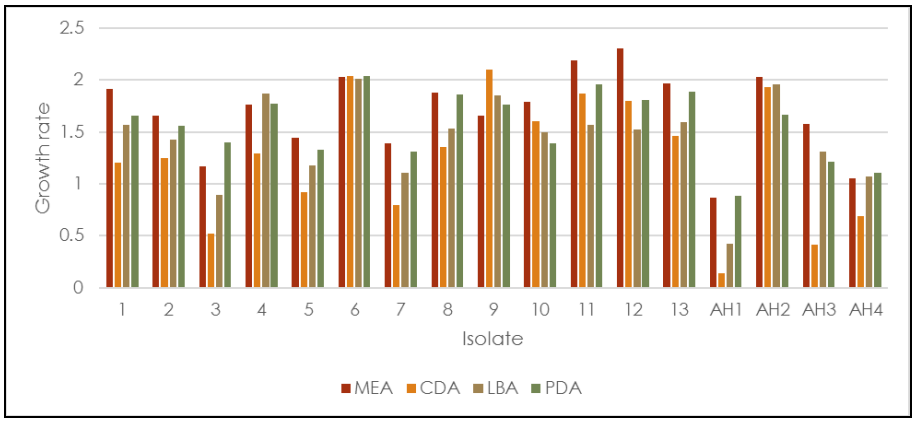


Fig. 5. Effect of culture media on radial growth of *Phellinus noxius* isolates on different media; MEA, CDA, LBA and PDA

***Determination of enzyme activity of the brown root disease-causing fungus,* Phellinus noxius**

Two Pectinolyic enzymes *i.e.* pectin lyase (PL) and polygalacturonase (PG) were assayed. Thiobarbituric acid method was used to determine the pectin layase activity and the agar plate method and viscocity reduction method were used to determine polygalacturonase activity.

In all the four isolates under investigation, the pectin lyase enzyme production (which is proportionate to the absorbance) was significantly higher at 16 days of incubation. Moreover, one isolate has shown higher enzyme production at 6 days of incubation as well (Fig. 6). In the viscosity reduction method, polygalacturonase enzyme production (which is proportionate to the diameter of the clear zone) was significantly higher at 10 days of incubation (Fig. 7).

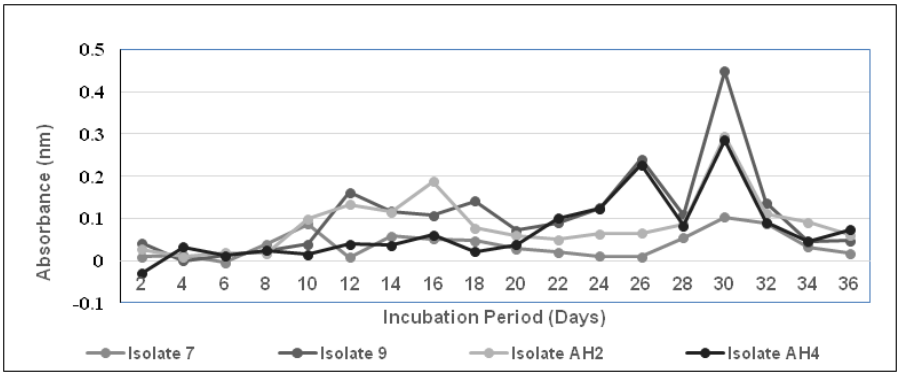


Fig. 6. Production of pectin lyase by *Phellinus noxius* isolates in liquid cultures, assayed using Thiobarbituric acid method

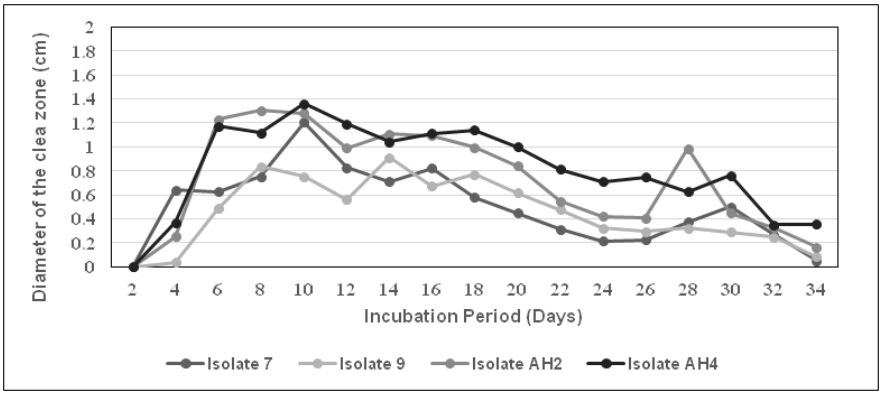


Fig. 7. Production of polygalacturonase by *Phellinus noxius* isolates in liquid cultures, assayed using cup plate method

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

Field trials established at Moneragala and Dartonfield to investigate the influence of agro-climatic conditions on the spread of the disease were inoculated with the brown root disease-causing fungus, *Phellinus noxius* (M K R Silva, T H P S Fernando and B I Tennakoon).

***In vitro* comparison of *Rigidoporus microporus* the cause of White Root Disease of *Hevea brasiliensis* with the associated decaying fungi**

Identification of white root disease under field conditions has sometimes become a problem due to the presence of other morphologically similar fungi. In the presence of cover crops the organic matter around the plants are more and on them these friendly micro-organism communities grow luxuriously. Growers mis-identify these friendly fungal growth as the pathogenic white root disease fungus. These leads to many plant protection and also environmental problems. This study reveals the fungal organisms living surrounding the root systems which appears more or less similar to *Rigidoporus microporus* (Fig. 8) (T H P S Fernando, D S Siriwardene and A H M N R Aberathne).

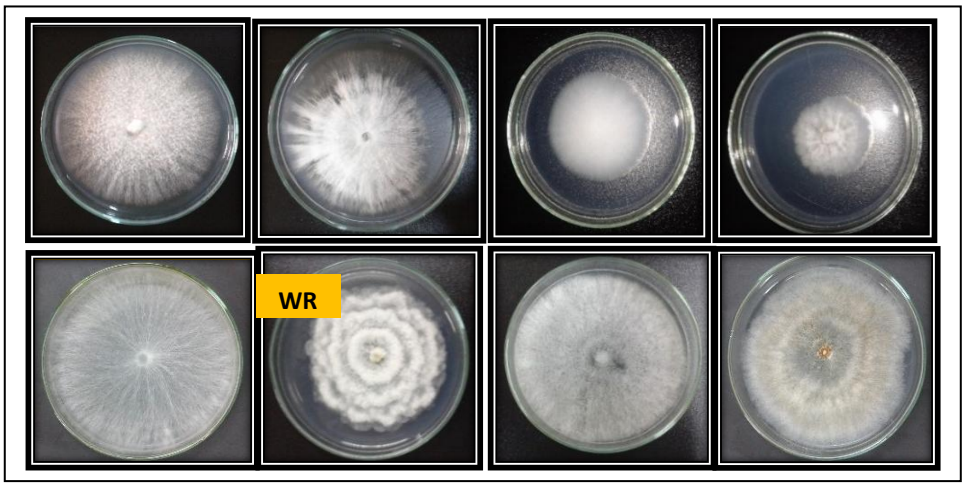


Fig. 8. The fungi isolated from the rubber and cover crop roots showing more or less similar morphological characters to white root disease fungus. WR – *Rigidoporus microporus*

Studies on the biology of the associated organisms of patch canker disease of rubber

Collection of disease specimens from different locations of the country and isolation of the pathogen is continued in a specifically developed medium in order to evaluate the associated organisms. In addition, molecular diagnosis of organisms will

be done through gene sequencing (Samudra Gunarathne, T H P S Fernando and N Nishantha).

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

Screening of the clones against secondary leaf fall disease

Screening of the clones against Powdery mildew was initiated for the year 2016 but could not proceed due to transport problems (T H P S Fernando, M K R Silva, B I Tennakoon and S C P Wijayaratne).

Screening of the clones against Bark rot

The bud wood nursery at Kuruwita was prepared for the bark rot screening trials of the upcoming year by, pollarding, manuring and weeding (M K R Silva, T H P S Fernando and B I Tennakoon).

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 4) (T H P S Fernando, E A D N Nishantha and E A D D Siriwardena).

Table 4. *Survey on Corynespora leaf fall disease - 2015*

Clone	ADSI *	Clone	ADSI *
RRIC 121	0	RRISL 221	0
RRIC 102	0	RRISL 222	0
RRIC 130	0	RRISL 202	2.2
RRISL 203	0	RRISL 200	3.5
PB 260	0	RRISL 2000	0
RRIC 133	1.0	RRISL 2002	0
RRISL 201	1.26	RRISL 2004	0
RRISL 205	0	RRISL 2005	0
RRISL206	0	RRISL 2006	0
RRISL210	0	GPS 1	0
RRISL211	0	PB 255	1.0
RRISL215	0	PR 255	0
RRISL216	0	PR 305	0
RRISL217	0.8	RRII 105	1.0
RRISL219	0	PB235	0
RRISL2001	0	BPM 24	0
RRISL2003	0	RRISL 200	3.0
RRISL 218	1.4	Centennial 2	0
RRISL 204	0	Centennial 3	1.0
RRISL 202	2.36	Centennial 4	0
RRISL 208	1.4	Centennial 5	0
RRISL 220	0		

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

Maintenance of nurseries for screening purposes – Ratnapura District

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, S C P Wijayaratne).

Establishment of a nursery for screening purposes – Padiyathalawa

A nursery site was selected at the Rubber Development Department premises in Padiyathalawa. Land preparation practices have been completed. Planting materials consisting of 50 rubber clones to be screened are ready to be planted (T H P S Fernando, M K R Silva, B I Tennakoon, E A D D Siriwardena and S Sandaruwan: Funded by Development Project 23/1/15).

Establishment of a nursery for screening purposes - Dartonfield

A nursery site was selected at the Rubber Development Department premises in Padiyathalawa. Land preparation practices have been completed. Planting materials consisting of 50 rubber clones to be screened are ready to be planted (T H P S Fernando, M K R Silva, E A D D Siriwardena and B I Tennakoon: Funded by Development Project 23/1/15).

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

The WRD survey – Government Nurseries

A survey was carried out to inspect the white root disease condition in government nurseries. This inspection was arranged based on complaints received by the stakeholders on the presence of white root disease. This survey could not be continued during the year 2015 successfully due to the transport problems (T H P S Fernando, all staff of Plant Pathology & Microbiology Dept.).

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).

Identification of potential pests disease problems of rubber in non-traditional areas to develop improved management strategies (Development Project Funded by the Ministry of Plantation Industries P 23/1/15)
Below actions were made under the above project.

- Rubber growing areas in different non-traditional areas were traced.
- Two Research Assistants were recruited and trained. In the month of December 2016, one of the RAs resigned.
- A questionnaire was prepared to carry out the surveying in Uva province to find potential Pests and Diseases.
- Clonal screening nurseries in Padiyathalawa/Monaragala/Dartonfield: Sites have been selected. Land preparation is in progress and preparation of planting materials was completed.
- Isolation of pathogens from rubber and intercrops is also in progress. Disease samples were collected from rubber and other intercrops in non-traditional rubber growing areas, Symptoms were recorded.
- Establishment of disease clonal clearings consisting of ten clones. Each clone consisting with 50 replicate trees (Extent – 01 ha each).

Selected sites

Site	
Kandakaduwa Farm, Polonnaruwa	Army Camp
Padiyathalawa	Rubber Development Department premises
Vavuniya	Smallholder
Monaragala	Smallholder

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

Biological Control of *Hevea* Diseases (23/P/05)
Identification of indigenous soil microflora as biological control measures for white root disease of rubber growing lands in Sri Lanka
Sample collection

Collection of soil samples from main rubber growing areas to detect beneficial soil micro flora giving special reference to antagonistic fungi. Similar samples were bulked at the site and packed in polythene bags and stored at 4^0C container until return to the RRISL Lab.

- Polonnaruwa district (Kandakadu) - Three sites
- Kalutara district (Mirishena) - One site
- Ratnapura district (Kuruwita) - One site
- Ampara district - One site

Dilution plate technique and spread plate method was used to grow the soil fungi. After incubated for 6 days at 28^0C, the most abundant and visually different soil fungi were isolated. PDA was used as the media for the isolation of the soil fungi. Isolates were transferred until get the pure cultures. Pure cultures were stored for further studies (T H P S Fernando, Samudra Gunarathne, Poorna Balasuriya and E A D D Siriwardene: This project is partially funded by National Science Foundation 2016/AG/01).

A solid medium for biological control agents

Compost has been identified as a suitable medium for the introduction of Trichoderma inoculums 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, E A D D Siriwardene and Poorna Balasuriya: This project is partially funded by National Science Foundation 2016/AG/01).

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

Trials were carried out to test the applicaton of sulphur on the variability of PH and also on the beneficial soil microbe populations. Two experimental sites were selected in Nivthigala Kale and Dartonfield Estate. 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 National Science Foundation – Grant 2016/AG/01).

A liquid medium for biological control agents

A medium is being tested for the identified native bio control agents. Different kind of liquid/semi liquid compounds such as rubber serum, molasses, sugar waste, etc. is used. Further investigations are carried out to modify and develop the medium (Samudra Gunarathne and T H P S Fernando: This project is partially funded by the National Science Foundation Grant 2016/AG/01).

Studies on beneficial microbiology and microbiological testings (PP– 06)

Isolation of an antimicrobial protein purified from the Hevea latex

A protein is being isolated from the natural rubber latex which has potential antimicrobial properties. This protein is purified, subjected to antimicrobial assay and testing against *Hevea* pathogens (Samudra Gunarathne and T H P S Fernando).

Decorative handicrafts from partially decomposed rubber leaves

More environmental friendly method using rubber serum was tested for skeletanization of rubber leaves. Optimization of the medium for efficacy was also done. 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 and E A D D Siriwardena).

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 were done. Dual culture test was done against *Rigidoporus microporus* and twelve isolates were found effective (T H P S Fernando, E A D D Siriwardene and P W Balasooriya).

Table 8. *Soil samples collected sites of Sri Lanka*

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
RBL - Reddish Brown Latasolic
RBE - Red Brown Earths
IBL - Immature Brown Loam

Developing a national level bacterial culture collection

The national level culture collection will be used for industrial and bioremediation applications such as Rubber waste water treatments, Cadmium degradation, Glyphosate degradation, Polythene and petroleum oil degradation etc.

Bacteria were isolated from natural rubber serum, rubber latex, processed rubber samples, polluted aquatic bodies (marine environments and freshwater environments) and contaminated soil rhizosphere (Table 9 and Fig. 9). Screening of effective bacteria was carried out based on results of various biochemical and physical parameters (COD, TDS, pH, Turbidity, Atomic absorption *etc*.).

The experiment is continued to gene sequencing of effective bacteria and identification through homology search (NCBI). Successful cultures are maintained as a culture bank and commercialized according to the needs of the industries (Samudra Gunarathne and T H P S Fernando).

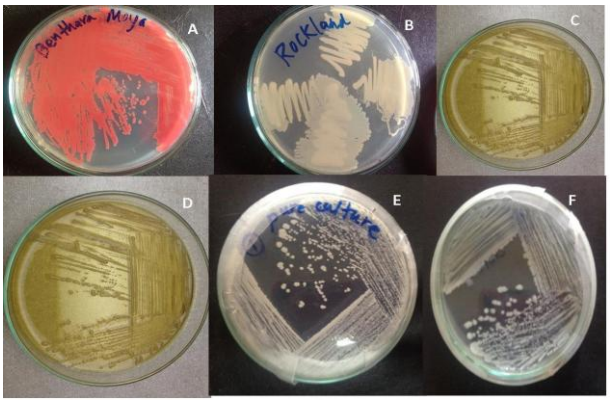


Fig. 9. Isolated bacteria from different habitats (Pure cultures)

Table 9. *Isolated bacteria with their potential applications*

Label	Origin of isolate	Application
A	Marine environment	Rubber waste water treatment/Cadmium degradation
B	Marine polluted environment	Rubber waste water treatment
C	Crape rubber sample	Rubber waste water treatment
D	Crape rubber sample	Rubber waste water treatment
E	Rubber serum	Rubber waste water treatment/ Cadmium degradation
F	Rubber serum	Rubber waste water treatment

Developing a national level Fungal culture collection

A collection of fungal cultures is maintained at the Plant Pathology & Microbiology Department in view of using them for research and development purposes. These pure cultures of beneficial and pathogenic cultures are provided for nationally and internationally important research and development purposes. The collection mainly consists of *Colletotrichum acutatum/Colletotrichum gloeosporioides/Corynespora cassiicola/Phytophthora spp./Rigidoporus microporus/ Phellinus noxius/Xylaria thwatsii/Fusarium solani/Nattrassia mangiferae/ Thanetephorus cucumeris/Rhizoctonia solani/Pestalotiopsis spp./Phomopsis spp./ Botrodiploidea theobromae*/*Trichoderma* spp./*Aspergillus* spp./*Penicillium* spp. (T H P S Fernando, M K R Silva, Samudra Gunarathne, E A D N Nishantha and P W Balasooriya).

Studies on miscellaneous projects (PP– 07)

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. 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).

Advisory visits and training programmes (PP – 08)

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 to the department by the Extension staff (T H P S Fernando and all staff).

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

SOILS AND PLANT NUTRITION

R P Hettiarachchi

DETAILED REVIEW

Staff

Mrs R P Hettiarachchi, Senior Soils Chemist, completed her PhD programme on "Biofilmed biofertilizer for improved plant growth and soil health of rubber nurseries and plantations" and obtained the degree with effect from 24th October 2016 while on duty throughout the year. Mr J M T S Jayasinghe and Mrs H A R K Jayawardana joined the department as Research Officers on 9th May 2016. Experimental Officers, Miss V Edirimanna, Miss A Thevarapperuma, Mr T Gunathileke, Mr J A S Chandrasiri, Technical Officers Mrs K E de Silva, Mr G C Malawaraarachchi, Mrs K M M E K Kulatunga and the English Stenographer Mrs L Rupasinghe were on duty throughout the year. Mr J M T S Jayasinghe and Mrs R H N S Alwis resigned from the institute on 30th September and 30th November 2016 respectively. Mrs C K Maheepala and Mr U Mitrasena, Experimental Officer, retired on 31th March and 19th December 2016 respectively.

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
	Annual General Meeting	Soil Science Society of Sri Lanka
	Committee Meeting	National Fertilizer Secretariat
	Role of Fertilizers: Current Status, their Benefits & Risks	Sri Lanka Association for the Advancement of Science
	Land Degradation Neutrality Target Setting Program (LDN-TSP)	Ministry of Mahaweli Development & Environment
	National Action Plan (NAP) of the United Nations Convention to combat Desertification	Ministry of Mahaweli Development & Environment
	Identify available data/Information on land degradation	Ministry of Disaster Management

Officer	Subject	Organization
RP Hettiarachchi	Banning Glyphosate	Ministry of Plantation Industries
HARK Jayawardana	Scientific Committee Meetings	RRISL
	Workshop on Results Frame Working	RRISL
	Plantation Crop Symposium	CRI
	Workshop on Laboratory Management	Measurement unit, Standards and Services Department
JMTS Jayasinghe	Scientific Committee Meetings	RRISL
	Workshop on Results Frame Working	RRISL
	Workshop on Fertilizer Policy in South Asia	University of Peradeniya

Seminars/Conferences/Meetings/Work-shops addressed

Officer	Subject	Organization
RP Hettiarachchi	"Availability of Plant Nutrition from Encapsulated Fertilizers Based on Rubber Latex and Coir Dust" Plantation Crop Symposium	CRI
	"Toxin free Agriculture"	Presidential Secretariat Office

Training programmes conducted

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

Advisory visits

Client	No. of visits
Plantations	03
Smallholdings	03

LABORATORY AND FIELD INVESTIGATIONS

Soil fertility management

Mass production of Mucuna bracteata *plants*

Objective of this activity was to provide *Mucuna* plants to small holders and also to estate sector. Nurseries were established in RRISL Substations in Nivithigalakele, Kuruwita and at Payagala Estate and 1000 polybagged *Mucuna* plants were issued for a price of Rs.25.00 per plant (Table 1).

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

Name of the Nursery	Number of plants	Recipient
Payagala	500	Private plantations
Kuruwita	300	Private plantations
Nivitigalakele Substation	300	Private plantations and RRISL
Galewatta	100	RRISL

(R P Hettiarachchi, U Mitrasena and A Thewarapperuma)

Biofilm biofertilizers (BFBF) for rubber

Biofertilizers support the plant growth through several mechanisms such as decomposition of organic materials and release of inorganic nutrients, increasing the availability of nutrients in the soil by solubilization, chelation, oxidation and reduction processes, increasing root surface area by inducing root growth promotion, enhancing other beneficial symbioses associated with plant and by combination of mode of actions.

Evaluate the effectiveness of BFBF on Nitrogen mineralization

This experiment was conducted using a leaching column technique under laboratory conditions to ascertain the mineralization ability of identified/selected biofilms. The columns were filled with a mixture of soil and sand and were placed on a rack and treatments were arranged in a completely randomized block design with five replicates. Treatments were arranged according to the experimental design and control treatment had no any amendment in the soil (T0), different BFBFs were tested separately as T1, T2, T3, T4 and T5. At the end of four weeks, mineral nitrogen in the column was recovered and tested for ammonium-N and nitrate-N (Table 2).

Table 2. *Available ammonium and nitrate nitrogen contents in the soil with different biofilm treatments at the end of the incubation period*

Combination of biofilm	Ammonium nitrogen (ppm)	Nitrate nitrogen (ppm)	Total mineralized nitrogen (ppm)
T_0- Control	7.28^{e}	31.65^{d}	38.93^{e}
T_1- B6F2	10.13^{d}	34.94^{d}	45.07^{d}
T_2- B12F2	12.75^{c}	43.82^{c}	56.57^{c}
T_3- B19F2	9.63^{d}	34.7^{d}	44.33^{d}
T_4- B23F2	25.92^{b}	63.65^{b}	89.57^{b}
T_5- B25F2	31.78^{a}	85.5^{a}	117.28^{a}

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

The control treatment without any biofilmed biofertilizer application gave the lowest contents of mineralized ammonium and nitrate. Significantly different highest mineralized ammonium and nitrate nitrogen was observed in the soil inoculated with the biofilm B25F2 and was the best compared to other biofilms.

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. Different treatments were tested according to the details reported in 2015 Annual Review. Plant growth assessments of leaf area, shoot dry weight, root dry weight and total plant dry weights of nursery plants at field conditions are given in Figure 1. Higher growth parameters were reported in BFBF treatments (+BFBF) compared to non-BFBF treatments (-BFBF) (Fig. 1). Almost all growth assessments of 50%F + BFBF treatment gave higher or equal growth parameters compared to 100%F treatment.

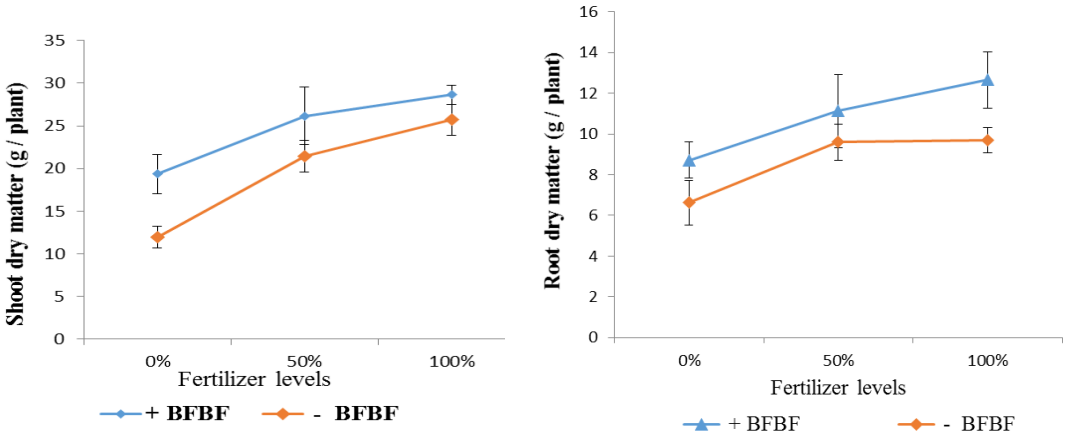


Fig. 1(a). Effect of different fertilizer applications on shoot dry matter and root dry matter of seedlings at field conditions

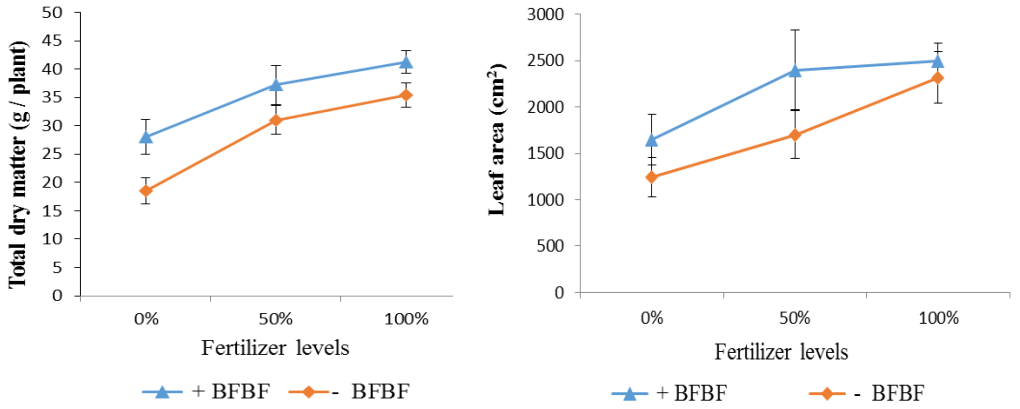


Fig. 1(b). Effect of different fertilizer applications on total dry matter and leaf area of seedlings at field conditions

At the end of the experimental period of seven months, it was noted that the P and K uptake of shoot, and root were higher with BFBF treatments compared to its respective non-BFBF treatments. Moreover, in many occasions 50% F with BFBF gave comparable or higher nutrient uptake values compared to 100% F treatments. It was further noted that the total plant nutrient uptake of P and K were higher with BFBF treatments compared to its respective non-BFBF treatments (Fig. 2).

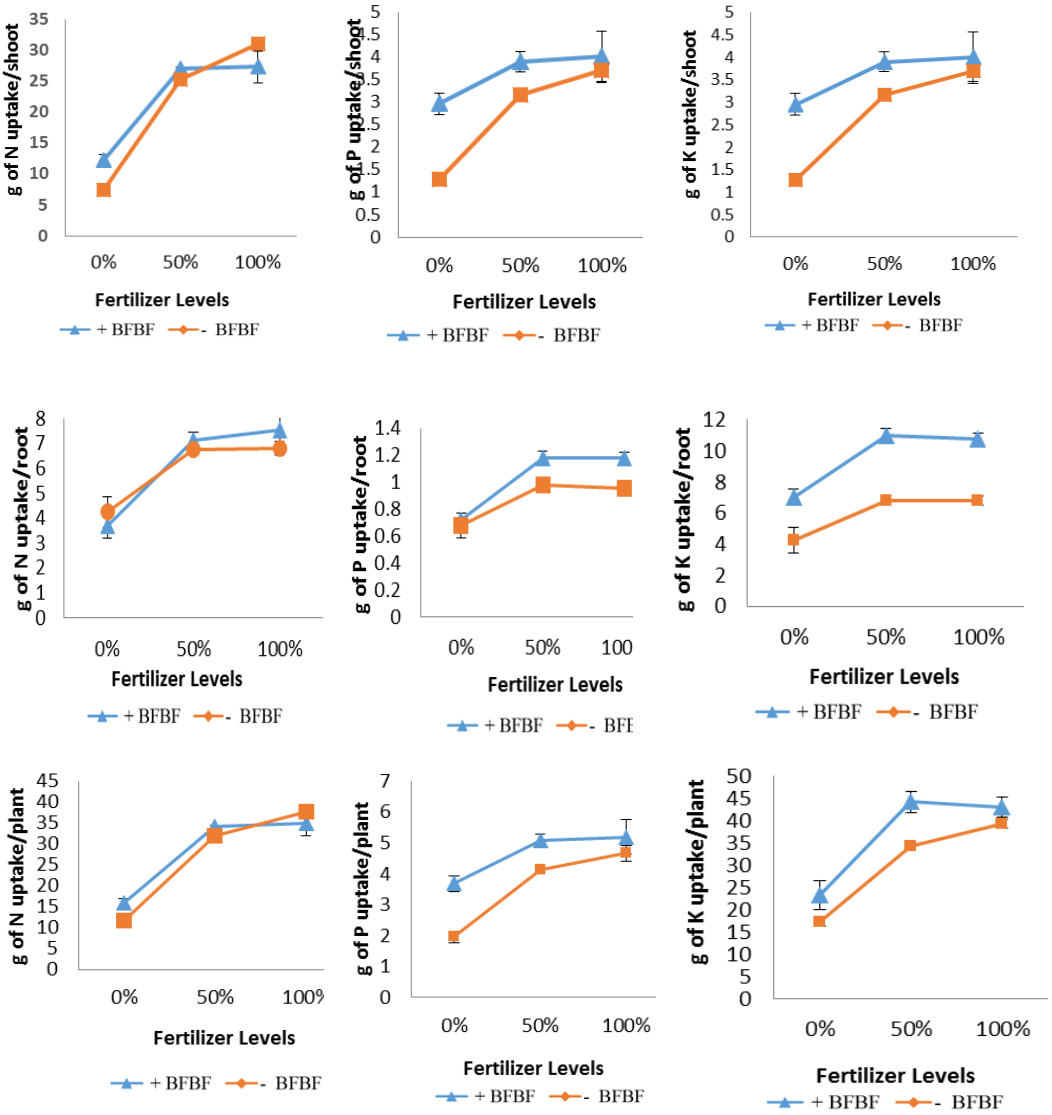


Fig.2. Effect of different fertilizer applications on nutrient uptake of shoot, root and total plant materials

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 reduced amount of chemical fertilizers for immature rubber plants

at field conditions. Two years old RRISL 203 plants was used and were tested according to the details reported in 2015 Annual Review. Plant diameter was measured throughout the experimental period is given in Table 3. The treatments having combined use of 50% recommended chemical fertilizer with BFBF (50% F + BFBF) and 75% recommended fertilizer with BFBF (75% F + BFBF) gave significantly higher plant diameter and also diameter increment values compared to recommended fertilizer treatment (100%F) at the time of fourteen months after planting.

Table 3. *Effect of different combinations of inorganic fertilizer and BFBF applications on growth of immature rubber plants*

Treatments	Plant diameter (mm)				Diameter increment
	3rd month	6th month	9th month	14th month	
100%F	14.7[a]	21.1[a]	31.1[a]	39.7[b]	25.0[b]
100%F+BFBF	15.0[a]	21.5[a]	30.6[a]	40.8[ab]	25.8[ab]
50%F+BFBF	14.8[a]	21.7[a]	31.5[a]	41.6[a]	26.8[a]
75%F+BFBF	14.4[a]	21.1[a]	30.4[a]	42.0[a]	27.6[a]

Means with the same letters in a column are not significantly different at $p< 0.05$.

Therefore, these studies have revealed that combined use of BFBF with modified fertilizer levels could enhance plant growth, up to their optimum levels.

Isolation of effective microbes from non-traditional rubber growing areas

Feeder root samples were collected from immature rubber plants and morphologically different bacterial cultures were isolated. Only very few isolates embedded within a matrix called Extracellular Polymeric Substances (EPS). They were evaluated for the formation of biofilm community structures and none of them formed biofilm.

Rehabilitation of degraded lands

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

This experiment was started in 2015 at Panawatta and Ekerella estates. The effect of environmental friendly agro management practices for the enhancement of soil fertility in degraded rubber lands were evaluated in this study. Moreover, the effect of combined use of agro management practices on the enhancement of soil fertility parameters such as, pH, organic carbon, total N, ammonium, available P, exchangeable K and Mg, cation exchange capacity (CEC) and microbial biomass carbon compared to normal estate practices were studied. Six months after the

establishment of combined use of agro management practices showed significant enhancement of above mentioned fertility parameters except CEC compared to normal estate practices (Table 4) (R P Hettiarachchi, U Mitrasena, V Edirimannne, T Gunathilake and G C Malawaraarachchi).

Table 4. *Soil fertility parameters after six months of the establishment of combined use of agro management practices compared to normal estate practices at Panawatta estate*

Assessment	Combined use of agro management practices	Normal estate practices
pH	5.48[a]	4.81[b]
Organic carbon (%)	1.31[a]	0.93[b]
Total N (%)	0.163[a]	0.125[b]
Ammonium N (ppm)	158.4[a]	115.6[b]
K (ppm)	100.95[a]	72.48[b]
Mg (ppm)	60.33[a]	51.66[b]
Available P (ppm)	22.14[a]	8.27[b]
Cation exchange capacity (cmol+/Kg)	3.6[a]	3.3[a]
Microbial biomass carbon (ppm)	311.43[a]	173.69[b]

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

Organic manure application for rubber nursery plants

Evaluation of the effectiveness of compost on rubber nursery plants

This experiment was designed to measure the growth of rubber plants throughout the nursery stage with different rates of compost. This included four treatments and were arranged in a completely randomized block design with ten replicates per treatment and one polybag as a replicate. Currently recommended 50 g of compost was used as the control treatment (T1) and T2, T3 and T4 had 100 g, 150 g and 200 g of compost respectively. The highest plant diameter and height values were observed with 100 g compost application (T2) throughout the experimental period of four months (Table 5). But, any enhancement of growth parameters with the application of more than 100 g of compost was observed in this study (R P Hettiarachchi and T Gunathilake).

Table 5. *Effect of different rate of compost applications on plant height and diameter of rubber nursery plants before bud grafting period*

Parameter	Treatment	Months after planting			
		1	**2**	**3**	**4**
Height (cm)	T1	43.78[a]	58.54[b]	73.9[b]	91.66[b]
	T2	45.82[a]	62.12[a]	82.12[a]	100.64[a]
	T3	44.4[a]	57.14[b]	76.88[b]	95.04[b]
	T4	44.14[a]	58.38[b]	74.14[b]	94.68[b]
Diameter (mm)	T1	4.57[b]	6.38[b]	8.03[b]	9.85[c]
	T2	4.88[a]	6.99[a]	8.81[a]	10.83[a]
	T3	4.67[ab]	6.53[b]	8.45[a]	10.34[b]
	T4	4.72 [ab]	6.64[b]	8.66[a]	10.7[b]

Means with same letters in a column under each parameter are not significantly different at $p< 0.05$.

The effect of half burned paddy husk and paddy husk ash on rubber nursery plants

An experiment was started in August 2016 to investigate the effect of incorporation of half burned paddy husk (HBPH) and paddy husk ash (PH ash) in to soil media of poly bagged nursery plants. Paddy husk is a good source of silicon which is a beneficial element for plant growth. The treatments were arranged in a completely randomized block design with ten replicates (Table 6).

Table 6. *Different treatment combinations of soil with HBPH and PH ash*

Treatment	Combination
T1	Soil + HBPH (4:1) media + recommended inorganic fertilizer and compost
T2	Soil + HBPH (4:1) media + recommended inorganic fertilizer without compost
T3	Soil + PH ash (4:1) media + recommended inorganic fertilizer and compost
T4	Soil + PH ash (4:1) media + recommended inorganic fertilizer without compost
T5	Soil + recommended inorganic fertilizer and compost

The plant diameter and plant height before bud grafting period is presented in Table 7. Plant height of all paddy husk treatments were comparable with that of control treatment at 4 months after planting. However, plant diameter of all treatments was significantly higher compared to the control at 3 and 4 months after planting. Plants from T3 treatment showed the highest plant diameter among the treatments at 4 months after planting. It can be suggested that paddy husk amendment would be beneficial for improving plant diameter (H A R K Jayawardana, J A S Chandrasiri, T Gunatilleke, P D S D O Rathnasooriya and R M Baddevidana).

Table 7. *Effect of different HBPH and PH ash applications on diameter and height of rubber nursery plants*

Parameter	Treatment	Months after planting			
		1	2	3	4
Height (cm)	T1	35.52[a]	43.92[ab]	57.04[b]	81.36[a]
	T2	36.66[a]	45.94[ab]	57.80[ab]	80.96[a]
	T3	35.76[a]	43.74[b]	59.12[ab]	81.62[a]
	T4	37.22[a]	46.50[a]	60.68[a]	84.70[a]
	T5	37.92[a]	45.66[ab]	60.24[a]	81.22[a]
Diameter (mm)	T1	3.89[a]	5.37[a]	7.05[b]	8.50[bc]
	T2	4.12[a]	5.35[a]	7.20[ab]	8.88[ab]
	T3	4.05[a]	5.35[a]	7.48[a]	9.08[a]
	T4	4.05[a]	5.34[a]	7.50[a]	8.90[ab]
	T5	3.61[b]	5.30[a]	6.40[c]	8.30[c]

Means with the same letters in a column under each parameter are not significantly different at $p< 0.05$

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

This experiment was not continued due to unavailability of the chemicals, specially the Monsanto's "Round Up" glyphosate weedicide, which has been banned by the government with effect of 12th March 2016.

Incubation study was conducted to study the effect of different weedicides on soil nutrient availability and microbial biomass carbon (MBC) content. This experiment was included five treatments and all treatments were arranged in a completely randomized block design included twenty one replicates per treatment with one polybag as one replicate. Not any chemical application treatment was maintained as control treatment (T1) and glyphosate 100 ml/16 L (T2), glyphosate 200 ml/16 L (T3), Gluphocinate Ammonium 80 ml/16 L (T4), Gluphocinate Ammonium 100 ml/16 L (T5) were maintained as other treatments. Samples were analyzed seven times during the incubation period of three months and above mentioned parameters were measured separately. It was observed no significant differences between treatments for soil fertility parameters; MBC, organic carbon (OC), available phosphorus and pH at different time intervals 7 and 35 days after incubation. However, values for pH, MBC and available P at 7th day interval recorded higher values compared to the values at 35 days interval for different treatments. But no differences were observed for soil OC at 7th day and 35th day intervals for different treatments (Table 8) (R P Hettiarachchi, A Thevarapperuma, T Gunatilleke and K M E K Kulatunga).

Table 8. *Effect of different fertilizer applications on some soil fertility parameters*

Treatment	pH		OC%		MBC (mg kg^{-1} soil)		Available P(ppm)	
	7 days	35 days	7 days	35 days	7 days	35 days	7 days	35 days
T1	4.6[a]	3.62[a]	1.211[a]	1.058[a]	205[a]	121[a]	35[a]	15[a]
T2	4.4[a]	3.51[a]	0.87[a]	1.125[a]	185[a]	102[a]	30[a]	18[a]
T3	4.4[a]	3.56[a]	1.04[a]	1.113[a]	169[a]	116[a]	27[a]	14[a]
T4	4.7[a]	4.07[a]	1.11[a]	1.160[a]	178[a]	93[a]	27[a]	18[a]
T5	4.7[a]	3.95[a]	0.92[a]	1.235[a]	205[a]	93[a]	29[a]	19[a]

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

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 completed at the end of 2015 and it could be observed that the half recommended fertilizer with micronutrient and biofertilizer gave comparable growth assessments compared 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

This experiment was started again to investigate the best fertilizer mixture for non- traditional rubber growing areas. Sites were selected in four different places; Moneragala, Vauniya, Padiyathalawa and Badalkumbura to evaluate the effectiveness of different treatments on immature rubber plants at field conditions. Four different treatments included conventional mixtures R/U 12:14:14 and R/SA 7:9:9:3 with K double recommended mixture and modified new fertilizer mixture based on past experimental results were tested (R P Hettiarachchi, U Mitrasena, V Edirimannne, J A S Chandrasiri and T Gunathilake).

Slow release fertilizer application

Experimental design was reported in Annual Review 2015. Plant diameter and height were measured throughout the after budgrafting period. At the end of the experimental period each plant was separated into leaves, stems and roots and their dry weights were recorded by drying the components and nutrient contents of each part were analyzed for N, P and K. It was found that there were differences among different treatments and slow release fertilizer application treatments T2, T3, T4 and T5 gave higher dry weight values of leaf, shoot and root compared to conventional recommended fertilizer application treatment (T1) (Fig. 3). Calculated total nutrient

uptake of the plant, total plant nitrogen uptake gave higher values for slow release fertilizer treatments compared to conventional fertilizer application treatment (Fig. 4). Moreover, slow release fertilizer applied at the rates of 15 g and 20 g gave higher values of total P and Mg uptake compared to conventional fertilizer application treatment (Fig. 4). Therefore, fertilizer application with tested slow release fertilizers gave higher plant growth and nutrient uptake compared to conventional fertilizers with reduced environmental pollution by releasing nutrients from slow release fertilizers according to the rate required by the plant.

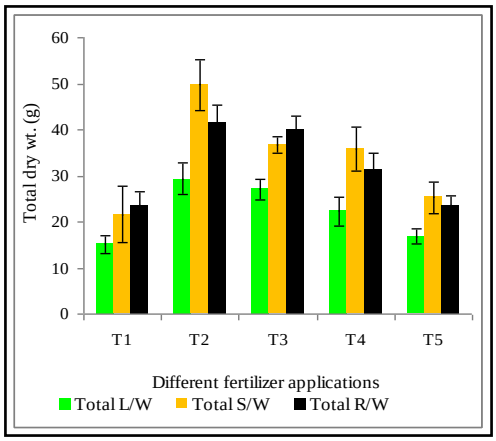


Fig. 3. Effect of different fertilizer applications on total leaf, stem and root dry weights of nursery plants

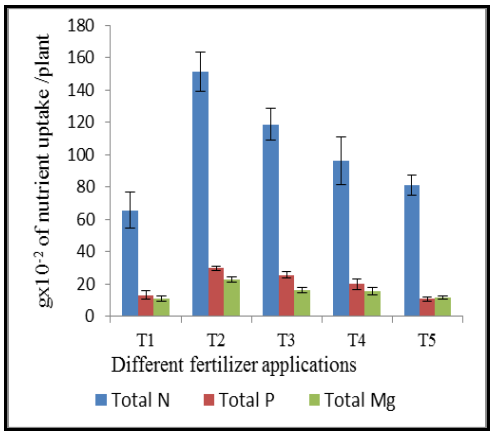


Fig. 4. Effect of different fertilizer applications on plant nutrient uptake of N, P and Mg of nursery plants

Coir and latex based slow release fertilizers

Fertilizer use efficiency of coir based slow release fertilizers and direct fertilizers

Fertilizer use efficiency can be increased by controlled release of nutrients to the soil by synchronizing it with the crop nutrient demand. The technique of encapsulation of fertilizers as a coir based product is an effective and economical method for overcoming some management problems associated with fertilizer applications. This study was conducted to determine the nutrient release pattern from inorganic fertilizers through membranes based on rubber latex and coir dust under *in-vitro* conditions. This experiment was conducted in polythene bags which did not have drainage holes. There were 10 treatment combinations (Table 9) and the experimental design was a completely randomized block design with three replicates.

Table 9. *Treatment combinations of the experiment*

Treatment	Combination
T1	Soil only
T2	Soil + Coir blocks (without fertilizers)
T3	Soil + Coir blocks (50g NPK + 25g Ks)
T4	Soil + 50g NPK + 25g Ks
T5	Soil + Coir blocks (100g NPK + 50g Ks)
T6	Soil + 100g NPK + 50g Ks
T7	Soil + Coir blocks (50g urea)
T8	Soil + 50g urea
T9	Soil + Coir blocks (50g MOP)
T10	Soil + 50g MOP

It was observed that encapsulated nitrogen fertilizer showed increasing trend during the experimental period and direct fertilizer application treatments gave a very high initial value and showed a marked decline from the beginning to the end of the experiment (Table 10). Moreover direct application of fertilizer gave higher values throughout the incubation period for exchangeable magnesium (Table 10). Similarly encapsulated fertilizer gave lower values compared with direct fertilizer application and much higher values compared to control treatment.

Table 10. *Effect of different fertilizer treatments on soil nitrogen (%) content*

Treatment	0 month	1.5 months	3 months	4.5 months	6 months	7.5 months
T1	0.178^{c}	0.135^{d}	0.141^{c}	0.130^{d}	0.110^{c}	0.169^{d}
T3*	0.180^{c}	0.375^{bc}	0.321^{b}	0.445^{b}	0.413^{ab}	0.405^{ab}
T4**	0.802^{a}	0.276^{cd}	0.385^{b}	0.280^{c}	0.298^{b}	0.129^{d}
T5*	0.148^{c}	0.562^{a}	0.216^{b}	$0,519^{b}$	0.349^{b}	0.416^{ab}
T6**	0.731^{a}	0.556^{a}	0.448^{ab}	$0,498^{b}$	0.506^{a}	0.279^{c}
T7*	0.190^{c}	0.379^{bc}	0.271^{b}	0.559^{b}	0.428^{ab}	0.357^{bc}
T8**	0.735^{a}	0.441^{ab}	0.595^{a}	0.482^{b}	0.503^{a}	0.398^{ab}

Means with same letters in a column are not significantly different at $p< 0.05$.
T1 = Control * - Encapsulated treatment ** - Direct fertilizer application treatment

Table 11. *Effect of difference fertilizer treatments on soil Mg (ppm) content*

Treatment	0 month	1.5 months	3 months	4.5 months	6 months	7.5 months
T1	22[c]	33[d]	26[d]	27[d]	32[e]	31[e]
T3*	30[c]	187[d]	209[d]	177[d]	179[e]	144[e]
T4**	2332[b]	2408[c]	1891[c]	4247[c]	3842[d]	4583[d]
T5*	28[c]	228[d]	272[d]	303[d]	205[e]	168[e]
T6**	4326[a]	4496[ab]	3154[ab]	8791[a]	8057[a]	8591[a]
T8*	24[c]	214[d]	256[d]	198[d]	181[e]	157[e]
T10**	2967[b]	3927[b]	2683[b]	6529[b]	5582[c]	6149[c]

Means with same letters in a column are not significantly different at $p < 0.05$.
T1 = Control * - Encapsulated treatment **-Direct fertilizer application treatment

Coir based slow release fertilizer application for immature rubber plants

This experiment was conducted in three estates; Millawa, Eduragala and Raigama to evaluate the effectiveness of coir based slow release fertilizer for immature rubber plants. Plants were fertilized according to the experimental design shown in Table 12. According to conventional manuaring schedule for immature rubber it should be started two months after planting and four split applications should be done throughout the first year. However, this coir based slow release fertilizers capsules were incorporated into the soil at the time of planting around the rubber plant at 30 cm radius. This method totally cut down labour usage for repeated fertilizer applications for first year plants and benefitted for the growers specially at the time of labour shortage. The design of this experiment was a randomized block with five replicates.

Table 12. *Treatment combinations of the experiment*

Treatment	Combination
T1	Recommended fertilizers for first year immature rubber plants
T2	Slow release fertilizer type 01
T3	Slow release fertilizer type 02

Services

Site-specific fertilizer recommendation by soil and foliar survey programme

Under this programme 3600 hectares of mature rubber fields were surveyed and 36 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. *Detailed report of the site specific fertilizer recommendation programme in 2016*

Estate	Extent surveyed (ha)	Estate	Extent surveyed (ha)
Palmgarden	112	Sapumalkande	199
Salawa	223	Reucastle	262
Panawatte	292	Illuktenne	74
Dewalakande	172	Mahaoya	57
Kelani	83	Neuchatel	278
Urumeewala	164	Siriniwasa	34
Bentota	200	Galatura	58
Ryewikiliya	20	Rabukkande	83
Eheliyagoda	48	Lelwala	38
Sunderland	65	Houpe	34
Rilhena	09	Kiriwanaketiya	106
Wellandura	16	Yataderiya	98
Hunuwala	81	Opatha	83
Frocster	157	Pelmadulla	75
Dewagiri	56	Poronuwa	67
Dartonfield	77	Mahawala	61
Madampe	160	Rassagala	18
Matuwagala	60	Agasland	10

Land selection and suitability for rubber cultivation

Under the routine land selection program 460 hectares of land were surveyed for the suitability of rubber cultivation and seven land suitability reports were issued. Details of the survey are given in Table 14 (R P Hettiarachchi and all the staff of the department).

Table 14. *Detailed report of the Land Selection program in 2016*

Place	Extent surveyed (ha)
Kataragama, Puhulara	32 ha
Nuwaragalathenna, Aranthalawa	63 ha
Haguranketha	40 ha
Badalkumbura, Madulla	55 ha
Yahangalawatta, Kurunegala	25 ha
Uhana, Ampara	44 ha
Damana, Ampara	200 ha
Total	460 ha

Analytical services

The Department analyzed approximately 1100 samples (5000 parameters) including 170 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. Miss N P S N Karunarathne assumed duties as a Research Officer with effect from 09.05.2016. Experimental Officer, Mr M K P Perera, Technical Officer, Mrs P D T L Madushani and Management Assistant, Miss H A M E Hettiarachchi were on duty throughout the year. Technical Officers, Mr R P S Randunu and A A A Nadeeshani resigned from the Institute with effect from 2016.09.19 and 2016.10.31, respectively.

Research students

Student name	University	Research topic
LAS Dilshani	School of Agriculture, Wariyapola	Induction training programme of Diploma in Agriculture
AKDS Niranjala PS Dharmasiri	Advance Technological Institute, Galle	Induction training programme of Higher National Diploma in Technology (Agriculture)

Seminars/Conferences/Workshops/Exhibitions attended

Officer/s	Subject/Theme	Organization
KVVS Kudaligama	6th Symposium on Plantation Crop Research	BMICH
	Symposium, Scientific Committee Meetings	Hotel Galadari
	Workshop on foreign funding	NSF
	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

Officer/s	Subject/Theme	
KVVS Kudaligama	Use of stimulant in low intensity harvesting	Induction Course for Planter Trainees, NIPM
	Low intensity harvesting	HNDT (Agri) - Gampaha
	Low intensity harvesting Dry rubber content determination	Rubber Extension Officers, NIPM
	Commercial application of S/2 d4 harvesting system	Sorana Plantation PLC
	Commercial application of S/2 d4 harvesting system	Marampola Estate, Pelmadulla

Field visits

Advisory - 02 visits
Experimental - 147 visits
Miscellaneous - 08 visits

Sample testing

% Dry rubber content of latex - 11 samples
Commercial Ethephon mixtures - 15 samples

LABORATORY AND FIELD INVESTIGATIONS

Biochemical assessment in latex to develop stimulation based harvesting systems in mega zone (BCP/01)

***Research and development on low frequency (LFH)/Low intensity harvesting (LIH) with liquid stimulation (BCP/01/a*)**

Commercial scale testing of S/2 d4 system was commenced at Kuruwita Substation of Rubber Research Institute of Sri Lanka with monthly application of 2.5% oil based and 3.3% water based ethephon.

Dry rubber content of latex in low intensity systems was comparable with S/2 d2 system. Productivity of water based ehtephon was 57 kg higher than that of S/2 d2 system whlist it was76 kg lesser in field applied with oil based ethephon (Table 1).

Table 1. *Performance of commercial scale S/2 d4 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/2 d2	-	165	37.51	29.12	8.74	4.8	1922
	S/2 d4	Water based	81	37.70	61.29	18.39	4.95	1979
	S/2 d4	Oil based	78	37.31	59.24	17.77	4.61	1846

The 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 as the 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 67 kg higher the average of S/2 d2 system. However, YPH of oil based ehtephon was 39 kg lower than the S/2 d2 field (Table 2).

Table 2. *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/2 d2	-	165	37.51	29.12	8.74	4.8	1922
	S/4 d3	Water based	102	37.61	48.74	14.62	4.97	1989
	S/4 d3	Oil based	103	37.73	45.71	13.71	4.71	1883

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 yield per hectare per year (YPH) of S/2 d1 2d/7 was 3.6% higher than that of S/2 d2 system (Table 3). 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 3. *Performance of commercial scale S/2 d1 2d/7 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/2 d2	-	165	37.51	29.12	8.74	4.80	1922
	S/2 d1 2d/7	Water based	94	39.51	52.98	15.90	4.98	1992

Performance of low intensity harvesting systems (LIH) in Intermediate zone Polgahawela Sub-station - IL1a agro ecological zone

Three LIH systems were tested for their feasibility in fields planted with RRIC 121 clone tapped at panel A in IL 1a agro-ecological zone of Intermediate Zone. Dry rubber content in latex recorded in all harvesting systems tested were comparable (Table 4). Although yield per tree per tapping was higher in all three LIH systems than in the traditional S/2 d2 system, its level of increase in S/2 d4 and S/4 d3 systems was below the expected level resulting in slightly less annual yield per

tree and hectare. Annual yield per unit length of tapping cut was comparable in all S/2 harvesting systems and was highest in S/4 system (Table 4).

Table 4. *Yield performance of different harvesting systems in IL1a agro-ecological zone*

Tapping system	Actual tapping days (per tree)	Dry rubber content (%)	Yield per tree per tapping (g)	Yield per length of cut (g/cm/yr)	Yield per tree per year (kg)	Yield per hectare per year (kg)
S/2 d2	133	39.06±0.18	35.49±1.00	120±2.70	4.69	1874
S/2 d3	89	37.68±0.41	52.53±2.58	121±5.58	4.62	1849
S/2 d4	71	37.30±0.34	66.25±2.43	113±5.58	4.37	1748
S/4 d3	89	39.68±0.08	45.94±1.64	182±2.65	4.04	1617

Average bark consumption per tapping was more or less similar in four harvesting systems. But due to the reduction harvesting intensity, annual bark consumption was greatly reduced increasing the lifespan of the trees under low intensity harvesting systems (Table 5). Therefore in LIH systems, expected duration of harvesting in base panels of S/2 d3, S/2 d4 and S/4 d3 systems showed considerable increase of 45%, 82% and 162%, respectively over that of traditional S/2 d2 system.

Table 5. *Annual bark consumption, bark consumption per tapping and expected lifespan under different harvesting systems*

Harvesting systems	Bark consumption (cm)		Expected lifespan with base panel harvesting
	Per tapping	Annual	
S/2 d2	0.12	15.30	31
S/2 d3	0.12	10.57	45
S/2 d4	0.13	8.40	57
S/4 d3	0.13	11.68	82

Trees affected with Tapping Panel Dryness (TPD) were below 10% in all the tapping systems. Traditional S/2 d2 system had 5.36% affected trees whilst S/2 d3 and S/4 d3 systems showed 4.17% and 5.77% TPD trees, respectively. In S/2 d4 system, trees affected with TPD was 6.8%.

Girth increment of S/2 d3 and S/2 d4 systems was significantly less than that of traditional S/2 d2 system whilst no significant difference was observed in S/4 d3 system. When compared to traditional S/2 d2 system, all three low intensity systems showed higher increment in bark thickness with significant values only in once in three days (d3) harvesting systems (Table 6).

Table 6. *Initial girth, annual girth increment, initial bark thickness and annual bark thickness increment in in different harvesting systems in IL1a agro ecological zone*

Harvesting systems	Girth (cm/year)		Bark thickness (mm/year)	
	Initial	Increment	Initial	Increment
S/2 d2	64.81	3.09±0.16	5.97	0.88±0.07
S/2 d3	63.66	2.84±0.10	5.69	1.14±0.07
S/2 d4	63.79	2.52±0.10	5.83	0.95±0.07
S/4 d3	68.47	3.64±0.15	5.81	1.20±0.09

Irrespective of the harvesting system, latex sucrose during wintering season was less than that recorded during high yielding period and this was much prominent in S/2 d4 and S/4 d3 systems (Fig. 1a). Except S/2 d4 system, others showed comparatively less latex thiol content during wintering period. Thiol content of S/2 d4 system in both seasons were more or less similar (Fig. 1b). Inorganic phosphorous content in S/2 d2 and S/2 d3 systems during high yielding period were significantly less than that in wintering period. However, this trend has changed vise versa in extended low intensity systems *i.e.* S/2 d4 and S/4 d3 systems (Fig. 1c).

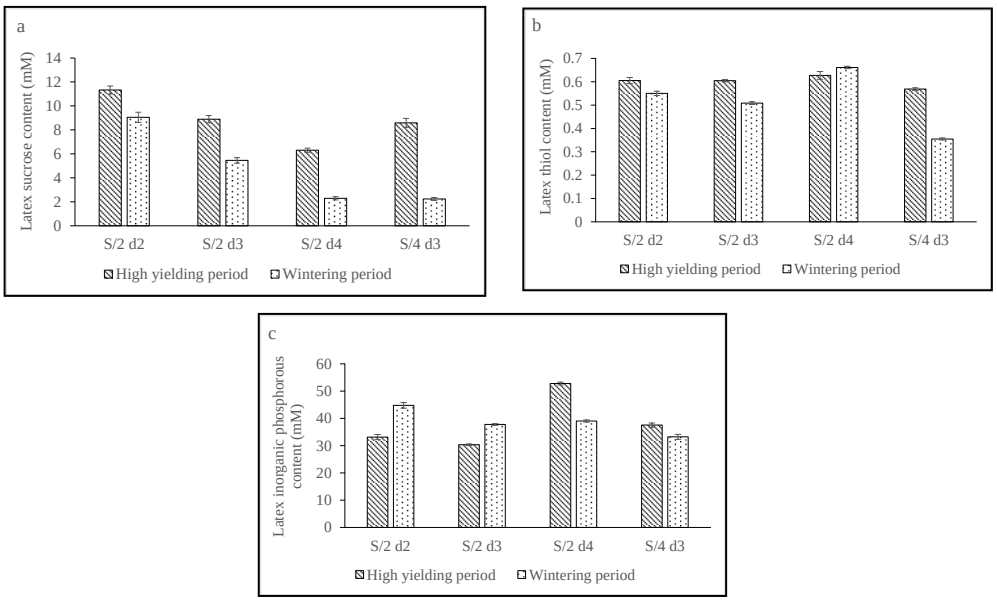


Fig. 1. Variation of (a) Sucrose (b) Thiol and (c) Inorganic phosphorus of latex harvested with different harvesting systems

Initial plasticity (Po), Plasticity retention index, Mooney viscosity, ash and nitrogen content of ribbed smoked sheets (RSS) produced under different harvesting systems met the standard levels stipulated by the SLR scheme of RRISL (Table 7) (V H L Rodrigo, K V V S Kudaligama, R P S Randunu, M K P Perera and P D T L Madushani).

Table 7. *Raw rubber properties of ribbed smoked sheets (RSS) produced in different harvesting systems in IL1a agro ecological zone*

Harvesting systems	Initial plasticity (Wallace units)	Plasticity retention index	Mooney viscosity (ML 1+4@ 100°C)	Ash (%w/w)	Nitrogen content (%)
S/2 d2	48.60±0.91	84.04±1.09	70.71±0.73	0.19±0.02	0.26±0.01
S/2 d3	51.21±1.03	84.74±1.23	72.71±1.06	0.22±0.02	0.27±0.01
S/2 d4	53.01±0.77	82.45±1.25	77.02±0.77	0.24±0.02	0.28±0.01
S/4 d3	49.72±0.98	86.37±1.53	72.31±0.95	0.18±0.02	0.27±0.01

Testing of S/2 + S/4↑ d4 system

In view of improving productivity levels of fields tapped on renewed bark, testing of a new combined low intensity harvesting system has been started at 5.76ha and 4.31ha replanted in 1986/1987 period at Gallewatta division of Dartonfield estate with average intake per tapper of 8.1kg and 7.6 kg, respectively. New tapping system with S/2 based lower cut together with S/4 based upper cut harvesting at once in four days (d4) frequency was begun in July, 2016. A new stimulation protocol with intermittent application of 2.5% ethephon was followed to get desirable yield levels. Daily yields were monitored as dry rubber content and volume of latex together with scrap weight. Throughout the period latex dry rubber content recorded was above 35% and average intake per harvester was about 11.3kg/day which showed a 44% increase over the S/2 d3 system used previously (Table 8).

Table 8. *Average yield performance of the S/2 + S/4↑ d4 system for initial five months*

Harvester	DRC (%)	GTT (g)	IPH (kg)
Harvester- 1	38	67.08	11.73
Harvester- 2	40	61.42	10.75
Harvester- 3	40	65.28	11.42

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

Commercial scale adaptation of recommended LFH/LIH systems with liquid stimulation (BCP/01/b)

Commercial scale adoption of S/2 d4 system has been started with 04 tapping blocks in Gallewatta division of Dartonfield estate replanted in 1986 with RRIC 121 genotype in January 2016 with 2.5% oil based ethephon as the yield stimulant.

2010 replanted tapping field from Nivithigalakele division of Dartonfield estate was also selected to investigate the adaptability of S/2 d4 system at commercial scale with the commencement of tapping (K V V S Kudaligama, V H L Rodrigo, R P S Randunu, M K P Perera and P D T L Madushani).

Improve knowledge on biochemical and physiological aspects in mega zone (BCP/02)

Under drier condition in Vauniya district, RRIC 121 genotype was monitored for the growth and physiological performance during the first five years after planting.

Obviously, girth and height of rubber plants gradually increased with the age. At the end of 1st year, average girth of plants was about 5.3cm and it increased up to 33.5cm at the end of 5th year (Fig. 2a). At 5th year after planting average height of plants has reached to 983cm (Fig. 2b). Assuming that girth and height development is linear, average increment of girth and height of plants during the period was 7.00 and 182.9 cm/year, respectively.

Root density of rubber plants were assessed in inter raw space and between two trees within the raw at three soil depths. Soil cores taken at three different distances from the tree were used for the analysis.

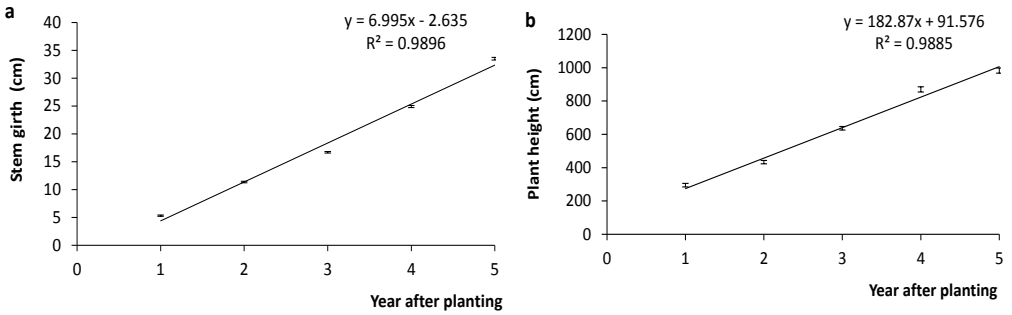


Fig. 2. Growth of RRIC 121 genotype planted in Vauniya

Generally root density in inter row space was higher than within the row. When soil depth and distance from plant increased, root density has decreased in both inter rows space and within rows (Table 9).

Table 9. *Variation of root density of 5 years old rubber plant of RRIC 121 genotype at different horizontal distances from the plant and soil depths*

Soil depth (cm)	Root density (mg/cm^3)					
	Within rows (distance from plant)			Inter rows space (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

Leaf chlorophyll content of rubber plants were measured using a SPAD 502 leaf chlorophyll meter. Leaf chlorophyll content gradually increased with age of plants at an average rate of 0.0027 mg/cm^2 per year. At the point of field establishment leaf chlorophyll content was 0.0205 mg/cm^2 in plants and this increased gradually to 0.0334 mg/cm^2 at 5th year (Fig. 3).

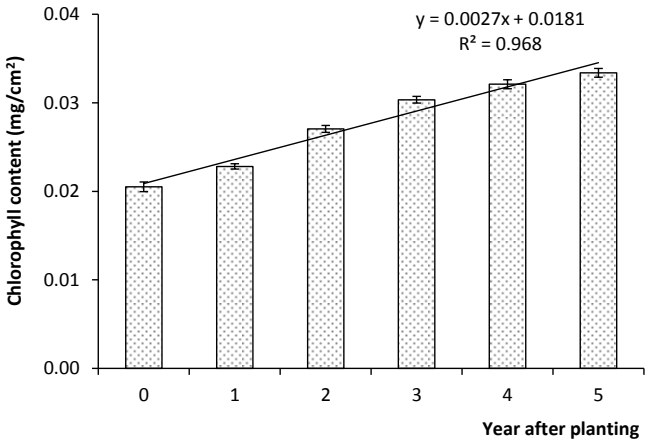


Fig. 3. Ontogenetic variation of leaf chlorophyll content of RRIC 121 genotype

The light response curves of photosynthesis of rubber were built up at 2010 and 2011 planted fields measurements on photosynthetic rates at varying light levels using a portable open system infrared-gas analyser (IRGA) (LI-6400, Li-Cor Inc., Lincoln, NE, USA). Two sets of measurements were made in each plant, one in the morning (between 1000h and 1100h) and next in the evening (between 1500h and 1500h) during the wet period. Using the software photosynthesis assistant, Ver. 1.12, light saturated rate of photosynthesis (A_{max}) and the apparent quantum yield of rubber (φ_{app}) were derived from light response curve. All measurements were confined to

most recently matured leaves which generally showed the highest rate of photosynthesis.

The light saturated rate of photosynthesis (Amax) was comparatively less in the afternoon than in morning hours irrespective of the age (Table 10). Nevertheless, Amax tended to increase with the age of plants (Fig. 4 & Table 10).

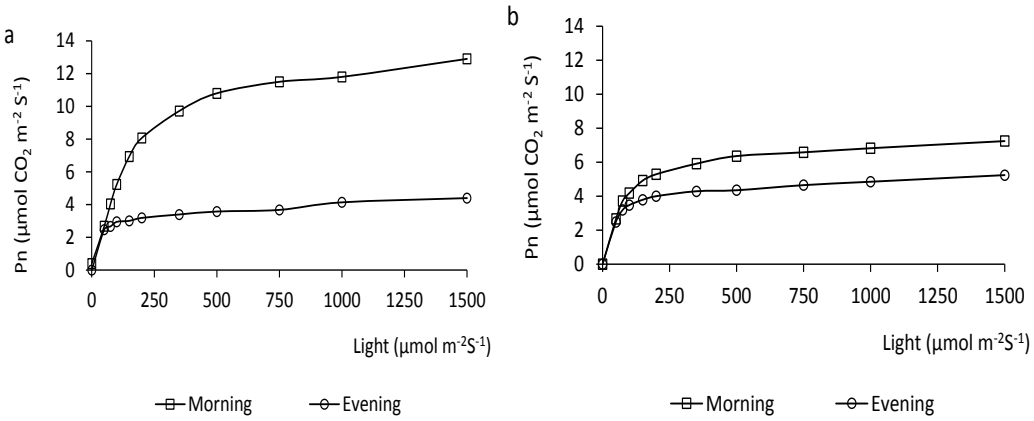


Fig. 4. Light response curves (LRCs) for CO_2 assimilation (Pn) built up during morning and afternoon hours of the day in **a).** Six and **b).** Five year old RRIC 121 genotype

Parameters of LRCs are given in Table 10

Table 10. *Light-saturated rate (Amax) and apparent quantum yield (φ) of photosynthetic CO_2 assimilation in rubber*

Planted year (age)	Time of measurement			
	Morning		Evening	
	Mean Amax (µmol m^{-2} s^{-2})	Mean apparent quantum yield (φapp)	Mean Amax (µmol m^{-2} s^{-2})	Mean apparent quantum yield (φapp)
2010 (6 years)	13.1	0.048	3.87	0.029
2011 (5 years)	7.27	0.043	5.04	0.035

Biochemical and physiological screening of *Hevea* genotypes for different agro climates to increase the production and productivity of plantations (BCP/03)

Performance of three genotypes planted in 2014 in a smallholding in Vauniya district was monitored during the year.

Plant height and girth had gradually increased with time. During the 1st and the 2nd years, RRIC 121 and RRISL 2001 genotypes had shown higher total height

than RRISL 203 genotype. Lowest girth was observed in RRISL 203 during both years whilst RRIC 121 and RRISL 2001 showed more or less similar girth (Table 11).

Table 11. *Growth performance of three* Hevea *genotypes*

Genotype	Growth performance			
	Height (cm)		Girth (cm)	
	1st year	2nd year	1st year	2nd year
RRIC 121	277	437	5.3	10.1
RRISL 203	229	397	4.8	9.6
RRISL 2001	270	443	5.7	11.1

In all three genotypes girth of plant increased with the age. Among the three genotypes tested, no significant difference was observed in girth increment of plants during dry season. However, in RRISL 2001 girth increment was significantly higher during the wet season and comparable girth increment was observed in RRIC 121 and RRISL 203 genotypes. Despite the genotypes, average girth increment during dry spell was 0.164 cm/month and this was increased to 0.600 cm/month during wet spell (Table 11).

In addition to that new experimental blocks were established at Vauniya, Kandakadu, Padiyathalawa and Mahaoya area with 10 clones during North Eastern monsoon season in 2016.

Biochemical and physiological analysis of rubber wood with respect to mechanical properties to increase the production and productivity of plantations (BCP/04)

Physical properties and biochemical components of RRIC 121 genotype under different age classes were planned to analyse to investigate the quality of rubber wood with age. Two age groups were completed during year 2016 (Table 12) and others being tested.

Moisture content of green wood was decreased with the age whilst density of wood increased. A significant increase in lignin content was also observed in wood aged 26 – 30 years (Table 12).

Table 12. *Average physical properties and biochemical components of RRIC 121 genotype under two age groups*

	Age groups (years)	
	21-25	**26-30**
Moisture content (%)	70.25	65.64
Specific gravity	0.29	0.30
Density (kg m^{-3})	599.42	610.56
Total extractives (%)	15.05	12.81
Holocellulose (%)	87.25	96.92
α-cellulose (%)	57.2	66.18
Hemicellulose (%)	30.05	31.48
Lignin (%)	16.53	26.20

Effect of climate change on biochemistry and physiology of rubber tree to facilitate the expansions of plantation crops into non-traditional areas (BCP/05)

Stomatal conductance of leaves had close association with environmental conditions. Stomatal conductance has decreased with increase in environmental temperature and decrease in relative humidity. Diurnal effect of wind speed on stomatal conductance was not much prominent; however, dry period was associated with high wind speed and low level of stomatal conductance (Fig. 5).

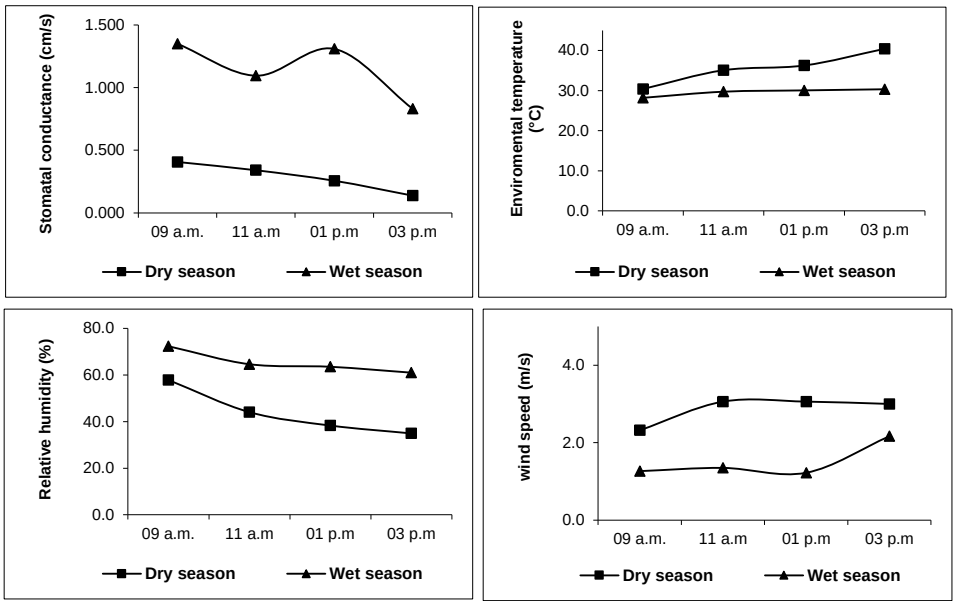


Fig. 5. Diurnal variation of stomatal conductance of 4 year old RRIC 121 genotype planted in 2010 with related environmental parameters in wet and dry seasons

No significant variation in stomatal conductance was observed with age. However there was a considerable seasonal effect. Average values of stomatal conductance during wet and dry periods were 1.09 cm/s and 0.37 cm/s, respectively (Fig. 6).

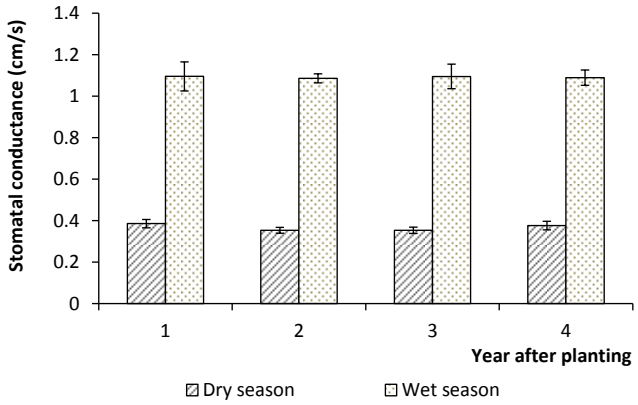


Fig. 6. Variation of stomatal conductance of RRISL 121 genotype with plant age in wet and dry seasons

Study 2 ***Growth and physiological performance of RRIC 121, RRISL 203 and RRISL 2001 genotypes planted in 2013***

Growth assessment

Plant height had gradually increased with time and a significant variation in height increment between wet and dry seasons were observed. During 1st and 2nd years, RRIC 121 and RRISL 2001 genotypes had shown higher total height than RRISL 203 genotype. During dry season all three genotypes showed more or less similar height increment. However, RRISL 203 showed a significant lower girth increment than the other two genotypes which showed comparable height increment during wet season (Fig. 7).

In all three genotypes girth of plant increased with the age. Among the three genotypes tested, no significant difference was observed in girth increment of plants during dry season. However, in RRISL 2001 girth increment was significantly higher during the wet season and comparable girth increment was observed in RRIC 121 and RRISL 203 genotypes. Despite the genotypes, average girth increment during dry spell was 0.164 cm/month and this was increased to 0.600 cm/month during wet spell (Fig. 8).

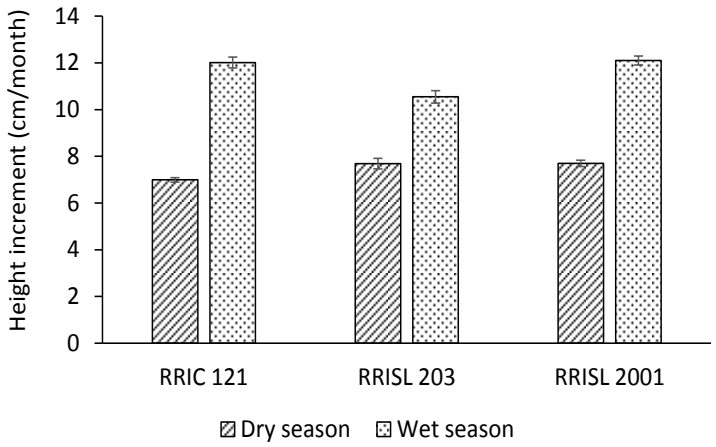


Fig. 7. Average height increment of three *Hevea* genotypes

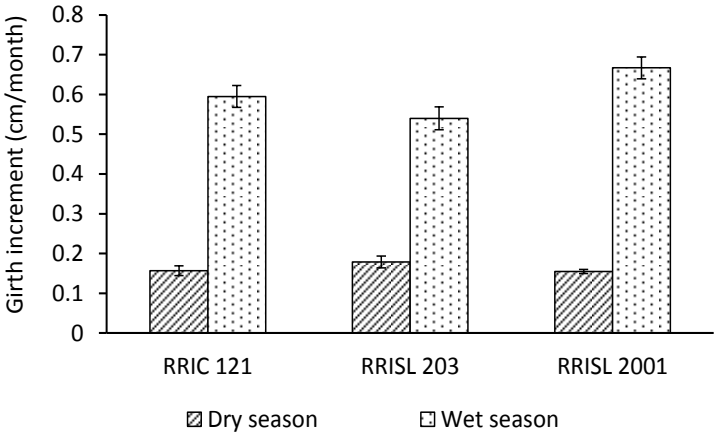


Fig. 8. Average girth increment of three *Hevea* genotypes

Despite of the genotype leaf chlorophyll content showed a significant decrease during dry season with more or less equal values between the three genotypes tested. During wet season RRISL 203 genotype showed comparatively higher leaf chlorophyll content than the other two genotypes (Fig. 9).

Generally all three genotypes showed significantly higher leaf epicuticular wax content during dry season. Out of three genotypes, RRIC 121 has shown the significantly highest leaf epicuticular wax content whilst RRISL 203 genotype showed the lowest values during both wet and dry seasons (Fig. 10).

Micro environment condition in fields under banana, rubber and open environment were analysed during wet and dry periods in Vauniya area.

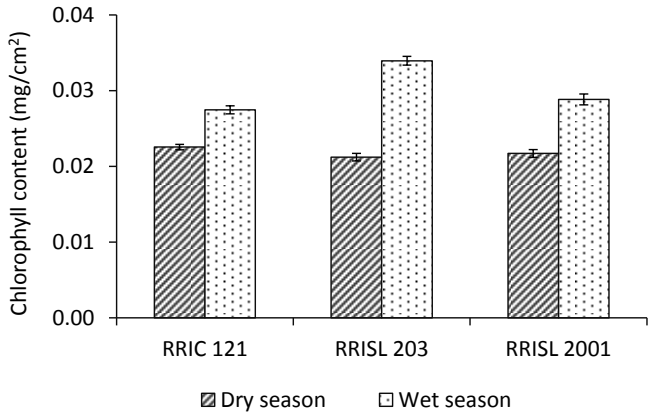


Fig. 9. Variation of average chlorophyll content of leaves of three *Hevea* genotypes during wet and dry seasons

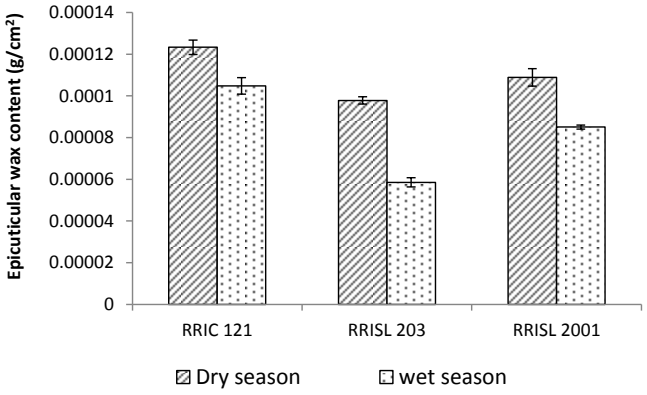


Fig. 10. Variation of leaf epicuticular wax content of three *Hevea* genotypes planted in 2013 during both wet and dry seasons

Miscellaneous experiments to increase the production and productivity of plantations
(BCP/06)

Geo-spatial analysis of biochemical and physiological factors for modelling the optimized latex yield of rubber (BCP/06/b)

Use of novel techniques such as Satellite Remote Sensing (RS) and Geographic Information System (GIS) to analyse spatial and biological factors related to the productivity of rubber plantation with different harvesting systems in Kuruwita Sub-station (Fig. 11) was the main objective of the present study.

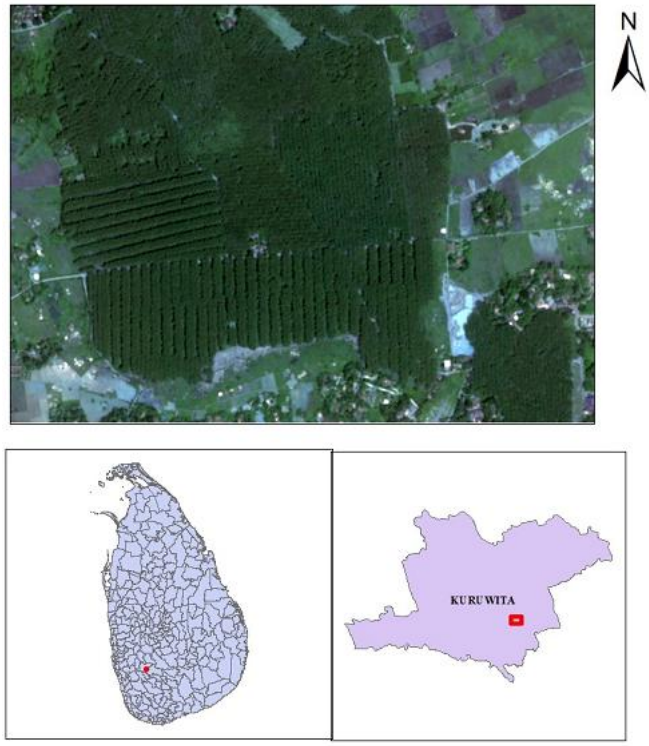


Fig. 11. Location map of rubber plantations in Kuruwita

Quikebird high resolution satellite images were used for RS analysis and 1:10000 scale topographic maps, climatological data and field observations were used for analysing spatial characteristics. Chlorophyll content of rubber leaves was measured using SPAD-502 Chlorophyll meter. Chlorophyll content and RS data were analysed using GIS and spatial statistical methods to determine variation of yield in

different harvesting systems in the rubber plantations. Yield parameters were correlated with chlorophyll content and NDVI range exhibited in the experimental plots.

A positive correlation was observed between chlorophyll content and rubber latex yield. Chlorophyll content of leaves was higher in south-eastern direction than north-eastern direction and NDVI and chlorophyll both were greater on grounds facing westwards than eastern slopes (Fig. 12).

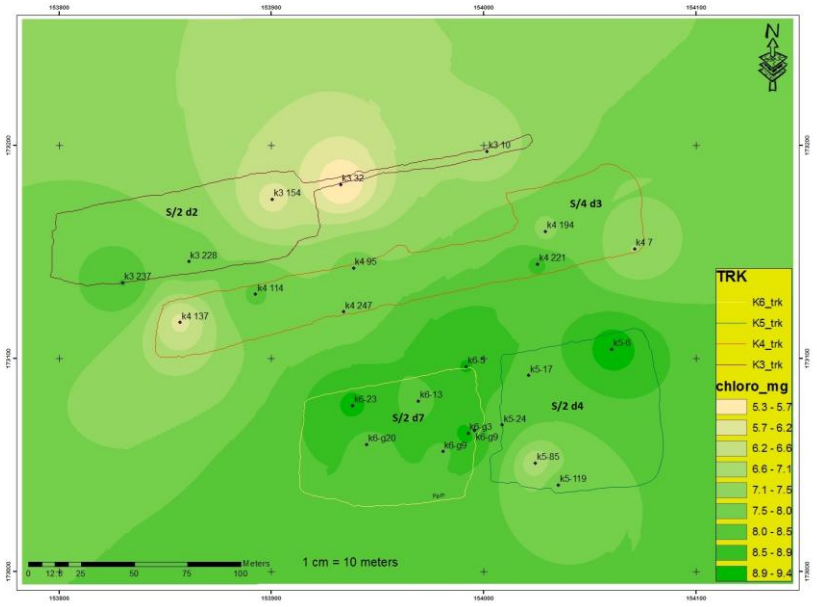


Fig. 12. Spatial distribution of chlorophyll in Kuruwita area (Interpolation was based on IDW method)

Though not significant chlorophyll content in leaves is greater in trees harvested by low frequency harvesting systems and the highest was recorded in S/2 d1 2d7 system compared to other systems such as S/2 d2, S/4 d3 and S/2 d4. The relationship between NDVI values and measured chlorophyll content was linear in rubber leaves at Kuruwita site (Fig. 13).

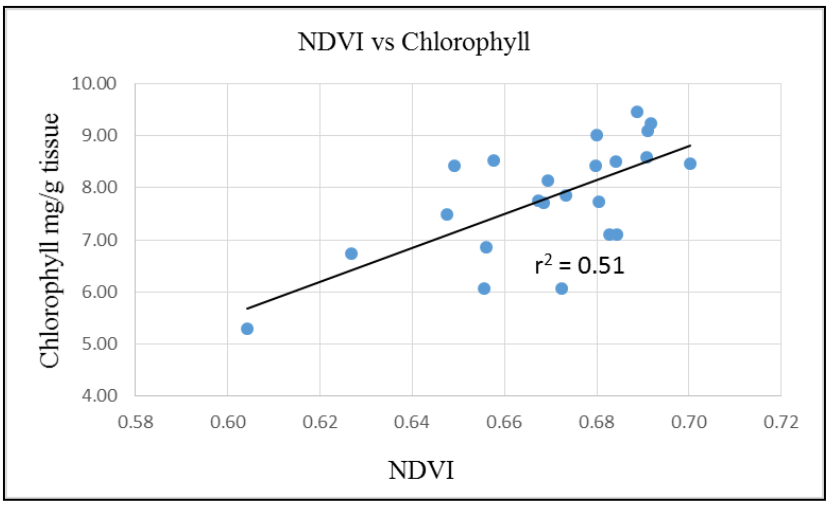


Fig. 13. Correlation between normalized difference vegetation index (NDVI) and total chlorophyll content in rubber leaves at Kuruwita site

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 W D Chandrasiri, Mr J A J Perera and Mr D R R A M G Abe Dissanayake Rubber Extension Officers retired from the services of ASD in March, April and May and August 2016 respectively.

Conferences/Meetings/Seminars/Workshops/Foreign tours attended

Officer/s	Subject/s	Organization/s
Anura Dissanayake	Smallholder plantations entrepreneurship development prgramme – Progress Review Meeting	IFAD Project reviewing team
	Strengthening of activities of group processing centres for a suitable working model	SPEnDP project Management (Monaragala)
	Progress Review Meetings	Ministry of Plantation Industries
PKKS Gunaratna	Agricultural Extension National Conference	Sri Lankan Agricultural Extension Society
	International Natural Rubber Conference Cambodia & presented a paper– 2016	IRRDB
RAD Ranawake	Study tour in Thailand	Ministry of Plantation Industries
Anura Dissanayake PKKS Gunaratna RAD Ranawake	Scientific Committee Meetings	Rubber Research Institute of Sri Lanka
	Symposium on Plantation Crop Research	Coconut Research Institute
	International work shop on coping mechanism for low rubber price	Rubber Research Institute of Sri Lanka & IRRDB

PROGRESS OF PROJECTS AND SERVICES

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

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

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

To demonstrate the value of adopting RRISL recommendations to increase the land use efficiency of rubber smallholdings, the extension strategy focused on farmer participatory development of selected rubber holdings as "Model rubber holdings" was continued successfully and 185 rubber holdings were developed (Table 1).

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

Region	No. of developed holdings	
	Mature	**Immature**
Colombo/Gampaha	5	5
Kegalle	34	32
Kalutara	25	25
Ratnapura	13	16
Galle/Matara	15	15
Total	92	93
		185

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

Advisory and extension support services were provided to maintain 38 "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*

Region	No. of model centers maintained	Total capacity (kg)
Colombo/Gampaha	3	2,250
Kegalle	10	1,405
Kalutara	8	7,300
Ratnapura	10	3,430
Galle/Matara	7	3,625
Total	**38**	**18,010**

Project 3 (ASD/01/C) Promotion of usage of rainguards

To popularize the rain guards technology as a short term strategy to increase the productivity of rubber smallholders, 46 rainguard demonstrations were established under supervision of Rubber Extension Officers (Table 3).

Table 3. *Details of rainguard demonstration holdings*

Region	No. of demonstrations established	Extent of the rubber land (ha)
Colombo/Gampaha	9	17.2
Kegalle	15	22.4
Kalutara	7	12.8
Ratnapura	8	16.8
Galle/Matara	7	35.2
Total	**46**	**104.4**

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

Advisory and extension services were provided for construction of 18 new RSS production centres and rehabilitation of 09 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/Gampaha	3	1
Kegalle	8	3
Kalutara	1	1
Ratnapura	4	3
Galle/Matara	2	1
Total	18	09

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

To popularize area specific intercropping systems to increase the income during immature period of rubber smallholdings, 28 intercropping demonstration plots were established (Table 5).

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

Region	No. of demonstrations	Extent (ha)
Colombo/Gampaha	4	9.0
Kegalle	6	3.8
Kalutara	8	6.0
Ratnapura	6	5.2
Galle/Matara	4	2.6
Total	28	26.6

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

Advisory and extension support services were provided to rehabilitate 81 immature and 89 mature substandard rubber holdings respectively (Table 6).

Table 6. *Rehabilitation of substandard rubber holdings*

Region	No of immature holdings rehabilitated	No. of mature holdings rehabilitated
Colombo/Gampaha	10	10
Kegalle	24	27
Kalutara	25	25
Ratnapura	8	13
Galle/Matara	14	14
Total	81	89

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

The concept of establishment of "forward march rubber villages" is widen with the selection 22 villages to up-grade as model villages. Basic data and information were collected. The project is in progress.

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

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

Table 7. *Details of projects related advisory visits*

Region	Nature of advisory visit							
	Model farm development	Rehabilitation of substandard rubber holdings	Introduction of Intercropping Systems	Introduction of rain guard technology	Maintenance of model RSS centers	Construction of new RSS centers	Rehabilitation of substandard RSS centers	**Total**
Colombo/Gampaha	72	122	4	15	13	27	10	**263**
Kalutara	299	237	35	40	52	15	15	**693**
Kegalle	247	209	22	46	31	50	9	**614**
Ratnapura	258	198	32	30	33	37	31	**619**
Galle/Matara	151	122	14	30	24	20	24	**385**
Total	**1027**	**888**	**107**	**161**	**153**	**149**	**89**	**2574**

Project 11 (ASD/02/C) "Vihidum Sathkara" Centrally planned special group advisory and Extension programmes for medium scale rubber estate owners in traditional rubber growing areas

Twenty four "Vihidum Sathkara" centrally planned special group advisory and extension programmes were conducted to increase the productivity of 54 medium scale Rubber estates in traditional rubber growing areas (Table 10).

Table 10. *"Vihidum Sathkara group advisory and extension programmes conducted for improvements of medium scale rubber estate*

Region	No. of programmes conducted	No. of medium scale estates benefitted
Colombo/Gampaha	2	7
Kegalle	8	13
Kalutara	5	15
Ratnapura	8	15
Galle/Matara	1	4
Total	**24**	**54**

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

Project 12 (ASD/03/A) Awareness raising programmes

Sixty seven awareness programmes were conducted to educate 1,196 rubber growers in traditional area on general aspects of rubber cultivation and immature up keep. Five hundred and forty three rubber farmers in the Monaragala district were also benefitted through 14 awareness programmes (Table 11).

Table 11. *Details of Awareness Raising Programmes conducted*

Region/District	No. of programmes conducted	No. of rubber farmers benefitted
Colombo/Gampaha	7	135
Kegalle	25	547
Kalutara	6	109
Ratnapura	23	199
Galle/Matara	6	106
Total	**67**	**1,096**
Monaragala	**14**	**543**

Project 13 (ASD/03/B) Mobile tapper training schools

As a solution to the tapper shortage in rubber growing areas, 12 mobile training programmes were conducted and 357 new harvesting assistants were introduced to the rubber industry. Also it was able to introduce 550 new rubber tappers to the rubber industry in Monaragala district through conducting of 18 tapping training schools (Table 12).

Table 12. *Details of Mobile Tapper Training Schools conducted in traditional rubber growing areas*

Region/District	No. of training programmes	No. of new harvesting assistants introduced
Kegalle	5	109
Kalutara	3	175
Ratnapura	2	32
Galle/Matara	2	41
Total	**12**	**357**
Monaragala	**18**	**550**

Project 14 (ASD/3/C) Skills development of rubber tappers

To upgrade the knowledge and skill levels of semi-skilled harvesting assistants, 52 skill development training programmes were conducted to improve the quality of tapping of 773 selected harvesting assistants (Table 13).

Table 13. *Details of skill development programmes conducted for semi-skilled rubber tappers*

Region	No. of programmes	No. of semi-skilled tappers trained
Colombo/Gampaha	5	92
Kegalle	14	195
Kalutara	9	169
Ratnapura	17	235
Galle/Matara	7	82
Total	**52**	**773**

Project 15 (ASD/3/D) Quality improvement of RSS

To improve the product quality of RSS produced by rubber smallholders, 49 one of day training programmes were conducted for the benefit of 523 selected RSS producers (Table 14).

Table 14. *Details of training programmes conducted for quality improvement of RSS*

Region	No. of training programmes	No. of RSS producers benefitted
Colombo/Gampaha	5	60
Kegalle	13	105
Kalutara	12	106
Ratnapura	14	90
Galle/Matara	5	62
Total	**49**	**523**

Project 16 (ASD/03/E) Training programmes on identification, control and eradication of white root disease

Forty five farmer training programmes were conducted to educate 648 rubber growers on identification, control and preventive measures of white root disease (Table 15).

Table 15. *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/Gampaha	2	64
Kegalle	13	184
Kalutara	10	156
Ratnapura	13	149
Galle/Matara	7	95
Total	**45**	**648**

Project 17 (ASD/03/ F) "Nipunatha Saviya" special training programmes to avoid/prevent in-discriminatory exploitation of rubber trees by smallholders

Twenty six full day workshops were conducted to educate selected rubber smallholders and their harvesting assistants totaling 634 on importance of adhering to RRI tapping recommendations to avoid in-discriminatory exploitation of rubber trees (Tables 16).

Table 16. *Details of "Nipunatha Saviya" special programmes conducted*

Region	No. of training programmes	No. of owners and tappers benefitted
Colombo/Gampaha	2	57
Kegalle	11	223
Kalutara	6	187
Ratnapura	2	36
Galle/Matara	5	131
Total	**26**	**634**

Project 18 (ASD/03/G) "Erambumata Athwalak" training for village youth on land preparation, contour lining, planting and value addition

Workshops were conducted to train sixty number of selected youth from Gampaha district on value addition of rubber in addition to training of five village youth from Homagama REO range in pre planting activities including lining, holing and soil conservation methods.

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

Preliminary works to establish two technology transfer centres as noval approach in effective extension were attended. The Regional Office premises of Kegalle and Ratnapura were selected for this purpose and some renovations been planned and instruments needed for these centers were received.

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.

Other special services provided by the ASD

Area specific needs and other requests by rubber smallholders were attended by REOo. Accordingly, advisory and extension activities were focused to address following issues and problems.

1. Technology transfer activities on contour lining for holing and soil conservation practices for new rubber cultivators.
2. Correction of tapping panel markings to avoid un-economical latex harvesting practices.
3. Introduction and demonstrations of technically improved new tapping knives

RUBBER TECHNOLOGY AND DEVELOPMENT

Dilhara Edirisinghe

DETAILED REVIEW

Staff

Dr (Mrs) D G Edirisinghe, Head of the Department was on duty throughout the year. Mrs G D D Senevirathne, Senior Research Officer obtained her PhD degree from the Queensland University of Technology, Australia. As she failed to resume duties at the end of year 2015, she was sent on vacation of post with effect from 31st December, 2016. Mr W D M Sampath, Research Officer was on duty throughout the year.

Mrs M K Mahanama, Experimental Officer retired from the Institute in January. Mrs S I Yapa, Mrs P C Wettasinghe, Mr S L G Ranjith, Mr P L Perera and Mrs Priyanthi Perera, Experimental Officers and Mr D G M J Abeywardena, Miss Gayathri Bhagyawedha and Mr K I D P Perera, Technical Officers were on duty throughout the year. Miss S M D Shashee Rekha De Alwis Wijerathne, Management Assistant was also on duty throughout the year.

Research students

Postgraduate students

- Mr W D M Sampath, MPhil student from the University of Moratuwa completed the experimental work of his research project on "Development of reactive blends from natural rubber and low density polyethylene" under the supervision of Dr (Mrs) D G Edirisinghe and Dr (Mrs) Shantha Egodage (Senior Lecturer, Dept. of Chemical and Process Engineering, University of Moratuwa).

- Mr Indika Perera, MSc (Polymer Science & Technology) student from the University of Sri Jayawardenepura completed the experimental work of 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 completed the experimental work of 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.

- Mr Ashan Mahanama, MSc (Materials Science) student from the University of Moratuwa initiated his research project on "Development of natural fibre filled natural rubber and synthetic rubber based composites for solid tyres" under the supervision of Dr (Mrs) D G Edirisinghe and Mr A M P B Samarasekera (Senior Lecturer, Dept. of Materials Engineering, University of Moratuwa).

Undergraduate students

- Mr W M S L Dissanayake, a BSc (Chemical Science & Technology – Special) undergraduate student from the Sabaragamuwa University of Sri Lanka completed his research project on "Effect of NR : LDPE blend ratio on properties of simple blends of NR and LDPE" under the supervision of Mr W D M Sampath.

Seminars/Training/Conferences/Workshops/Meetings attended

Officer/s	Subject/Theme	Organization
DG Edirisinghe	Training program on "Evaluation of inventions" at SLIDA	Sri Lanka Inventors Commission
	SRILANKAPLAST & RUBEXPO 2016 - CEO Forum	Plastics & Rubber Institute of Sri Lanka and Enterprising Fairs India Pvt. Ltd.
	Annual General Meeting	Plastics & Rubber Institute of Sri Lanka
	Training on "Scientific writing for scientists working in the NARS"	Sri Lanka Council for Agricultural Research Policy & University of Peradeniya
	Meeting on "Production of flame retardant foam"	Richard Peiris Natural Foams Ltd., Biyagama
	Meeting in regard to restructuring of IDB, Peliyagoda	Industrial Development Board (IDB)
	Meeting regarding the exhibition "Future Dreams 2016"	Ministry of Plantation Industries
	Workshop on "Coping mechanism for low rubber prices"	Rubber Research Institute of Sri Lanka & IRRDB

Officer/s	Subject/Theme	Organization
DG Edirisinghe	Sectoral Committee Meeting on "Chemical & Polymer Technology"	Sri Lanka Standards Institute
	Meeting regarding the "International Exhibition on Tea, Rubber, Coconut and Related Products"	Ministry of Plantation Industries
DG Edirisinghe WDM Sampath	Scientific Committee Meetings	Rubber Research Institute of Sri Lanka
DG Edirisinghe WDM Sampath	Workshop on "Statistical designing and analyzing" conducted by Prof. Thattil and Dr L Suriyagoda	Rubber Research Institute of Sri Lanka and University of Peradeniya
DG Edirisinghe, WD M Sampath DGMJ Abeywardena	Meeting with Director, Army Rehabilitation Centre regarding the novel prosthetic foot	Army Rehabilitation Centre, Ragama
D G Edirisinghe WDM Sampath	6th Crop Symposium	Crop Research Institutes
DG Edirisinghe PL Perera	Seminar on commercializing inventions	Sri Lanka Inventors Commission
DG Edirisinghe PL Perera	Participation in "National Inventors Day" celebrations held at Nelum Pokuna Theatre	Sri Lanka Inventors Commission
WDM Sampath	Workshop on "Rubberized road" in Thailand	Rubber Research Institute of Thailand & Rubber Authority of Thailand
WDM Sampath, KIDP Perera DGMJ Abeywardena	Workshop on "Writing an Impactful Research Article"	Rubber Research Institute of Sri Lanka and University of Peradeniya
WDM Sampath	Laboratory Quality Management	Measurement Unit, Standard and Service Department, Diyagama
WDM Sampath	Meeting regarding the exhibition "Future Dreams 2016" (Provincial Science & Energy Event)	Ministry of Education & Sri Lanka Sustainable Energy Authority
DGMJ Abeywardena	Seminar on "Finite element analysis in rubber product manufacture"	Plastics & Rubber Institute of Sri Lanka
SLG Ranjith KID P Perera	Seminar on "Statistical Methods"	Rubber Research Institute of Sri Lanka
PL Perera	LABEXPO Exhibition, Colombo	

Officer/s	Subject/Theme	Organization
KIDP Perera	In-house training on "Rubber Technology"	Cochin University, India
	Lecture on "Finite element Method; A Tool for Engineers"	Plastics & Rubber Institute of Sri Lanka

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

Officer/s	Subject/Theme	Beneficiary/Client
DG Edirisinghe	Testing of latex and latex based products	MSc Students (Polymer Technology) - University of Moratuwa
	Introduction to natural rubber latex characteristics	National Diploma in Plantation Extension Management-NIPM
	NR latex, composition and its characteristics	National Diploma in Plantation Management-Rubber Agronomy & Processing – NIPM
	Natural rubber latex characteristics	Professional Programme in Rubber Manufacture & Factory Practices – NIPM
	Technology Update - Current research projects and future focus	Research & Technical staff of RRISL
	Evaluation of inventions in the Southern Province for the "Sahasak Nimavum 2016", National Exhibition for Inventions & Innovations (served as a Jury Member)	Sri Lanka Inventors Commission (SLIC)
DG Edirisinghe WDM Sampath PC Wettasinghe PL Perera SLG Ranjith Priyanthi Perera	RUBEXPO & SRILANKAPLAST 2016	Plastics & Rubber Institute of Sri Lanka and Enterprising Fairs India Pvt. Ltd.
WDM Sampath	Compounding ingredients for latex and dry rubber	Students of the Certificate Course in Rubber Technology - PRISL
	Rubber product manufacture as a cottage industry	Rubber Development Officers - Rubber Development Department

Officer/s	Subject/Theme	Beneficiary/Client
WDM Sampath PL Perera	Participation in the "Business Clinic" of "Business Fair 2016"	Department of Entrepreneurship, University of Sri Jayewardenepura
WD M Sampath KIDP Perera	"Future Dreams 2016" – St. Johns College, Panadura	Ministry of Education & Sri Lanka Sustainable Energy Authority
PC Wettasinghe	Workshop on "Rubber based products manufacture" in Ratnapura District - Kukulegama	Thurusaviya Fund
	Workshop on "Rubber based products manufacture" in Galle District - Hibutugoda	Thurusaviya Fund
PC Wettasinghe Gayathri Bhagyawedha	Workshop on "Rubber based products manufacture" in Kalutara District – Handapangoda	Thurusaviya Fund
SI Yapa KIDP Perera	Workshop on "Rubber based products manufacture" in Kalutara District – Gulawita	Thurusaviya Fund
	Workshop on "Rubber based products manufacture" in Ratnapura District – Niralgama	Thurusaviya Fund
	Workshop on "Rubber based products manufacture" in Kalutara District, Polegoda	National Institute of Plantation Management
SLG Ranjith	Workshop on "Rubber based products manufacture" in Kalutara District – Walallavita	Thurusaviya Fund
	Workshop on "Rubber based products manufacture" in Pitabeddara, Galle	Rubber Development Department & National Institute of Plantation Management
	Workshop on "Rubber based products manufacture" in Ratnapura District - Opanayake	Rubber Development Department & National Institute of Plantation Management
	Workshop on "Rubber based products manufacture" in Kalutara District – Mahagama	Rubber Development Department & National Institute of Plantation Management
SLG Ranjith	Workshop on "Rubber based products manufacture" in Kamburupitiya, Matara	Rubber Development Department & National Institute of Plantation Management

Officer/s	Subject/Theme	Beneficiary/Client
PL Perera	Field week in regard to celebrating 100 years of setting up agriculture colleges	Sri Lanka School of Agriculture, Kundasale
	Workshop on "Rubber based products manufacture" in Kalutara District – Paleda	Thurusaviya Fund
	Workshop on "Rubber based products manufacture" in Katuwana, Galle	Rubber Development Department & National Institute of Plantation Management
	Workshop on "Rubber based products manufacture" in Kegalle District, Bisowela	Thurusaviya Fund
	Workshop on "Rubber based products manufacture" in Haraliyadda, Matale	Rubber Development Department & National Institute of Plantation Management
PL Perera SLG Ranjith	Workshop on "Rubber based products manufacture" in Boys Town, Ragama in collaboration with the Advisory Services Department, RRISL	Group of boys rehabilitated by the Church in Boys Town, Ragama
PL Perera PC Wettasinghe	Trade & Educational Exhibition – Eheliyagoda	Ministry of Education
PL Perera DGMJ Abeywardena	Training on "Manufacture of cast products" in Karapitiya, Galle	Temple in Karapitiya, Galle
Priyanthi Perera	Workshop on "Rubber based products manufacture" in Mirigama	Thurusaviya Fund
	Structure – property relationship of polymers	Students of the Certificate Course in Rubber Technology - PRISL
	Workshop on "Rubber based products manufacture" in Kalutara District, Walallawita	Rubber Development Department & National Institute of Plantation Management
	Workshop on "Rubber based products manufacture" in Kalutara District - Kelinkanda	Thurusaviya Fund
DGMJ Abeywardena	Workshop on "Rubber based products manufacture" in Kegalle District	Rubber Development Department & National Institute of Plantation Management

Officer/s	Subject/Theme	Beneficiary/Client
DGMJ Abeywardena	Workshop on "Rubber based products manufacture" in Kurunegala District - Ganegoda	Thurusaviya Fund
	Workshop on "Rubber based products manufacture" in Kegalle District - Mawanella	Rubber Development Department & National Institute of Plantation Management
	Workshop on "Rubber based products manufacture" in Ratnapura District, Kiriella	Rubber Development Department & National Institute of Plantation Management
Staff of the department	Field training programme on "Rubber product manufacture"	Undergraduate students of Palm & Latex Technology and Value Addition – Uva Wellassa University
Staff of the department	Training program on latex based and dry rubber based products manufacture	National Institute of Plantation Management and Smallholder Plantation Entrepreneurship Development Programme (SPEnDP)
Staff of the department	Practical demonstrations on latex and dry rubber based products manufacture	BSc (Agri. Sp.) undergraduates of the Department of Plantation Management, Wayamba University of Sri Lanka
Staff of the department	Practical demonstrations on rubber product manufacture and testing	BSc (Palm & Latex Technology & Value Addition) undergraduates of the Uwa Wellassa University

Industrial visits

The following institutes/industries/factories were visited during the year for development/trouble shooting work.

Officer	Industry/Organization
DG Edirisinghe, WDM Sampath & DGMJ Abeywardena	Ranaviru Sevena, Ragama
DG Edirisinghe	Soil Tech. Ltd.
DG Edirisinghe & M K Mahanama	Raw Rubber Processing Factory – Ratnapura

LABORATORY INVESTIGATIONS

Latex technology

Development of a natural rubber latex based adhesive for shoes

Two natural rubber latex based adhesive compounds were produced using centrifuged latex at the request of a rubber small holder. The compounds were forwarded to carry out trials on shoes. As the trials were successful, the technology on adhesive preparation was transferred to the SME on request by conducting a workshop (D G Edirisinghe, S I Yapa, Hasara Samarasinghe – Polymer Chemistry Dept. and H Hewamulla - Polymer Chemistry Dept.).

Dry rubber technology

Development of environmental friendly natural fibre filled rubber composites

(a) Development of pandanas fibre filled rubber composites

A series of NR based composites was prepared according to a middle layer solid tyre formulation by partially replacing the widely used toxic reinforcing filler carbon black with pandanas fibre (2 mm in length) according to the ratios given in Table 1. Cure characteristics and physico-mechanical properties of all the four composites were evaluated and the results obtained are given in Table 2.

Table 1. *Carbon black: pandanas fibre ratios of the composites*

Composite No.	C0 (Control)	C1	C2	C3
Carbon black	60	45	30	15
Pandanas fibre	0	15	30	45

Table 2. *Physico-mechanical property results of carbon black and pandanas fibre filled NR vulcanizates*

	Composite No.			
Property	**C0**	**C1**	**C2**	**C3**
Hardness (IRHD)	62	51	71	56
Modulus at 100% elongation (MPa)	2.7	1.8	2.6	1.7
Modulus at 300% elongation (MPa)	4.8	5.1	4.3	2.5
Tensile strength (MPa)	5.1	8.4	6.3	4.0
Elongation at break (%)	359	441	449	414
Tear strength (N/mm)	35.3	29.8	29.8	23.8
Resilience (%)	67	65	63	64
Compression set (%)	27	7	19	11

The vulcanizates containing pandanas fibre exhibit higher elongation at break and lower compression set in comparison to the control. Physico-mechanical properties of the vulcanizate prepared by replacing 50% of the carbon black with pandanas fibre are closer to or even better than those of the Control. However, 75% replacement of carbon black with pandanas fibre markedly reduces properties such as hardness, moduli, tensile strength and tear strength. There is not much of a difference between the resilience of the four NR vulcanizates and the value is above 60%. This indicates that there is no marked change in heat build-up when carbon black is partially replaced with pandanas fibre upto 75%.

Elongation, resilience and hardness of the 30:30 carbon black : pandanas fibre containing vulcanizate is in agreement with the requirements for middle layer of solid tyres. However, modulus at 300% elongation and tensile strength needs to be improved. Therefore, work will be continued to achieve the required values for modulus and tensile strength in solid tyre application (D G Edirisinghe, W D M Sampath and P C Wettasinghe).

(b) Development of water hyacinth fibre filled rubber composites

Seven NR vulcanizates were prepared by partially replacing carbon black with the powder of the dried water hyacinth fibres, at 10 phr intervals. The total filler loading was kept constant at 60 phr. The Control was the 60 phr carbon black filled composite. Cure characteristics and physico-mechanical properties of the vulcanizates were evaluated. Hardness and resilience of the vulcanizate produced with 60 phr of water hyacinth fibre (without any carbon black) were higher than those of the other vulcanizates. The Control and 60 phr water hyacinth fibre filled vulcanizate showed lower compression set in comparison to the other vulcanizates. Also, the Control showed the lowest abrasion volume loss among the vulcanizates.

The vulcanizates containing both the filler types showed high compression set values than those containing only one type of filler. Further, the strength properties of vulcanizates containing water hyacinth fibres were lower than those of the Control. However, the ageing properties of the former were superior to those of the latter (D G Edirisinghe, M K Mahanama, A M P B Samarasekera (Senior Lecturer, Materials Engineering Department, University of Moratuwa) and Ashan Mahanama - MSc (Materials Science) student, University of Moratuwa).

Development of rubber compounds with modified NBR glove waste

A request was made by Dipped Products Plc. to modify NBR glove waste to use as a rubber component in blends with virgin NR to manufacture rubber products. Five different rubber compounds were prepared using the following rubber compositions. Reclaimed rubber used in these compositions was prepared according

to mechano-chemical reclamation process and the milling time employed was 5 minutes.

Table 3. *Rubber compositions used in the rubber compounds*

Compound No.	Rubber Composition
NS 1	100% Virgin NR
NS 2 (Control 1)	85% Virgin NR + 15% Virgin NBR
NS 3 (Control 2)	85% Virgin NR + 15% NBR glove waste
NS 4	85% Virgin NR + 15% NBR glove waste reclaimed with a novel reclaiming agent
NS 5	85% Virgin NR + 15% NBR glove waste reclaimed with TMTD

Cure characteristics, physico-mechanical and ageing properties of the rubber compounds were determined and the results are tabulated below.

Table 4. *Physico-mechanical properties of rubber compounds*

Compound No.	NS 1	NS 2	NS 3	NS 4	NS 5
Hardness (IRHD)	39	49	39	39	42
Modulus at 100% elongation (MPa)	2.29	2.74	2.33	2.44	2.16
Modulus at 300% elongation (MPa)	8.17	7.71	-	4.09	6.89
Tensile strength (MPa)	15.42	12.92	5.85	6.25	7.88
Elongation at break (%)	432	381	266	327	337
Tear strength (N/mm)	26.73	32.30	16.93	23.54	23.99
Resilience (%)	64	49	48	48	54
Abrasion volume loss (mm^3)	191	187	350	269	229
Compression set (%)	10.16	14.92	20.38	18.93	17.54

Table 5. *Percentage retention of physico-mechanical properties after ageing*

Compound No.	Tensile strength (%)	Modulus at 100% elongation (%)	Elongation at break (%)	Tear strength (%)
NS 1	81	130	78	112
NS 2	79	140	88	101
NS 3	114	146	91	143
NS 4	122	130	99	107
NS 5	93	149	91	131

As expected, properties of NS 2 (Control 1) containing virgin rubbers were superior to those of NS 3 (Control 2) containing waste and NS 4 and NS 5 containing reclaimed rubber. It is interesting to note that the mechanical properties of NS 4, prepared with a novel reclaiming agent are better than those of NS 3. Physico-mechanical properties such as hardness, modulus at 100% elongation, elongation at break, tear strength, abrasion volume loss and compression set of NS 4 were comparable to those of NS 5, prepared with the conventional reclaiming agent tetramethylthiuram disulphide (TMTD). Further, percentage retention of tensile strength and elongation at break of NS 4 after ageing were higher than those of NS 5.

Development of rubber-plastic composites for special applications

(a) Effect of peroxide loading on properties of NR and LDPE composites

A series of 70:30 NR/LDPE composites was formulated with equal amounts of sulphur (0.5 php), but varying the dicumyl peroxide (DCP) loading from 0-0.9 php. The composite without DCP (with sulphur alone) was considered as the Control. The composites were prepared by melt mixing using a Brabender Plasticorder at a temperature of 130^0C and rotor speed of 60 rpm. Total mixing time was kept constant at 14 minutes. NR/LDPE composites were compressed in an electrically heated hydraulic press at 150^oC under 3.5 bar pressure for 15 minutes to produce 2 mm thick sheets. Physico-mechanical, chemical, ageing and morphological properties were evaluated according to ISO and ASTM test methods.

Variation of hardness of NR/LDPE composites at different DCP loadings is shown in Figure 1. Hardness of all the composites was in the range 55 to 65 IRHD. Hardness increases (11% compared to the Control) up to DCP loading of 0.3 php and decreases thereafter with the increase of DCP loading. Increase in hardness of the composite with DCP loading of 0.1 php compared to the Control is due to the formation of additional crosslinks in the NR phase with the addition of DCP. Further increase in DCP loading up to 0.3 php may have produced more crosslinks in the NR phase, and between NR and LDPE phases.

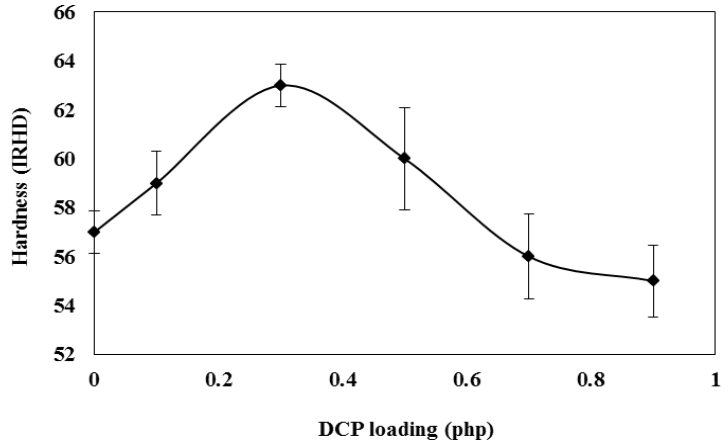


Fig. 1. Hardness of NR/LDPE composites at different DCP loadings

Stress-strain curves for 70:30 NR/LDPE composites at all DCP loadings exhibit similar elastic behavior as shown in Figure 2 indicating that the continuous phase of the composites is NR. With the incorporation of 0.1 php loading of DCP, the elasticity increased and it may be associated with the increase of crosslink density in the NR phase. Sulfur crosslinked rubber shows high elasticity than DCP crosslinked rubber due to the presence of flexible polysulphide crosslinks. DCP crosslinked rubber has mainly rigid C-C crosslinks between the macromolecular chains.

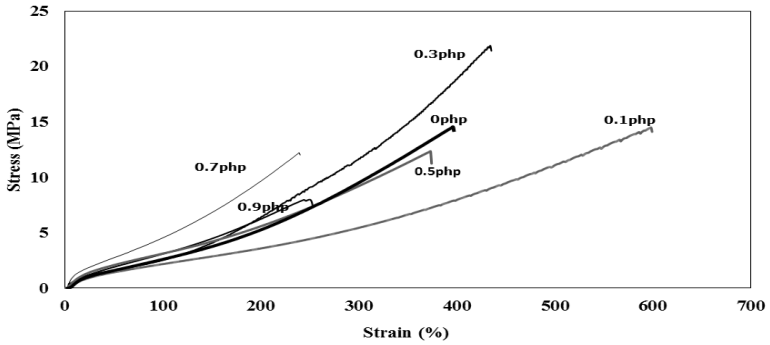


Fig. 2. Stress-strain curves of NR/LDPE composites with DCP loading

Figure 3 shows a marked increase in tensile strength from 0 to 0.3 php DCP loading and a decrease thereafter. The highest tensile strength is shown at the DCP

loading of 0.3 php and may be associated with the highest crosslink density of the composite and/or with the highest degree of crystallinity of the LDPE phase.

As expected, composites at all DCP loadings showed high tear strength values compared to the Control (Fig. 4). Tear strength is highest at the DCP loading of 0.3 php. This may be attributed to reduction in crack propagation during tearing due to improvement of interfacial adhesion between NR and LDPE phases. Improvement in interfacial adhesion could be a consequence of increased crosslink density as evident from results of hardness.

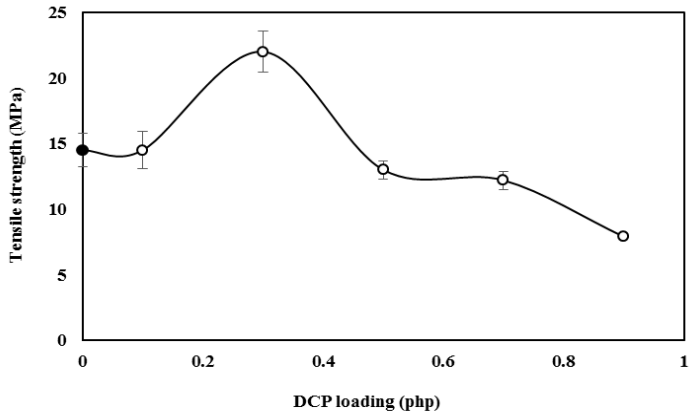


Fig. 3. Tensile strength of NR/LDPE composites at different DCP loadings

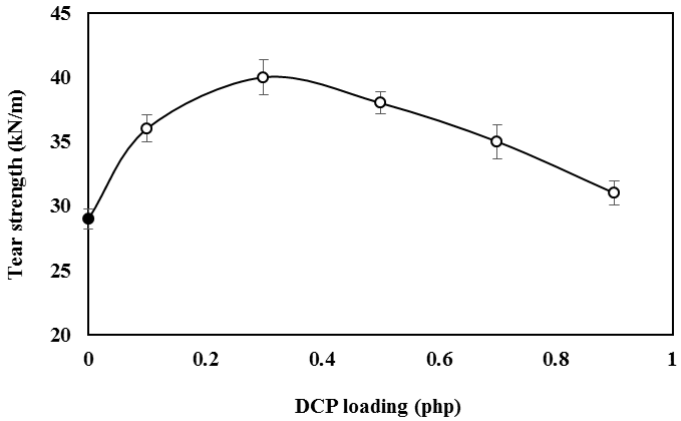


Fig. 4. Tear strength of NR/LDPE composites at different DCP loadings

Figure 5 exhibits higher values for the gel content of composites containing DCP compared to the Control confirming that DCP generates more crosslinks in the NR phase of the composites. The highest gel content is shown at DCP loading of 0.3 php. However, there was no significant difference between the gel content of the five composites containing DCP.

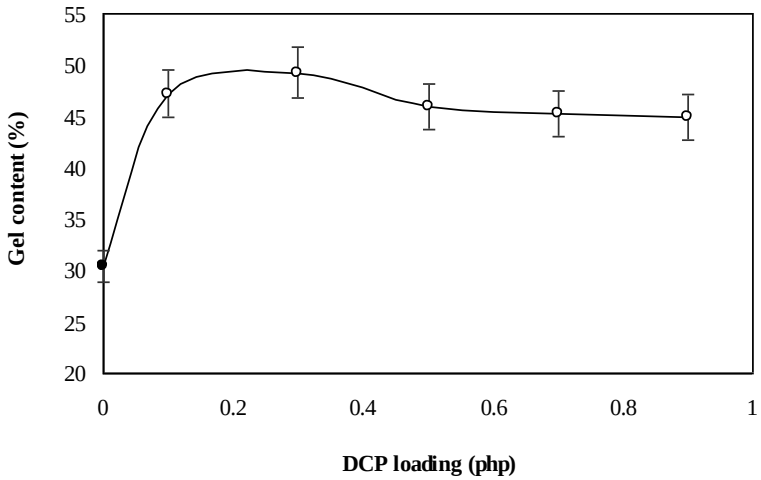


Fig. 5. Gel content of NR/LDPE composites at different DCP loadings

Table 6 indicates that all composites containing either sulfur vulcanizing system alone or both DCP and sulfur vulcanizing systems are highly resistant to ageing or in other words thermal degradation. Percentage retention of mechanical properties was greater than 100 for the Control and was between 94-97 for the other composites.

Table 6. *Ageing properties of NR/LDPE composites at different DCP loadings*

DCP loading (php)	Retention of tensile strength (%)	Retention of elongation at break (%)
0	118	104
0.1	95	97
0.3	98	97
0.5	95	98
0.7	96	97
0.9	94	96

Table 7 shows the glass transition temperature (Tg), melting temperature (Tm) and degree of crystallinity of composites. Tg of NR increases with the addition of a DCP loading of 0.1 php confirming that the formation of additional crosslinks in the NR phase by DCP. With further increase of DCP loading, there is a slight increase in Tg indicating formation of more crosslinks at the NR phase. Tm of LDPE also increases with the addition of a DCP loading of 0.1 php and is associated with the higher degree of crystallinity of the LDPE phase. The highest degree of crystallinty is shown at the DCP loading of 0.3 phpp.

Table 7. *Thermal properties of NR/LDPE composites at different DCP loadings*

DCP loading, php	T_g (^{0}C)	T_m (^{0}C)	Degree of crystallinity (%)
0	-58.6	109.3	16.6
0.1	-56.8	110.0	19.5
0.3	-56.5	110.8	20.8
0.5	-56.4	110.5	18.9
0.7	-56.3	109.8	15.2
0.9	-55.9	108.3	15.6

Figure 6 (a-c) show tensile fracture surfaces of the Control and the composites at DCP loadings of 0.3 and 0.9 php. The fracture surface of the Control is rough (Fig. 6a), while that of the composite at DCP loading of 0.3php is smooth (Fig. 6b). Fracture surface of the composite at DCP loading of 0.9 php shows rough fracture along with porosity in the composite (Fig. 6c).

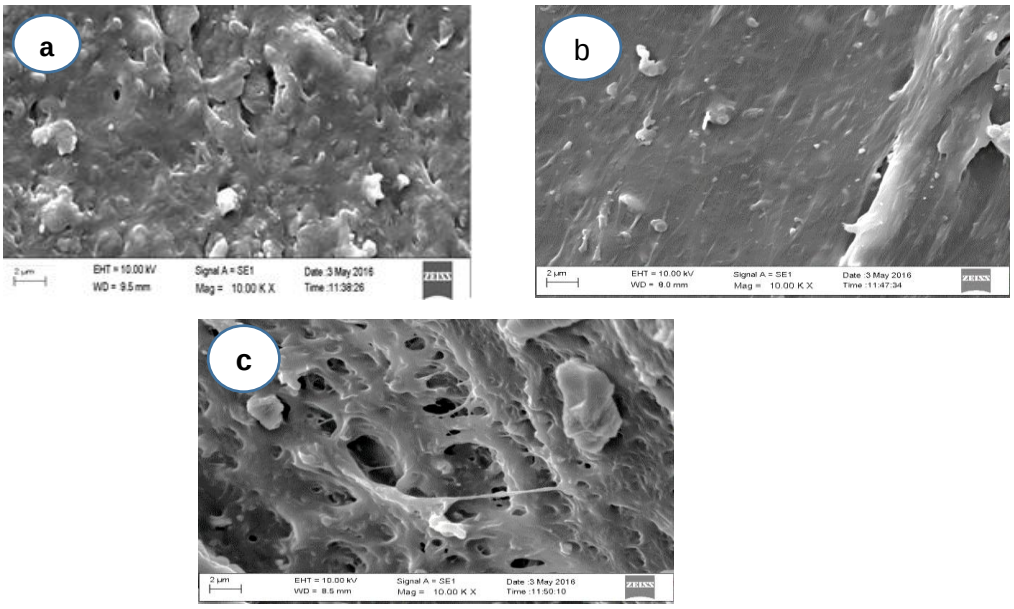


Fig. 6. SEM images of tensile fracture surfaces of composites at different DCP loadings (magnification x 10.000) a) Control b) 0.3 php c) 0.9 php

(W D M Sampath, D G Edirisinghe and S M Egodage - Senior Lecturer, Dept. of Chemical and Process Engineering, University of Moratuwa)

(b) Effect of blend ratio on physico-mechanical, chemical and morphological properties of NR/LDPE blends

A series of simple blends of NR/LDPE was formulated by varying the NR: LDPE blend ratio from 90:10 to 10:90 at 20 w/w% intervals and 100% LDPE was used as the Control. The blends were prepared using a Brabender Plasticorder by melt mixing at a temperature of 150˚C, and at a rotor speed of 60 rpm. Simple blends were prepared using a hydraulic press operated at a temperature of 150˚C. Physical, chemical and morphological properties were evaluated according to ISO and ASTM test methods. There was no significant variation in water absorption with NR:LDPE blend ratio. All the NR/LDPE simple blends dissolved in boiled p-xylene and hence these blends have poor solvent resistance. Further, swelling resistance in p-xylene increased with the increase of NR loading, which means solvent resistance increased with the increase of LDPE loading. Tensile strength decreased with the increase in NR loading, while elongation at break increased. Hardness of the blends was not

significantly different. Swelling resistance in p-xylene increased with the increase of NR loading, which means solvent resistance increased with the increase of LDPE loading.

The SEM image of a simple NR/LDPE blend at a specific blend composition illustrated relatively large agglomerates of LDPE phase. Further, the results revealed that blends with different properties required for different applications could be obtained by varying the blend ratio. A research paper titled "Effect of blend composition on physical, chemical and morphological properties of natural rubber / low density polyethylene blends" was presented at the Winc 2016 Wayamba International Conference held during 19-20th August, 2016 at the Wayamba University of Sri Lanka (W D M Sampath and W M S L Dissanayake – BSc (Chemical Technology) undergraduate student, Sabaragamuwa University of Sri Lanka).

Industrial extension

The following properties were tested and test reports were issued to the companies at their request.

Hardness of sole crepe samples	**Physico-mechanical properties of rubber/plastic compounds**	**Physico-mechanical properties of rubber/plastic products**
Kegalle Plantations,	Sharmini Rubber Industries	ATG Ceylon (Pvt.) Ltd.
Pallegama Estate	Elastomeric Engineering Ltd.	Textrip (Pvt.) Ltd.
Kegalle Plantations	Laugfs Corporation (Rubber) Ltd.	Sri Lanka Institute of Textile &
Atale Estate	Global Rubber Industries	Apparel
Elpitiya Estate	US Lanka Rubber Solutions (Pvt.)	Mapa Lalan (Pvt.) Ltd.
	Ltd.	Midas Safety Company
Panawatta Estate	Abia Group of Company (Pvt.) Ltd.	Dipped Products Ltd.
Dewalakanda Estate	Samson Reclaim Rubber Ltd.	Vaughan Chemicals (Pvt.) Ltd.
	Industrial Development Board	Lalan Rubbers
	Trelleborg Lanka (Pvt.) Ltd.	Road Development Authority
	Dipped Products Ltd.	
	Aroma Company Ltd.	
	Starco Lanka (Pvt.) Ltd.	
	Road Development Authority	
	Autoways (Pvt.) Ltd.	
	Unicorn Tyre Retreading (Pvt.) Ltd.	

The following compound developments were conducted on request.

Compound development	Client
NR latex based adhesive for shoes	Rubber smallholder cum entrepreneur
NR based compound for roofing sheets	Back Office Medicine Company
NR based compound with good adhesion property	Midas Safety Company
Infant play item out of NR	Green Rubber Toy Company
Bat grip out of NR	Cricket Coach
NR/NBR/polyvinyl chloride (PVC) blend	Sharmini Rubber Industries

POLYMER CHEMISTRY

I H K Samarasinghe

DETAILED REVIEW

Staff

Dr (Mrs) A H L Nilmini, Head of Polymer Chemistry Department resigned from the institute on 01st of March 2016. Mrs I H K Samarasinghe, Research Officer was assigned as the in charge of overall activities of the department with effect from 02nd May 2016 and was on duty throughout the year. Mr Y R Somarathna was recruited to the Department as a Research Officer with effect from 1st of June 2016. Mrs Nirmala Jayawardena, Experimental Officer was on duty throughout the year. Mrs Hiruni Hewamulla, Technical Officer was on duty throughout the year. Miss Kalani Edirisinghe and Mr Tharindu Perera, Technical Officers resigned from the Institute with effect from 5th August 2016 and 02nd December 2016, respectively. Mr M A D W K Thilakarathne, Management Assistant was on duty throughout the year.

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

Officer/s	Subject/Theme	Organization
IHK Samarasinghe	Five day national workshop on Separation Techniques in Natural Product Research	Institute of Fundamental Studies, Kandy
	Workshop on International Grants	National Science Foundation
YR Somarathna	One week Certificate Course in Rubber Technology	Cochin University of Science & Technology, India & Indian Rubber Institute, Kerala Branch, India
IHK Samarasinghe YR Somarathna	45th Scientific Committee Meeting	Rubber Research Institute of Sri Lanka
	Workshop on Scientific Writing	Rubber Research Institute of Sri Lanka
	Workshop on Statistical Methods & Crop Modeling	Rubber Research Institute of Sri Lanka
	6th Symposium on Plantation Crop Research	CRI, RRI, TRI and SRI

Lectures/Seminars/Conferences/Training conducted

Officer/s	Subject/Theme	Beneficiary/Client
IHK Samarasinghe	Manufacture of centrifuged latex	Induction Course for Planter Trainees - NIPM
YR Somarathna	Certificate Course in Rubber Technology	Certificate course students of Plastic and Rubber Institute
Staff of the department	Analytical Techniques on polymer characterization (FTIR, DSC & DMA)	Batch of students of National Diploma in Technology, University of Moratuwa
Staff of the Department	Field training program on "Polymer Technology"	Undergraduate students of Palm & Latex Technology and Value Addition - Uva Wellassa University

LABORATORY INVESTIGATIONS

Development of an environmental friendly preservative for NR latex as a replacement for TMTD/ZnO preservative system

At present, a mixture of ammonia, with TMTD/ZnO is the most common and industrially accepted preservative system for concentrated NR latex in the rubber industry. TMTD is now considered as a chemical that generates nitrosoamine, which is a well-known cariogenic substance. The present work attempted to develop a new environmentally friendly preservative system using a commercially available low toxic anti-microbial compound. Several trails were carried out to evaluate effectiveness of the new preservative system. It was observed that the new system maintains the required levels of VFA. However, MST values were not achieved within the required duration. Hence, the trials are being carried out to address this issue (A H L R Nilmini, Nirmala Jayawardena and Hiruni Hewamulla).

Evaluation of raw rubber properties of RSS made out from blends of Skim Natural Rubber Latex and Field Natural Rubber Latex

Skim latex is a material generated as a by-product during the manufacture of concentrated latex using the centrifugation process. After centrifuging the fresh field latex, 5-10% of total rubber together with an enhanced proportion of the non-rubber constituent in the original latex remains in the serum phase or skim latex. The skim latex is composed of small rubber particles in range of 0.04 to 0.4 µm with the mean particle diameter of about 0.1µm, while those of large rubber particles in concentrated latex is from 0.1 to 3 µm with a mean diameter of 1 µm.

Skim latex is generally converted into crepe form and is treated as a low grade rubber due to its higher protein (hence nitrogen) content than the conventional grades of rubber. However, it was recently noted that there is a potential of adulteration of field natural rubber latex with the skim latex and the blend is used for the manufacture of conventional type Ribbed Smoked sheet Rubber. This yields

unexpected processing problems due to the unavailability of the literature on the raw rubber and curing properties of RSS made out of these blends. Therefore, an experiment was commenced to prepare RSS from skim and normal field latex blends and to evaluate their performance. The latex blends were prepared according to the volume ratios shown in Table 1. These latex blends were coagulated using formic acid and processed into RSS following the standard manufacturing procedure of RSS.

Table 1. *Volume ratios used to prepare the latex blend series*

Sample No	SNR0	SNR20	SNR40	SNR60	SNR80	SNR100
Natural Rubber Latex (L) (DRC 30%)	6.67	5.34	4	2.67	1.34	0
Skim Latex (L) (DRC 5%)	0	8	16	24	32	40
% Skim rubber in the sample (W/W)	0	20	40	60	80	100

Skim latex used for the experiment was obtained from Lak Latex (Pvt) Ltd. and Natural rubber latex was obtained from the estate belong to Rubber Research Institute. Skim latex and Natural rubber latex volumes were mixed according to the volumes given in Table 1 to prepare the blend series. SNR0 and SNR 20 samples were diluted to 10% DRC after mixing by adding fresh clean water prior to coagulation. Formic acid was added until pH reach to isoelectric point in order to achieve proper coagulation. It was observed that formic acid consumption was gradually increased due to the increase amount of Skim latex. Soft coagulum which is suitable to manufacture RSS sheets were obtained for all samples except SNR100 which contained only Skim rubber latex (I H K Samarasinghe, S Siriwardene and Dushanthi Lakmini).

Development of coir pith encapsulated slow releasing fertilizer block

A production process was developed to manufacture cube shaped coir encapsulated fertilizer blocks on the request of Soils & Plant Nutrition department. A special rubber compound was developed and used to bind the coir matrix. A mixture of fertilizer was incorporated to the blocks during the manufacturing process. The experiment was focused to develop a manufacturing process to produce the blocks with the required moisture content, level of porosity and rate of nutrient release. The blocks developed were found to be quite durable, user friendly, light weight and inexpensive qualifying them for the use in the field. A batch of 400 coir blocks were produced and given to Soils and Plant Nutrition department to evaluate the effectiveness of these blocks as a slow releasing fertilizer blocks (I H K Samarasinghe and Tharindu Perera).

Development of latex based adhesive for footwear industry

A medium scale rubber state owner requested to develop a latex based adhesive for a special type of shoes. This adhesive should act as a bonding agent that promotes adhesion between textile and paper. Natural rubber latex based adhesive with required adhesive bond strength, stability and viscosity was developed after carrying out several trials.

The development was carried out collaboratively with the Rubber Technology and Development department (D G Edirisinghe, I H K Samarasinghe, Hiruni Dhanukamale and S I Yapa).

Development of a low cost polymer based water proofing cement

An entrepreneur requested to develop a new low cost polymer based water proofing cement that can replace the presently available imported and high cost waterproofing cement. High cost of the bonding agent has resulted in higher manufacturing cost and unfavorable market environment. In order to overcome this problem, a new polymer based bonding agent, which will give the similar properties of currently using imported bonding agent was developed. Firstly, the currently using bonding agent was identified using polymer characterization techniques. Then several low cost compounds that show similar properties of the presently using compounds were identified. Trails are being carried out with newly identified compounds including NR with non-ionic surfactants and several low cost synthetic rubber lattices in order to meet the desired properties of the water proofing cement (Y R Somarathne).

Industrial extensions

Both technical and consultancy services were provided to the following industries.

- Macksons Paints Lanka (Pvt) Ltd.
- Lalan Rubber (Pvt) Ltd.
- Richard Pieris Natural Foams Ltd.
- ACL Plastics PLC
- DR Home Appliances (Pvt) Ltd.
- Dipped Products PLC
- Jafferjee Brothers Exporters (Pvt) Ltd.
- Sunshine Packaging Lanka Ltd.
- DSI
- Ceylon Electricity Board
- National Water Supply & Drainage Board
- Sri Lankan Institute of Textile Apparel
- ATG Lanka (Pvt) Ltd.
- Textrip (Pvt) Ltd.
- Laughs Corporation (Rubber) Ltd.
- Sri Lanka Railways

RAW RUBBER AND CHEMICAL ANALYSIS

A P Attanayake

DETAILED REVIEW

Staff

Mrs A P Attanayake, Research Officer was the in-charge officer of overall activities of the department throughout the year. Mrs I H K Samarasinghe, Research Officer was transferred to the Polymer Chemistry department and Mr A M K S P Adhikari, Research Officer was assumed duties since 2nd May 2016.

Mrs L Wanigatunga, Experimental Officer retired from the duties with effect from 12th April 2016 after providing an outstanding 37 years of service to the Institute. Mrs H V K Gamage, Mr L P P Vitharana, Mrs C Lokuge and Miss M Wijesekera, Experimental Officers were on duty throughout the year. Miss S P Wijewardana, Technical Officer was on duty throughout the year. Miss D Lakmini, Technical Officer resigned from duties with effect from 11th July 2016. Mr G Gunasena, Management Assistant was transferred to the Accounts Department with effect from 06th September 2016. Miss W D D Samanmali, Management Assistant was on duty throughout the year.

Research Students

- Mr Deshan E Weeraratne, BSc students from Faculty of Applied Science, Department of Chemistry, University of Sri Jayewardenepura, completed his final year research project on "Identification of acetone extractable non-rubber in Raw Natural Rubber" under the supervision of, Mrs Anusha Attanayake.
- K A Shashi Udayanga BSc students from Faculty of Applied Science, Department of Chemistry, University of Sri Jayewardenepura, completed his final year research project on "Physical Properties of RRISL 203 Clone under the supervision of, Mrs Anusha Attanayake.

Training Programmes

Training Programmes were carried out for the following Officers/students as detailed below.

Client	Subject
Miss T MWathsala Nimanthi - Lak Latex (Pvt) Ltd.	Latex Testing
Mr AT Rajakaruna - Camso Loadstar (Pvt) Ltd.	Raw Rubber Testing
Wayamba University	Latex Testing

Lectures/Seminars/Workshops/Meetings attended

Officer/s	Subject	Organization
AP Attanayake	Head of the department Meeting	Dartonfield, RRISL
AP Attanayake	Meeting with secretary	Dartonfield, RRISL
AP Attanayake	Staff Meeting	Dartonfield, RRISL
AP Attanayake	Workshop of editing & reviewing research articles	ITI
AP Attanayake IHK Samarasinghe	Workshop on "Scientific writing"	Dartonfield, RRISL
AP Attanayake IHK Samarasinghe	Workshop on statistical design	Dartonfield, RRISL
IHK Samarasinghe	Kandy National workshop on separation techniques in natural product research	NIFS

Lectures/Seminars/Workshops/Meetings conducted

Officer/s	Subject	Organization
AP Attanayake	Lecture on "Sampling of latex & dry rubber for students from National Diploma in Plantation extension management 2014/2016"	National Institute of Plantation Management
AP Attanayake	Raw rubber testing	National Diploma in Technology, University of Moratuwa

LABORATORY INVESTIGATIONS

Effect of ethephon stimulation for dynamic - mechanical properties

Effect of ethephon stimulation for the dynamic - mechanical properties has not been studied previously. Thus, there is a need to study the above subject as the present scenario in the world is changed to low frequency harvesting system.

Un-fractioned-unbleached crepe rubber was prepared from mono clonal (RRISL 121) mature rubber trees from the Galewatta Division and Dartonfield Estate, for the experiment. The treatment plots were set up allocating 25 trees to each plot. Trees in each block were stimulated with different concentrations of ethephon ranging from (3%-4%) and un-stimulated rubber kept as the control sample. Tapping frequency was half spiral once in three days. ACS 1 gum compound was prepared from raw rubber for the analysis.

A complete rheological analysis such as frequency sweep and strain sweep tests are performed on the Rubber process analyzer (RPA) at 130^0C in order to access the differences in molecular weight, molecular weight distribution and branching. To

verify the branching effect on polymers – LAOS test was performed on the three samples and Lissajous diagram was observed at maximum strain of 90^0C.

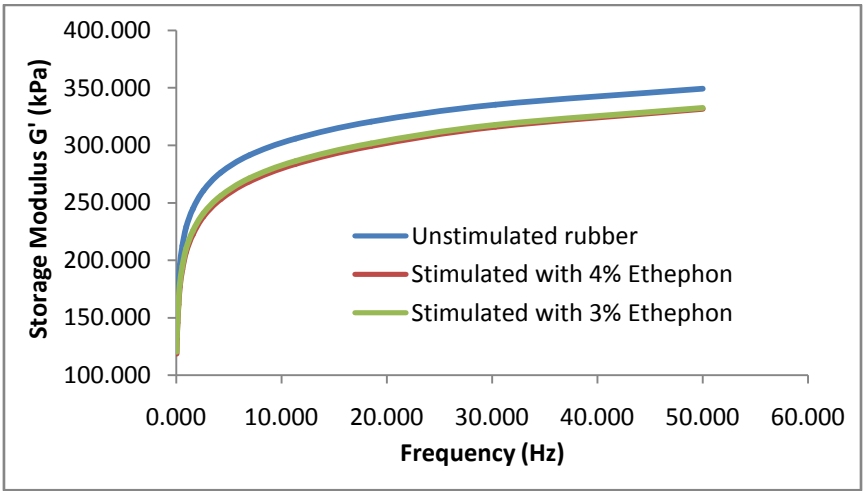


Fig. 1. Variation of storage modules with frequency

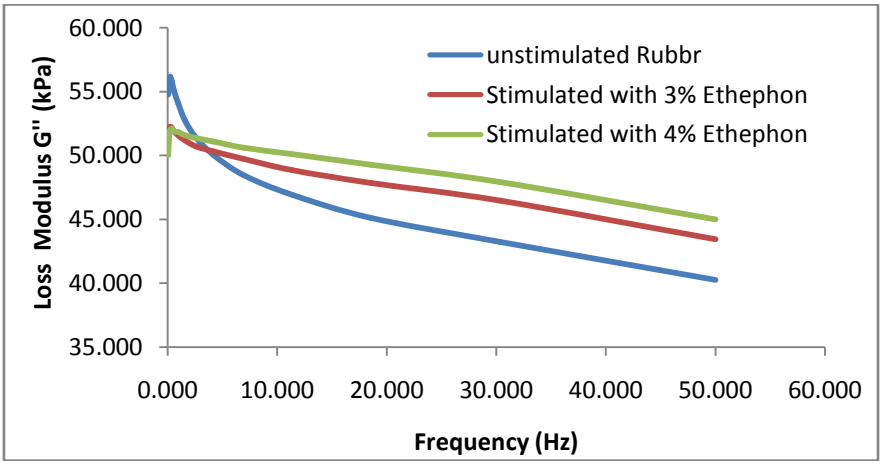


Fig. 2. Variation of Loss modules with frequency

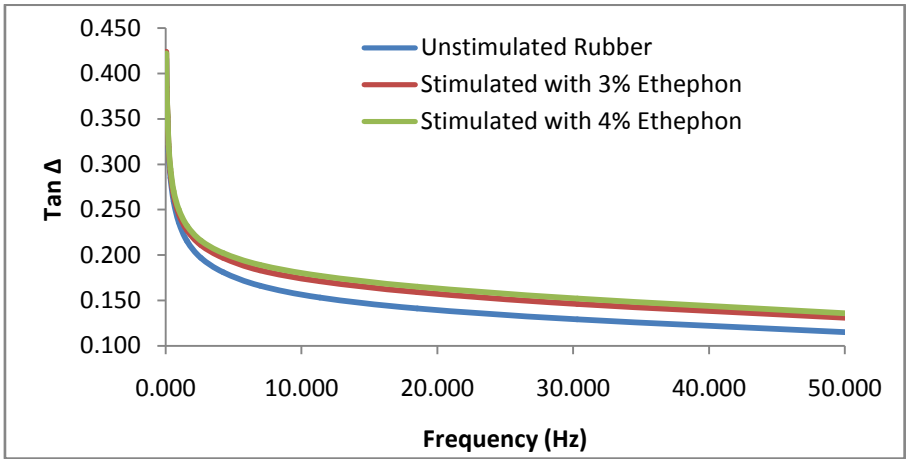


Fig. 3. Variation of Tan Δ value with frequency

The frequency sweep test data shows clearly that the control sample shows higher modulus compare of the ethephon applied samples, which signifies that the molecular architect are different (Fig. 1 & 2). The tan delta trend of frequency sweep data shows that the relaxations pattern of the lower molecular fraction of ethephon applied samples are different than the control sample (Fig. 3).

The strain sweep test results (LAOS test) prove that all the test polymers are linear in nature with no branching effect as it is observed from the calculated LCB index and the Lissajous diagram from the above observations, it is clear that control sample has a higher molecular weight and different relaxation behavior, therefore the Mooney value ML (1+4) of control is higher than ethephon applied samples (A P Attanayake, C Lokuge and L P Vitharana).

Establishment of new test method for the determination of dirt content

Oil based bleaching agent used as the peptizer for the recently used method for the determination of dirt content. However due to toxicity of above chemical, a new method was adopted by using copper oleate as the peptizer. There was no significant difference in results between two test methods (A P Attanayake and L P Vitharana).

Method development for the determination of poly-isoprene content in raw rubber by using FT-IR pectroscopic data

The determination of poly-isoprene content in natural rubber is an important test for rubber industry and the researchers since it is the polymer component in natural rubber. The ISO 5945-1982 test method was used for this test until the year

2015. Here, highly carcinogenic chromium trioxide is used as the oxidizer with concentrated sulfuric acid to digest poly-isoprene in raw rubbers. Considering the health effect with the formation of many hazardous fumes now it is temporary stopped to determine using that method until finding a proper alternative for those hazardous chemicals. Therefore determination of poly-isoprene by using a spectroscopic method is very useful and suitable as it is a hazard free technique. Then few research trials were conducted using FT-IR spectrometer (Thermo-Nicolet-600). It is expected to do more trials to establish a test method for poly-isoprene content in raw rubbers (A M K S P Adhikari and A P Attanayake).

Investigation of latex and raw rubber properties of 2000 series clones

There are few newly recommended clones developed by the Genetics and plant breeding department. However, most of the raw rubber and latex properties were not yet being investigated. Therefore, as it is a very important requirement for the determination of latex and raw rubber properties of those newly recommended clones the department started to test and analyze those properties of RRISL-2000 series clones as an ongoing project. In this regard seven clones were selected in the Clyde Estate for testings. Few trials were conducted successfully and expected to complete in the next year (A M K S P Adhikari, A P Attanayake, H V K Gamage, L P P Vitharana, C S Lokuge, D M S Wijesekara and S P Wijewardena).

Investigation of green strength of some selected clones

Green strength is one of the most important parameter of natural rubber latex and it is recorded that the natural rubber has high green strength than synthetic rubbers. Therefore, in general natural rubber has high tensile and tare properties. In this research it is expected to investigate green strength of RRISL 200 series clones. At the first stage 3 clones with the control were studied. Three trials were conducted for each clone (Table 2).

Table 2. *Green strength of selected clones*

Clone	Avg. green strength (MPa)
RRISL 121 (Control)	2.01
RRISL 208	0.92
RRISL 216	1.91
RRISL 219	1.01

(A M K S P Adhikari, A P Attanayake and C S Lokuge)

Analytical service

Samples tested during the year were as follows.

Miscellaneous analysis	No. of samples
Raw rubber samples	401
Latex sample	279
Chemical sample	31
Bleaching agent samples	32
Testing certificates	386

RAW RUBBER PROCESS DEVELOPMENT AND CHEMICAL ENGINEERING

S Siriwardena

DETAILED REVIEW

Staff

Mr Y C Y Sudusinghe assumed duties as a Research Officer at the department with effect from 9th May, 2016. Messrs Chandrika Nalini, U M S Priyanka, A K D Warnajith Prasad, C Rohanadepa, Experimental Officers were on duty throughout the year. Mrs A R Melani de Alwis, Management Assistant was also on duty throughout the year.

Dr U N Rathnayake, Head of the Department resigned from the Institute on 23rd February, 2016 after serving 20 years at the department. Messrs Shehan Ghouse, Bimani Kannangara and B A D Balasuriya who were recruited to the Department as Technical Officers in 2015 resigned with effect from 11th March, 15th September and 28th July 2016 respectively.

Research students

MSc students

- Mr B A D M Balasooriya, a MSc student of University of Sri Jayewardenepura, completed his research project titled "Mechanical properties and processability of skim rubber/polyethylene blends" under the supervision of Dr Susantha Siriwardena

- Mr S D R P Samarasinghe, MSc (Polymer Science & Technology) student from the University of Sri Jayawardenepura carried out the experimental work of his research project on "Preparation of liquid natural rubber using micro-irradiation and performance evaluation as a curative tackyfiers in tyre industry" under the supervision of Dr Susantha Siriwardena

Achievements

- The project led by Dr Upul Rathnayake collaboratively with Rubber Technology and Development department and "Ranaviru Sevena" Army Rehabilitation Center on the development of a novel prosthetic foot with high performance and a light weight using a hybrid nanomaterial filled natural rubber composites was awarded National Science Award, 2016 organized by National Science Foundation.

Lectures/Seminars/Meetings and Workshops

Officer/s	Subject	Organization
S Siriwardena	Induction course for planter trainees	National Institute of Plantation Management
	MSc Lectures on Rubber Chemistry	University of Sri Jayewardenepura
	Diploma in Polymer Technology - Raw rubber manufacture	Plastics and Rubber Institute of Sri Lanka
	Graduateship in Polymer Technology-polymer chemistry and natural rubber for rubber product manufacture	Plastics and Rubber Institute of Sri Lanka
	SRILANKAPLAST & RUBEXPO 2016 - Seminars and CEO Forum	Plastics & Rubber Institute of Sri Lanka and Enterprising Fairs India Pvt. Ltd.
	Scientific Committee Meetings	Rubber Research Institute of Sri Lanka
	Estate Committee Meeting	Rubber Research Institute of Sri Lanka
	Research Review Meeting	Rubber Research Institute of Sri Lanka
	Progress Review Meetings	Ministry of Plantation Industries
	Smallholder Tea and Rubber revitalization project stakeholder workshop	Ministry of Plantation Industries
	Rubber Master Plan Implementation Meeting	Ministry of Plantation Industries
	Annual General Meeting	Plastics & Rubber Institute of Sri Lanka
	Consultative Committee Meeting on Greener procurement	Ministry of Mahaveli Development & Environment (MMDE)
	Workshop on “Statistical designing and analyzing” conducted by Prof. Thattil and Dr. L. Suriyagoda	Rubber Research Institute of Sri Lanka and University of Peradeniya
	Workshop on “Coping mechanism for low rubber prices”	Rubber Research Institute of Sri Lanka & IRRDB
S Siriwardena YCY Sudusingha	National Diploma in Plantation Extension Management	National Institute of Plantation Management
	6th Crop Symposium	Crop Research Institutes

Officer/s	Subject	Organization
YCY Sudusinghe	Laboratory Quality Management	Measurement Unit, Standard and Service Department, Diyagama
	Certificate course in Rubber Technology and Plastic technology - Monomers for Raw rubber manufacture	Plastics and Rubber Institute
	Scientific writing workshop	Rubber Research Institute
	Training on statistical design and analysis	Rubber Research Institute
YCY Sudusinghe and UMS Priyanka	Seminar on water quality and human health	Institute of Chemistry
UMS Priyanka	Workshop on writing winning research proposal	Sri Lanka SLIDA, conducted by ISF
AKD Warnajith	Five workshop on "Manufacture of sheet rubber and single day smoke drying system"	Thurusaviya Fund
Staff of the department	Technology Update - Current research projects and future focus	Research & Technical staff of RRISL
	Training program on "Raw rubber processing" for Rubber Development Officers	Rubber Development Department
	Field training program on Raw rubber manufacture	BSc (Palm & Latex Technology & Value Addition) undergraduates of the Uwa Wellassa University
	Three training program on sheet rubber manufacture and drying systems	Smallholder Plantation Entrepreneurship Development Programme (SPEnDP)

Invited lectures

Dr Susantha Siriwardena delivered a lecture on "Present scenario and Economic significance of rubber plantation sector at the induction course for Planter Trainees – 2016 conducted by, National Institute of Plantation Management.

Services

Technical support, testing services and 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 continued to provide to Thurusavia annual programs by extending of the services of resource personal and technical expert panels for evaluating quotations, issuing smoke house plans, inspection of construction and operation activities of sheet rubber processing centers and single day smoke drying units.

Collection of waste water samples from raw rubber processing and allied industries and analysis of waste water parameters were carried out throughout the year.

Special training

Mr A K D Warnajith, an Experimental Officer participated in a foreign training program jointly organized by IFAD and Thailand Rubber Authority on "Raw rubber manufacture in non-traditional areas in Thailand from 20th-29th November, 2016.

Advisory visits

Services provided	No. of factories/visits
Process and quality improvements	06
Waste water treatment	03
Waste water sample collection for testing	69
Plans issued for construction of new SS drying systems with capacity less than 100 kg	10
Miscellaneous advisory and troubleshooting visits	08

Sample testing and certificates issued

Samples tested	Number of Samples/certificates
Waste water - rubber related	76/62
Waste water - non rubber related	31/23
Processing water	10/06
Miscellaneous samples (metal ions, ZnO, *etc*.)	47/22
Analysis of extractable proteins	20/6
No of "certificates of epidemic prevention" issued for sole crepe	24

LABORATORY AND FIELD INVESTIGATIONS

RRPD-01-d: Natural rubber latex sludge as filler for rubber compounds

A physical process was developed in the previous year to improve the filler properties of the sludge which is generated as a byproduct during the centrifuged latex manufacture. However, it was found that these filler particles still have tendency to agglomerate because of their high surface energy. It is known that advantage offered by the use of filler can be obtained only if these particles distributed evenly in the polymer matrix without agglomeration. Therefore, in an attempt to further improve the filler dispersion of the physically processed sludge, fillers surface was modified through a chemical treatment process using three surface active modifires namely stearic acid, Triethoxy Vinyl Silain (TEVS) and zinc stearate. They were coated to the filler surface. Processed sludge with particle size less than <25µm was subjected to surface modification. NR/Surface modified sludge composites with 60 phr filler loading were prepared. The processing safety and the tensile properties of these three composites were studied. It was found that processing safety of the stearic acid coated sludge containing compound is better than other two treatments (Fig. 1). This may be due to de- acceleration of sulphur vulcanization by acids.

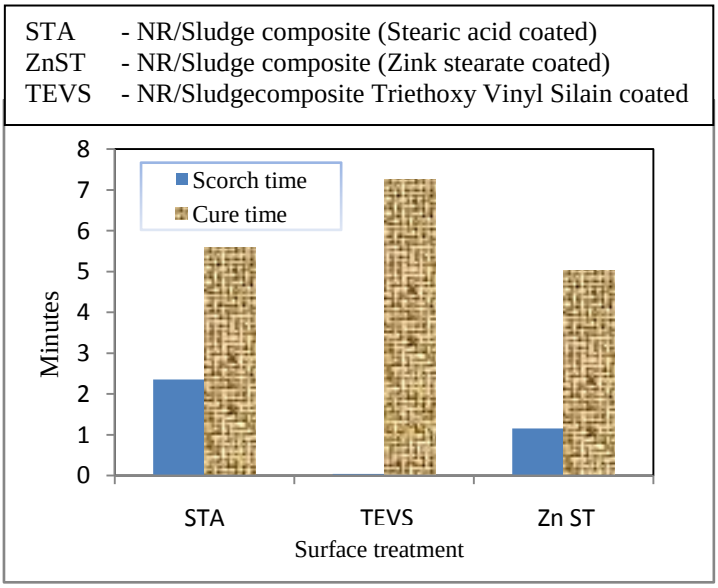


Fig. 1. Scorch time and cure time t90 of sludge filled Natural rubber compounds

Figures 2, 3 and 4 shows tensile properties of different composite treated with different coating treatments. Tensile strength of stearic acid coated sludge containing

compound showed the highest tensile strength (Fig. 2). This inferred that better dispersion of sludge and reduction in agglomeration of filler particles have been achieved in dispersion of the stearic acid coated sludge in NR matrix. Highest elongation at break also obtained for the stearic acid coated sludge containing compound (Fig. 3) which may be due to presence of excess stearic acid in the filler leading to slippage of polymer chains leading to increase of elongation at brake.

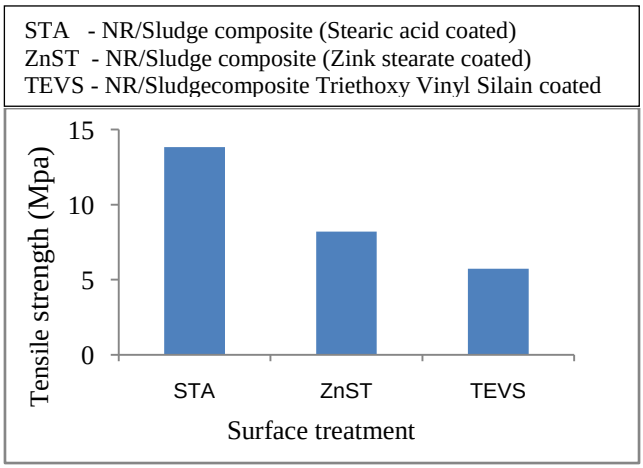


Fig. 2. Tensile strength of sludge filled Natural rubber compounds

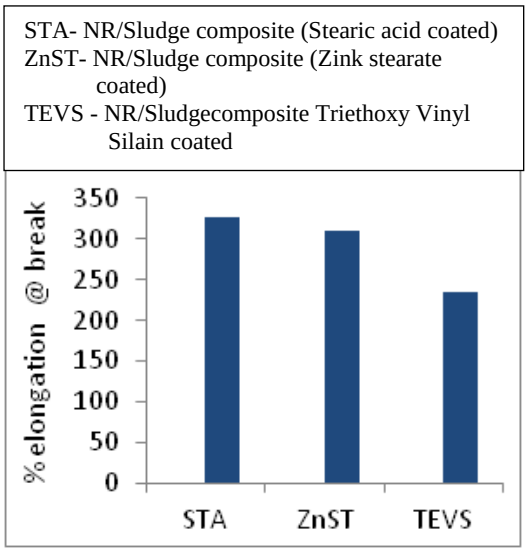


Fig. 3. Elongation at brake of sludge filled NR composites

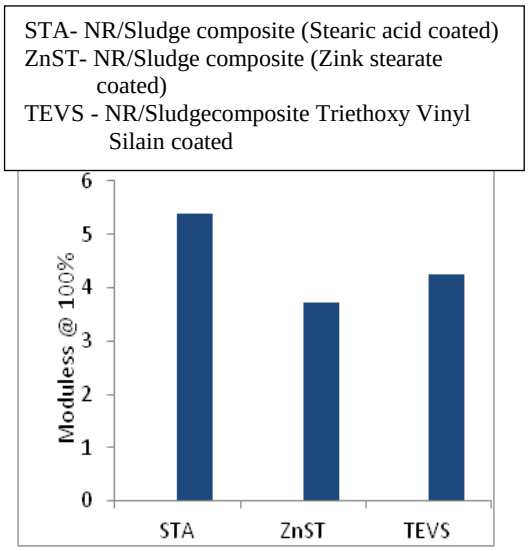


Fig. 4. Modules @ 100% of sludge filled NR filled NR composites

Stearic acid coated NR composites exhibited higher Modules (M100) (Fig. 4) than other two composites showing the advantage of stearic acid treatment than the other two treatments used. As M100 is related to filler–rubber interaction and dispersion of filler in elastomer, it could be inferred that the presence of stearic acid on the surface of the filler may probably influence to increase the modules by increasing the reinforcement effect of the filler. Figure 5 (a-c) shows the effects of chemical treatments on the hardness, resilience and compression set of sludge incorporated NR composites. According to Figure 5(a) Zn stearate coated sludge containing NR/Sludge composite showed highest hardness value. However, Stearic acid coated sludge containing compound showed better mechanical properties such as rebound resilience and compression set when compared to the sludge modified by other surface modifiers.

When overall performance is considered, it could be deduced that stearic acid could be the most suitable surface modifier for modification of natural rubber sludge to be used in NR composites.

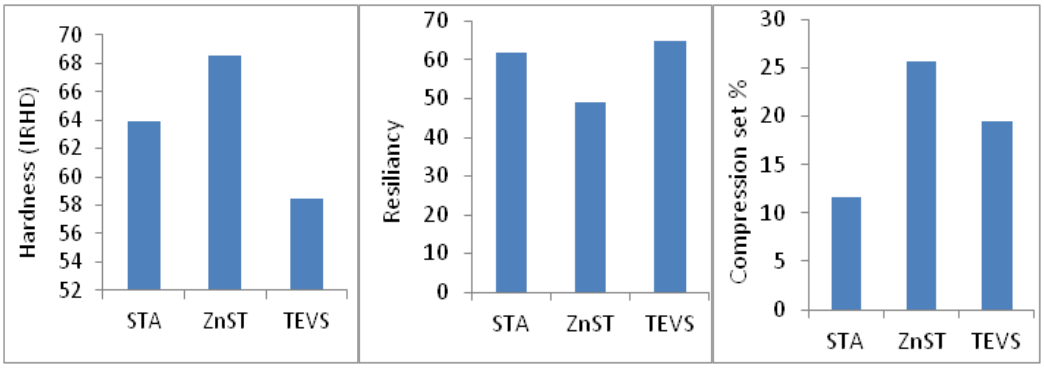


Fig. 5. Mechanical properties of modified sludge treated NR composites

RRPD-05 (d): Mechanical properties and processability of skim rubber (SKCL)/Polyethylene (PE) thermoplastic elastomers

Skim rubber crepe laces (SKCL) - a by-product manufactured at the centrifuged latex manufacturing factories through acid coagulation of skim latex was melt blended with Polyethylne at 1:1 ratio at 140ºC. The same skim rubber was blended Sri Lanka Standard Rubber 20 (SLR 20) at the identical conditions. Both blends were dynamically vulcanized at different sulphur concentration. Recipes used were shown in Table 1.

Table 1. *Compounding formulations used to prepare the TPEs*

PE	**50**	**50**	**50**	**50**	**50**
NR (SLR 20 or SKLC)	50	50	50	50	50
Zinc oxide (phr)	2.5	2.5	2.5	2.5	2.5
Stearic acid (phr)	1	1	1	1	1
CBS (phr)	1	1	1	1	1
TMTD (phr)	1.25	1.25	1.25	1.25	1.25
IPPD (phr)	0.75	0.75	0.75	0.75	0.75
Sulphur (phr)	0.0	0.25	0.5	0.75	1.0

Hardness of the SKCL/PE blends and SLR/PE blends cured at different sulphur levels is shown in Figure 6. Hardness values exhibit almost similar values for all the blends. It was seen that cross-linking agent concentration has no significant effect on hardness of these blends. In rubber/plastic blends, hardness may be mainly governed by the properties of the continuous phase. In these blends, rubber: plastic ratio is fixed and vulcanized rubber particles may be dispersed in a continuous PE phase. However, it could be observed that SKLC/PE blends exhibit slightly higher hardness than that of the SLR20/PE blends. Skim rubber is rich with higher protein content which is responsible for the higher hardness of the skim rubber compared to other natural rubber types. Therefore, this slight increase of the hardness reflects the minor effect of the rubber phase in rubber/PE blends.

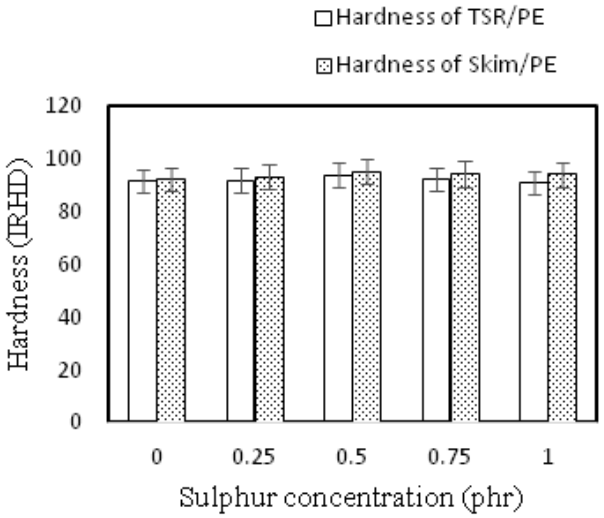


Fig. 6. The effect of sulphur concentration on the hardness of skim/PE and SLR/PE

The degree of swelling of the both types of blends at different sulphur concentrations is shown in Figure 7. The gradual decrease in swelling index with increasing curing agent content reflects the resistance exerted by the crosslinks on the penetration of the solvent molecules. It provides evidence of the dynamic vulcanization of the rubber phases. This implies that both rubber types have shown the similar vulcanization characteristics despite the presence of higher protein content and metal ion in the skim rubber phase. However, skim/PE blends have lower swelling indices values than SLR/PE blends. This difference may be either due to higher crosslinked density, or the incompatibilization non-polar solvent molecules due to enhanced polar nature of the skim phase or the lower content of actual rubber present in the skim rubber phase than the rubber phase in SLR/PE blends. Fig. 8 shows the oil absorbance decreases with the increase in sulphur concentration. As explained earlier, formation of cross-links in the rubber phase has created a resistance to penetrate the oil molecules too. It can also be observed that skim/PE blends shows the lower oil absorbance than its control (SLR/PE). The solvent used is ASTM no 3 and it is a non-polar fluid whereas skim is a material with relatively high content of polar materials than the SLR. Therefore, SLR and the oil used are become more "like dissolve like" materials and show the high oil absorbance *i.e*. less oil resistance.

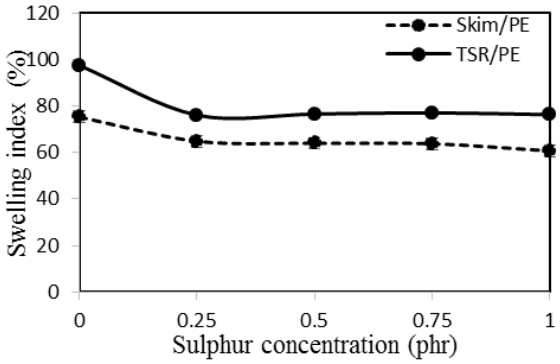


Fig. 7. The effect of sulphur concentration on the swelling index of skim/PE and TSR/PE blends

The tensile strength of both blend series before and after ageing are presented in Figures 9 and 10 respectively. It could be clearly seen that as the sulphur concentration increases, the tensile strength of the blends increase up to 0.25 phr and thereafter, no significant increase was achieved for skim/PE blends. The initial increase in the tensile strength is attributed to the vulcanization of the rubber phase on the blend. However, tensile strength values after ageing show a drop in the skim/PE blends while SLR/PE blends show an improvement. Thermal degradation of the

rubber phase taken place during the ageing may be responsible for this drop of tensile properties in skim/PE blends. Improvement in tensile strength in SLR/PE blends may be attributed to the effect of post curing. This suggests that thermal degradation is overshadow the possible post curing in skim phases during the ageing whereas post curing is predominant than thermal degradation in SLR. For SLR/PE blends, lower tensile values are exhibited in comparison to skim/PE blends. As evidenced by the morphological studies SLR particles were found to be larger than skim rubber particles in the blend. Therefore, it could be argued that physical interfacial interaction intensity between rubber and PE phases is poorer in SLR/PE blends causing inferior tensile strength in these blends.

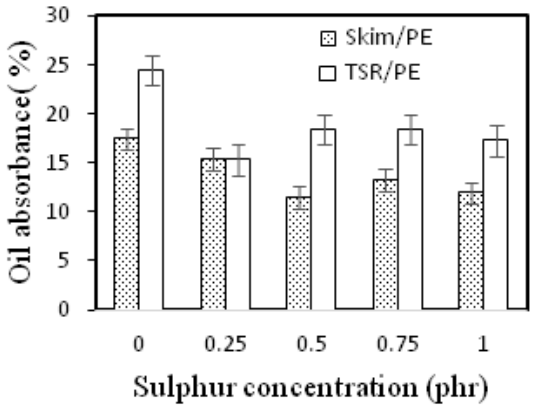


Fig. 8. The effect of sulphur concentration on the oil absorbance of skim/PE and TSR/PE

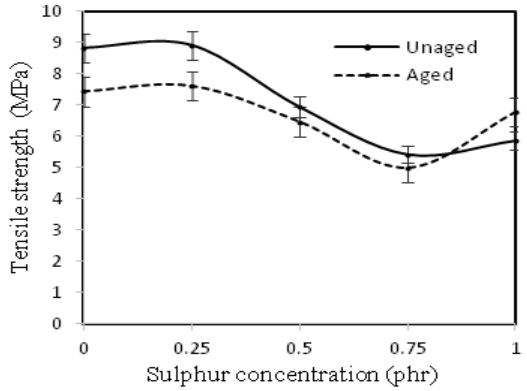


Fig. 9. Tensile strength of skim/PE (50/50) blends dynamically vulcanized at different sulphur concentrations

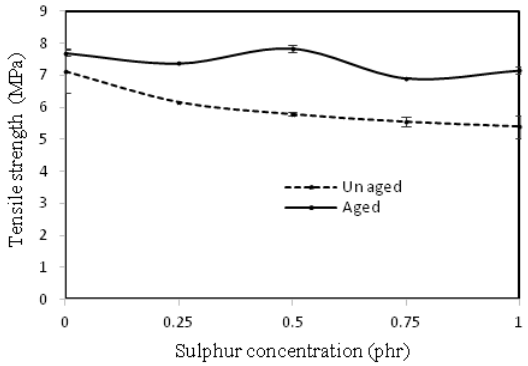


Fig. 10. Tensile strength of SLR/PE (50/50) blends dynamically vulcanized at different sulphur concentrations

Skim/PE (50/50) blends cured with sulphur were reprocessed to study the processability and the properties of the blends prepared by the reprocessed materials. In order to study the re-proceesability, the residues of the test specimens used for tensile tests and scraps of blends were reprocessed for seven minutes at the same temperature and the rotor speed used for melt mixing, however, without addition any other ingredients. Figure 11 and 12 represent thetorque development patterns of skim/PE and SLR/PE blends respectively.

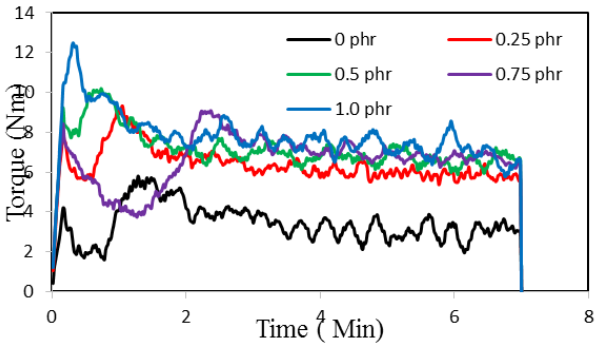


Fig. 11. Torque development during reprocessing for skim/PE blends at different sulphur levels

As soon as the rotors were started, a sudden rise of the torque was observed due to the high resistance exerted on the rotors against their rotation by the cold material. However, as the material attains the mixing temperature, the viscosity of the material reduces and a lower torque value is registered within 2-3 minutes. This

torque is then remains stable for another five minutes without a drop. This clearly shows that all unvulcanised and vulcanised blends of skim/PE, TSR/PE blends could be reprocessed to yield a polymer melt. While showing the similar reprocesable characteristics of skim/PE blends similar to TSR/PE blends, this study shows the reprocessability of skim/PE (50/50) blends similar to plastic materials. Skim rubber is a well known material prone to thermal degradation than the other grades of natural rubbers. However, skim rubber did not show a uncommon degradation in the blend during the recycling process at 140^0C. This observation suggests possible protection provided to skim phase by the continuous PE phase which may act as the main stress and heat absorbance medium during the recycling.

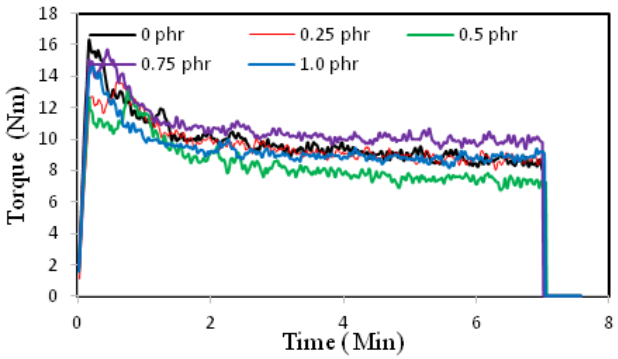


Fig. 12. Torque development during reprocessing for SLR/PE blends at different

Different loading of EPDM was introduced skim/PE blend cured at 0.25 ph sulphur in order to evaluate the performance of EPDM as a compatibilizer for these blends. It was found that EPDM was an effective comaptibilizer for skim/PE blends. The effect of EPDM loading level on mechanical properties of the blends was evaluated. They are presented in Figures 13-16. Hardness values of skim/PE blends with different EPDM content is show that there is no significant effect on the EPDM content on the hardness of the blends. EPDM is added to the blend, while keeping the rubber: PE ratio constant and therefore, PE remains as the continuous phase. The hardness of the material is predominantly governed by the continuous phase of the blend. Therefore, it could be inferred that addition of EPDM up to 20% has not resulted in phase inversion of the blend.

Figure 14 shows tensile strength of skim/PE blends compatibilized with different EPDM levels. The results indicate that tensile strength of the blends increase gradually up to addition of 10% EPDM and beyond which, there is no significant improvement in the tensile properties. Therefore, it could be inferred that two phases have become more compatible when EPDM is introduced to the skim/PE phase. As

the EPDM content increase, it dilutes the plastic phase resulting in possible reduction in the tensile strength. It is also revealed that despite the presence of higher amounts of polar materials such as proteins in the skim rubber, it has not shown any noticeable influence on the compatibilizing effect of EPDM between the skim phase and PE phase. Therefore, it could be concluded 10% of EPDM as the optimum EPDM content for compatibilization of skim rubber/PE blends under the used processing conditions. Therefore, 10% of EPDM content could be considered as the optimum EPDM content for 50/50 skim/PE blends dynamically vulcanized with sulphur at 0.25 phr. The elongation at break for the dynamically vulcanized skim/PE blends increases with the increasing EPDM contents (Fig. 15). It could also be seen that the rate of increase in elongation level off at 10% EPDM content. All the blends studied were dynamically vulcanized with sulphur at 0.25phr. Therefore, the level of crosslink density of all the samples could be considered as equal. However, as the EPDM content increases, percentage of extendable material and the softening effect are increased. As a result, gradual increase of elongation at break with increasing EPDM could be expected. The effect of EPDM content on modulus at 100% elongation of dynamically vulcanized skim/PE blends with sulphur at 0.25 phr is shown in Figure 16. As the EPDM content increases as the third component, it results in lowering the overall crystallinity. Consequently, modulus at 100% decreases with the increasing EPDM content. Based on the overall results, the optimum EPDM content for the skim/PE blends under the processing conditions used in this work was found to be 10%.

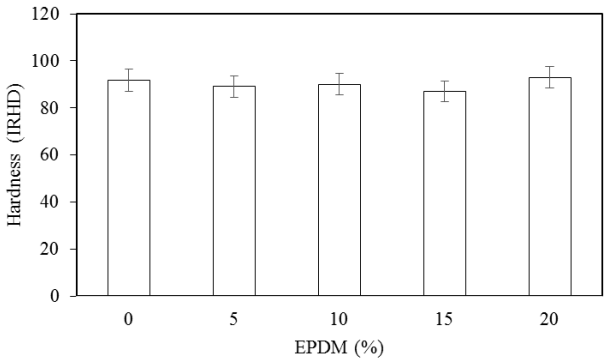


Fig. 13. Hardness of skim/ PE blends with different EPDM levels

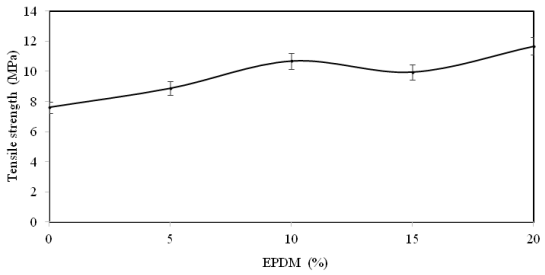


Fig. 14. Tensile strength of dynamically vulcanized (0.25 phr) 50/50 skim/PE blends compatibilized with different EPDM levels

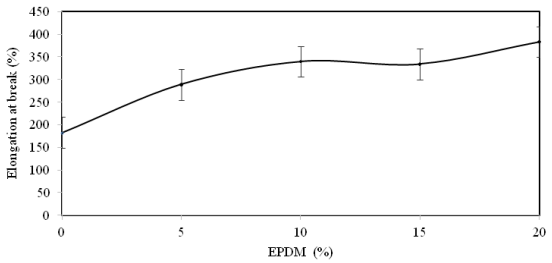


Fig. 15. Elongation at break of dynamically vulcanized Skim/PE blends with different EPDM levels

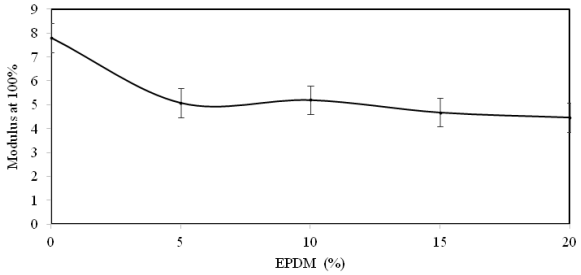


Fig. 16. Effect of EPDM content on modulus at 100% elongation of dynamically vulcanized skim/PE blends with sulphur at 0.25 phr

RRPD-05 (E): Physico Mechanical Properties of Linear Low Density Polyethylene (LLDPE) and Un-fractioned and Unbleached Crepe Rubber (UFUB) Blends

The project was carried out to evaluate the mechanical properties of polymer blends based on Low Density Polyethylene (LLDPE) and Un-fractioned and Unbleached Crepe Rubber (UFUB) in comparison with LLDPE and Standard Lanka Rubber (SLR) blends. The other objectives of the study were to evaluate onset

vulcanization times of the LLDPE/UFUB melt mixed blends with different Sulphur concentrations, to study of processing behaviour of the blends by studying stabilization torque development during mixing and compare processing characteristics of the two blends. The both blends were prepared using melt blending process. Rubber phase was dynamically vulcanized at different suphur concentrations. The recopies used were shown in Table 2.

Table 2. *Recipe used for preparation of LLDPE/UFUB and LLDPE/SLR(10) blends*

Ingredient	**Amount (phr)**
Natural Rubber (SLR or UFUB)	50
Plastic (LLDPE)	50
ZnO	2.5
Stearic acid	1.0
IPPD	0.75
TMTD	1.25
CBS	1.0
Sulphur	(0.0to1.0)

The results showed LLDPE/UFUB blends could be prepared through melt mixing similar to LLDPE/SLR blends (Figs. 17a and b). The onset vulcanization times of both blends decrease with the increase of sulphur concentration. LLDPE/UFUB blends show lower onset vulcanization times than the other blend systems at each sulphur concentration (Fig. 18). Figure 19 shows that hardness values of the blends did not show a significant difference in their hardness properties at each sulphur concentration. The tensile strength and elongation at break percentage of the LLDPE/UFUB blends registered higher values than that of LLDPE/SLR blends as it could be seen in Figure 20 and 21 respectively. However, it was also noted that resistance to aging of LLDPE/UFUB blends lower than that of the LLDPE/SLR blends (Fig. 22). This study concluded that the both blends exhibit the same processing characteristics while LLDPE/UFUB blend has the higher cure rate and tensile properties.

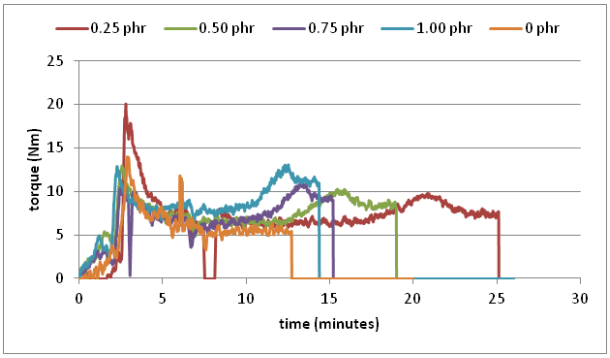


Fig. 17 (a). Torque development in different UFUB/LLDPE blends with different sulphur concentrations

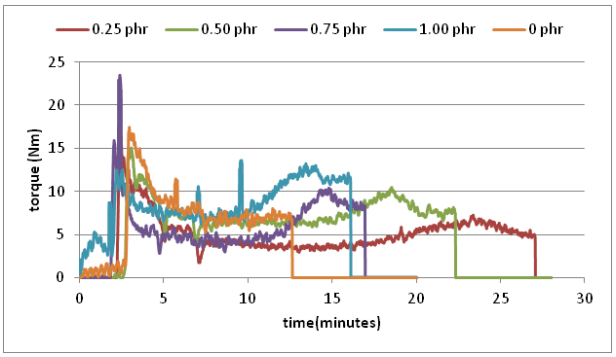


Fig. 17 (b). Torque development in different LLDPE/TSR blends with different sulphur concentrations

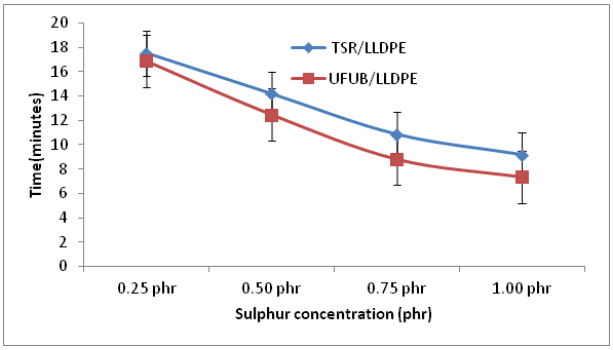


Fig. 18. Onset vulcanization time of the blends with different sulphur concentrations

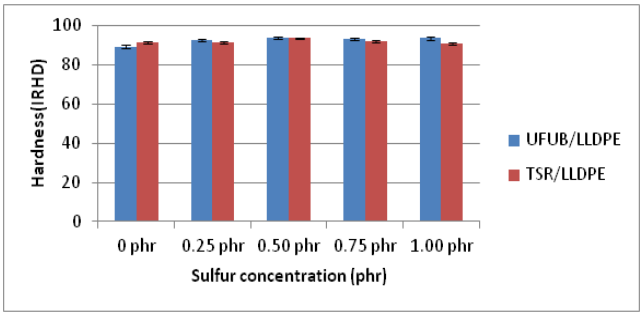


Fig. 19. Variation of hardness of the blends with different sulphur concentrations

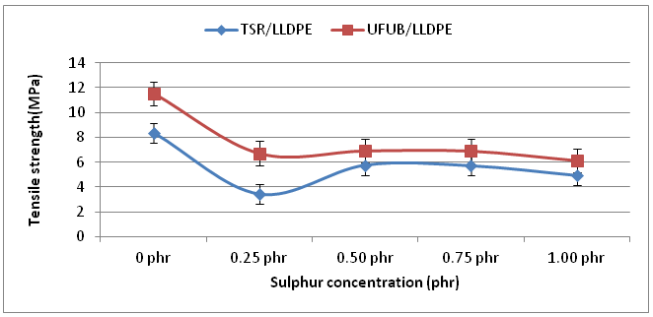


Fig. 20. Variation of unaged tensile strength of the blends with different sulphur concentrations

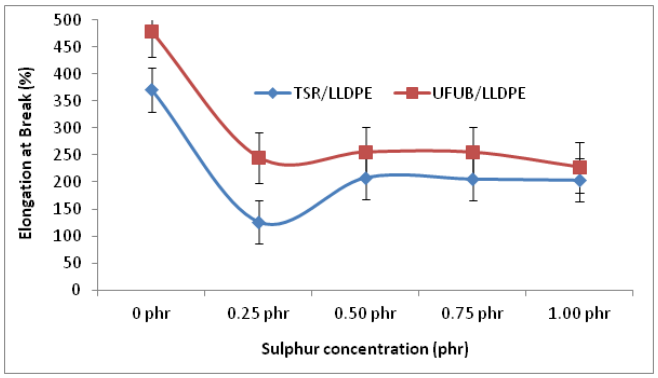


Fig. 21. Variation of elongation at break of the blends with different Sulphur concentrations

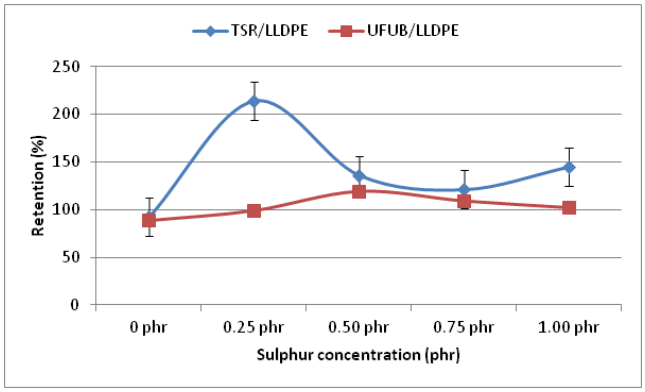


Fig. 22. Retention % of tensile strength of the blends with different sulphur concentrations

ADAPTIVE RESEARCH

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.

Seminars/Training/Workshops/Exhibitions conducted

Officer/s	Subject/Theme	Beneficiary/Client
SMM Iqbal	Rubber cultivation in Non-traditional areas and adaptive research	Lalan Rubber – Latex supplier training
	- do -	School of Agriculture/Bibile
		Rubber smallholdings
	National Agricultural Exhibition - Ampara	National Institute of Plantation Management (NIPM)
	Rubber cultivation in Non traditional areas - Induction Course for planter Trainees	Rubber Development Officers of RDD and smallholders in Monaragala and Ampara districts

Seminars/Training/Workshops/Meetings/Conferences attended

Officer/s	Subject/Theme	Organization
SMM Iqbal	Consultative Committee Meetings on Rubber cultivation in non traditional area	Rubber Research Board (RRB)
	Presentation of a research paper titled "Growth performance of young rubber (*Hevea brasiliensis*) in the Dry Zone of Sri Lanka; an investigation in Vavuniya district"	Sixth Symposium on Plantation Crop Research, Sri Lanka
	District Agriculture Progress Meeting	District Secretariat Kilinochchi

Officer/s	Subject/Theme	Organization
ES Munasinghe	Seminar on crop diversification	Council for Agricultural Research Policy (CARP)
	International Rubber Conference, Cambodia	International Rubber Research & Development Board (IRRDB)
	Programme Advisory Committee Agriculture	Higher National Diploma in Technology (HNDT) (Agriculture)
SMM Iqbal, ES Munasinghe, BMDC Balasooriya	Organizational Results Framework	MPI
	Plantation Crop Symposium	CRI, TRI, RRI & SRI
	Workshop on coping mechanism for low rubber price	IRRDB & RRI

Research students

- A M D H Abayakone, an undergraduate student Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, carried out his final year research project on 'Biomass Production and Carbon Sequestration in New Genotypes of *Hevea brasiliensis*' under the supervision of Dr (Mrs) E S Munasinghe.

Visits

Experimental visits	87
Advisory visits	10

FIELD INVESTIGATIONS

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.

- As per the decision of progress review meeting at Ampara, a new hand bill (in Sinhala) was prepared and distributed at RDD extension programme, Exhibition at Polannaruwa and Ampara. The title of the hand bill was "සැමට සෙත සලසන නැගෙනහිර m%දේශයේ රබර් වගාව"
- A planting demonstration according to the refined techniques was exhibited at the National Agricultural Exhibition at Ampara.

- Assessments on socioeconomic impacts of rubber cultivation
  The study was initiated to investigate how best rubber can contribute to stabilize the rural community by improving the socioeconomics of livelihood in rubber growing communities of Padiyathalawa DS division. Thirty smallholdings at harvesting (having mature rubber fields) were selected and interviewed for information collection on changes in five livelihood capital assets in consequence with rubber cultivation.
- Assessments on rubber yields
  In order to identify the yield potential and seasonal variation of yield at smallholder condition, daily yield records of farmers in Padiyathalawa DS division have been monitored throughout the year. Accordingly, average annual latex yield was recorded as 1280 kg/ha at early stage of harvesting and average number of tapping days was 121per year.

(S M M Iqbal, E S Munasinghe, V H L Rodrigo, 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, mature rubber, rubber/cinnamon intercrops and also of cashew plants were done. Latex collected from the mature rubber fields was processed to RSS and 33818 sheets with the weight of 12638kg were produced within the year (V H L Rodrigo, S M M Iqbal, P A Lakshman, B M D C Balasooriya, E S Munasinghe and P M M Jayathilake).

Adaptive research in Monaragala (ARU/01/c)

Rubber/Sugarcane intercrop

Details of this experiment were given in Annual Review 2009.

Girth (at 120 cm height) and total height of rubber trees were gathered (Table 1). Average girth and height declined with the delay in planting, two whorl plants performed better than one whorl plants.

Table 1. *Growth of rubber plants (7 years after planting)*

	Girth (cm) (at 120 cm height)		Total height (m)	
	one leaf whorl plants	two leaf whorl plants	one leaf whorl plants	two leaf whorl plants
Onset of rainy season	44.8	45.8	16.82	16.93
2 weeks after	44.4	45.5	16.60	16.58
4 weeks after	43.0	43.6	16.19	15.79
6 weeks after	42.4	42.9	16.08	15.92
8 weeks after	42.5	43.0	15.15	16.09
10 weeks after	37.5	40.3	14.32	15.53

Rubber/Banana intercrop

Details of this experiment were given in Annual Review 2011.

Girth (at 120 cm height) and total height of rubber trees were gathered (Table 2). Average girth and height declined with the delay in planting, two whorl plants performed better than one whorl plants.

Table 2. *Growth of rubber plants (5 years after planting)*

	Girth (cm) (at 120 cm height)		Total height (m)	
	One leaf whorl plants	Two leaf whorl plants	One leaf whorl plants	Two leaf whorl plants
Onset of rainy season	32.3	32.5	9.89	10.82
2 weeks after	31.9	32.0	9.56	10.31
4 weeks after	29.8	30.5	9.10	9.71
6 weeks after	28.9	29.2	8.90	9.42
8 weeks after	28.4	28.8	8.62	8.90
10 weeks after	25.8	26.9	8.28	8.65

(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)

- Performance of rubber in early stages of growth in the Dry Zone of Sri Lanka was investigated in Vavuniya District. Growth of rubber was measured continuously at approximately one year intervals in two sites planted in December 2010. In addition, five sites selected from subsequently planted years (three from 2011 and one from 2012 and 2013 plantings) were also used for the same growth measurement. The study showed that rubber cultivated in this region under smallholder conditions has a reasonable growth with an average annual girth

increment rate of 8.6cm. As the first record for the Dry Zone in the country, the growth curve for the immature phase of rubber was established. Despite some effects of dry weather on photosynthesis and associated physiological parameters, no evidence for permanent damages to photosynthetic apparatus was recorded.

- Rubber plants (clone RRIC 121, RRISL 203 and RRISL 2001) were established in two small holdings namely Skandapuram and Vishwamadu in Killinochchi District. The holding at Skandapuram was discontinued due to the farmers nelegence. The holding at Vishwamadu, Punnaineeravi is in progress. Rubber planting was done as paired row system to provide more space (60 feet spacing between paired rows) (Fig. 1 & 2). Fist application of fertilizer was done. Initial growth and physiological assessments were recorded by Plant Science Department (Data will be produced in the review of Plant Science department). First application of fertilizer and other agronomical practices were done according to the RRISL recommendation.

Fig. 1. Rubber intercropped with ground nuts

Fig. 2. Rubber trees nine months of planting

- Applications of fertilizer were done in all adaptive research trials
- Two field visits were carried out by the staff of adaptive research unit

(S M M Iqbal, V H L Rodrigo, 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)

Objectives and details were reported in the annual review of 2015. RRIC 100, RRIC 121 and PB 86 were the three clones known to most of the smallholder farmers. Few farmers are aware about RRISL 203 clone. Farmers who are engaged in full time farming in the areas where there are high rainy days tend to practice daily tapping during the dry period. This farmer group is more preferred to have PB 86 clone since

other clones are susceptible to tapping panel dryness when practicing daily tapping. Most of the farmers accept as RRIC 121 a good clone and some farmers experienced patch cancer problem in their fields where RRIC 121 was planted. In the areas where flooding is occurred, people are aware that RRIC 121 is susceptible to flooding condition prefer to cultivate seedling rubber although rubber subsidy is not applicable in this case (B M D C Balasooriya, E S Munasinghe, V H L Rodrigo S M M Iqbal and P M M Jayathilake).

Assessment of availability, demand and use of rubber fertilizer in Monaragala district(ARU/02/b)

Details of the study was reported in the annual review of 2015. Based on the market survey conducted in Monaragala district, it was found that Lakpohora and several other private companies are handling fertilizer market in the area. During mid-2015, rubber fertilizer was available in the area. According to the dealers in the area, at the end of the year, rubber fertilizer was not available since there was no demand for rubber fertilizer followed by low rubber prices prevailed in the market. The changes in the government policies at that time have also influenced the less availability of fertilizer in the market. During mid - 2016, rubber fertilizer was available in the area although there is no such demand for rubber fertilizer.

Sulphate of Ammonia (SA) based 7: 9: 9: 3 fertilizer mixture which is recommended for immature rubber clearings was available at the dealers of private agro chemical companies while urea based mixture (12: 14: 14) was available at Lakpohora agents. However, for mature clearings, urea based (18: 6: 24) mixture was available with all most all of the dealers in the area. The reason was fertilizer companies did not prepare SA based fertilizer mixture for mature rubber.

According to the smallholder survey, most of the farmers were aware about the type of fertilizer mixture that they used. Some farmers did not have idea about the fertilizer mixture and they used to buy what is available in the market as rubber fertilizer. Most of the time fertilizer application was limited to the immature period (B M D C Balasooriya, E S Munasinghe, V H L Rodrigo S M M Iqbal and P M M Jayathilake).

Possibility of shortening the lifespan of rubber under different productivity improvement scenarios *(ARU/02/c)*

The study was aimed to investigate how the land productivity of rubber would determine the lifespan of cultivated rubber under Sri Lankan conditions. Financial viability of rubber cultivation was analysed within the practically possible range of increasing land productivity and to examine the consequences of such effects on the decision of reducing the economic lifespan of the rubber tree. Lifecycle analyses were undertaken in this regard considering the two principal parameters of productivity improvement, *i.e.* increase in yield per tree and increase in effective

stand per hectare. Financial worthiness was tested using Net Present Value (NPV), Benefit Cost Ratio (BCR) and Internal Rate of Return (IRR).

Under general circumstance with intensified tapping during the last six years of lifespan, financial worthiness (NPV at 10% discount rate) of cultivating rubber was found to be LKR 0.16 Mn/ha with 30 year lifespan; however, the best lifespan was 20 years with the highest NPV of LKR 0.35 Mn/ha. Latex yield increase in terms of both yield per tree and tree stand, had no effect on the maintenance of the highest NPV at 20 years. However with increasing the tree yield by 5%, 10% and 15%, NPV at the best lifespan (20 years) increased to LKR 0.44 Mn, 0.53 Mn and 0.62 Mn/ha, respectively. Similarly with maintaining the greater number of trees (*i.e.* 10%, 20% and 40% increase from the present level), NPV with 20 year lifespan increased to LKR 0.81Mn, LKR 0.87Mn and LKR 0.99 Mn/ha, respectively. In the present low price situation, 20 year lifespan was identified as the best option with the increase in both yield per tree and tree stand for high level of profitability (*e.g.* the combined effect of 5% yield increase at tree level and 10% improvement in tree stand has increased NPV up to LKR 0.92 Mn/ha). Agronomic feasibility of increasing yield potentials of rubber plantations and social implications in shortening the lifespan of rubber trees are examined (E S Munasinghe and V H L Rodrigo).

BIOMETRY

Wasana Wijesuriya

DETAILED REVIEW

Staff

Dr (Mrs) Wasana Wijesuriya (Principal Research Officer) and Experimental Officers; Mrs Chintha Munasinghe and Mr Vidura Abeywardene were on duty throughout the year. Mrs W W L S Sashikala joined the Biometry section with effect from 15th August 2016 as a Management Assistant.

Seminars/Trainings/Workshops addressed/conducted

Mrs Wasana Wijesuriya conducted the following trainings.

Subject/Theme	Beneficiary/Client
Climate conditions, rainfall distribution in rubber growing areas and observation of meteorological data	National Institute of Plantation Management-Smallholder Plantation Entrepreneurship Development Programme (SPEnDP)

Seminars/Conferences/Meetings/Workshops attended

Mrs Wasana Wijesuriya attended the following Meetings/Conferences.

Subject/Theme	Organization
Stakeholder workshop to formulate National research priorities on Natural Resources Management	Sri Lanka Council for Agricultural Research Policy (SLCARP)
Progress Review Meetings	Ministry of Plantation Industries (MPI)
Scientific Committee Meetings of Rubber Research Institute of Sri Lanka (RRISL)	RRISL
NSF National Thematic Research Programme (NTRP) on food security	National Science Foundation (NSF)
World Meteorological day Policy level dialogue on potential integration of new climate change projections into development planning in Sri Lanka	Department of Meteorology (DoM)
International Conference on "Coping mechanism for low rubber price"	RRISL & International Rubber Research and Development Board (IRRDB)

Mrs Wasana Wijesuriya, Mrs Chintha Munasinghe and Mr Vidura Abeywardene attended the following conference:

Subject/Theme	Organization
7th Symposium on Plantation Crops Research	Coconut Research Institute

Seminars/Conferences/Workshops addressed

Mrs Wasana Wijesuriya addressed the following Seminars/Conferences/ Workshops.

Subject/Theme	Organization
Experiences & lessons learnt : 2015/16 North East Monsoon season (December 2015 to February 2016)	13th Monsoon forum, Department of Meteorology
Experiences & lessons learnt: 2016 Southwest Monsoon Season (May to September 2016) and Part of the 2nd Inter-Monsoon Season (October to mid-November 2016)	14th Monsoon forum, Department of Meteorology
Drought Indices to Identify Rainfall Anomalies in Rubber Growing Areas of Sri Lanka/ Sustainability of the NR Industry : Issues, Challenges & Opportunities	IRRDB International Rubber Conference, Siem Reap, Cambodia
Importance of Statistics in Agricultural & Industrial Research at the 10th Technology Update	RRISL

Research students

- Mr M W H Gayan has been involved on a research titled "Suitability of different drought indices under Sri Lankan conditions based on statistical considerations and practical use" for his MSc degree at the Faculty of Agriculture, University of Ruhuna under the guidance of Dr (Mrs) Wasana Wijesuriya

RESEARCH

Developments, modifications and applications of statistical techniques for the rubber sector

During the year under review, pertinent research material to produce guidelines for the following areas of statistics have been collected. The areas covered; a) Design and analysis of on-farm trials, b) Statistical process control and c) Multivariate statistical methods in relation to the research in the rubber sector. The objective of this activity is to familiarize the statistical techniques among the researchers and to encourage use of these methods in the proper manner.

Research on climate change and variability

Comparing drought indices

The Standardized Precipitation Index (SPI) and Standardized Precipitation and Evapotranspiration Index (SPEI) which are popular drought indices in today's context were compared in this study. SPI need only rainfall data and SPEI, in addition

requires temperature data to estimate Evapotranspiration in a particular location. This study compared SPI and SPEI in the Wet, Intermediate and Dry Zones of Sri Lanka employing data from 1983 to 2015. Three stations each from Dry (Ampara, Iranamadu, Vavuniya), Intermediate (Badulla, Moneragala, Wellawaya) and Wet Zones (Galle, Ratnapura and Agalawatta) were selected for the study. The software provided by the National Drought Mitigation Centre was employed in generation of SPI and SPEI series.

The results of paired 't' test and Simple Linear Regression (SLR) between SPI and SPEI values for different scales in different locations are given in Table 1, 2 and 3 and were used to compare the results generated for SPI and SPEI. The results of paired 't' test were non-significant in all the locations for the scales; 3 and 6, which are the most relevant to agricultural crops.

According to the results of SLR, the departures from the 1:1 is the lowest in locations in Wet Zone, with b_o ranging from -0.002 to 0.009 and b_1 ranging from 0.942 to 0.964. Comparatively higher departures were observed in the locations of intermediate and Dry Zone (Table 1, 2 and 3). This suggests that SPI can be used instead of SPEI in the Wet Zone of Sri Lanka in quantifying rainfall anomalies. The closeness of SPI and SPEI which was measured by R^2 in the Wet Zone (0.925 to 0.968) and the intermediate zone (0.809 to 0.965) is high compared to that of the Dry Zone which reported R^2 values ranging from 0.678 to 0.884. Further studies are therefore needed to compare the drought categories represented by SPI and SPEI values in the locations of dry and intermediate zones to quantify the rate of misclassifications.

Table 1. *Results of linear regression and paired 't' test to compare SPI and SPEI series of different scales in the Dry Zone*

Station	**Scale**	**Results of Simple Linear Regression**			**Results of paired 't' test**	
		b_0	**b_1**	**R^2**	**Mean diff. between SPEI and SPI**	**Test statistic 't' and probability***
Ampara	3	0.007	0.824	0.678	0.007	0.230 (0.820)
	6	0.008	0.817	0.697	0.008	0.270 (0.783)
Iranamadu	3	-0.011	0.932	0.819	-0.013	-0.600 (0.548)
	6	0.003	0.911	0.835	0.002	0.110 (0.909)
Vavuniya	3	0.006	0.889	0.814	0.006	0.270 (0.790)
	6	0.011	0.876	0.783	0.011	0.480 (0.634)

*In parentheses

Table 2. *Results of linear regression and paired 't' test to compare SPI and SPEI series of different scales in the intermediate zone*

Station	Scale	Results of Simple Linear Regression			Results of paired 't' test	
		b_0	b_1	R^2	Mean diff. between SPEI and SPI	Test statistic 't' and probability*
Badulla	3	0.009	0.968	0.965	0.009	0.920 (0.357)
	6	0.012	0.967	0.962	0.012	1.220 (0.221)
Moneragala	3	0.009	0.907	0.862	0.009	0.460 (0.648)
	6	0.008	0.897	0.843	0.008	0.390 (0.694)
Wellawaya	3	0.006	0.901	0.850	0.006	0.300 (0.766)
	6	0.001	0.904	0.855	0.001	0.060 (0.956)

*In parentheses

Table 3. *Results of linear regression and paired 't' test to compare SPI and SPEI series of different scales in the Wet Zone*

Station	Scale	Results of Simple Linear Regression			Results of paired 't' test	
		b_0	b_1	R^2	Mean diff. between SPEI and SPI	Test statistic 't' and probability*
Agalawatte	3	0.001	0.960	0.957	0.001	0.070 (0.946)
	6	0.002	0.964	0.968	0.002	0.260 (0.795)
Galle	3	0.007	0.963	0.968	0.007	0.810 (0.420)
	6	0.006	0.964	0.967	0.006	0.600 (0.549)
Ratnapura	3	0.001	0.954	0.954	0.001	0.070 (0.942)
	6	0.001	0.956	0.956	0.001	0.060 (0.950)

*In parentheses

Variations in 6-month SPI and SPEI values representing the planting season of rubber and subsequent immature period

There is a close agreement between 6-months SPI and SPEI series as depicted in Fig. 1, 2 and 3. These figures can also be used to identify changes in occurring extreme events and to detect any trends in series. There weren't any significant trends at the probability level of 0.05 for the SPI and SPEI series according to the Mann-Kendall analysis (Table 4) for any of the locations. Positive trends, although not significant were observed for the other stations in the intermediate zone which signified the low risk for establishment of rubber during October/November planting

season in the intermediate zone. Vavuniya, although in the Dry Zone has positive trends for SPI and SPEI, while other two locations reported non-significant negative trends. It seems that there is no risk of increasing the condition of droughts in rubber growing areas considered in the study. Yet, the situation in Ratnapura area (Fig. 3) with several drought years in the recent years should be considered and necessary remedial measures are needed for management of rubber plantations, especially soil and moisture conservation.

Table 4. *The results of Mann-Kendall test for 6-month SPI and SPEI series for different locations*

Station	Period considered	SPI		SPEI	
		Mann-Kendall test statistic (S)	Z approx.	Mann-Kendall test statistic (S)	Z approx.
Agalawatta	May - October	-3	-0.03	-40	-0.60
Galle	May - October	-27	-0.40	-50	-0.76
Ratnapura	May - October	-124	-1.91	-122	-1.87
Moneragala	October - March	65	1.04	34	0.54
Wellawaya	October - March	112	1.80	60	0.96
Badulla	October - March	80	1.28	78	1.25
Ampara	October - March	-62	-0.99	-84	-1.35
Iranamadu	October - March	-12	-0.18	-38	-0.60
Vavuniya	October - March	25	0.39	10	0.15

Identification of temporal trends in rainfall anomalies of different rainfall seasons in Sri Lanka using the Standardized Precipitation Index (SPI)

A total of 25 locations representing the Wet, Intermediate and Dry Zones of Sri Lanka were selected for the study (Table 5).

Table 5. *Locations selected for the study listed under respective Climatic Zone*

Wet Zone	Intermediate Zone	Dry Zone
Agalawatte	Badulla	Jaffna
Galle	Kurunegala	Akkarayankulam
Kegalle	Matara	Iranamadu
Colombo	Hambantota	Vavuniya
Ratnapura	Moneragala	Anuradhapura
Katunayaka	Wellawaya	Ampara
Katugastota		Puttlam
Matale		Okkampitiya
Nuwara-Eliya		Batticaloa
		Trincomalee

In this study SPI values were calculated for different time scales; *viz.* two, three and five month's scales and relevant months related to the four rainfall seasons were extracted for further analysis. Trend analysis was done by the non-parametric Mann- Kendall test to identify trends in rainfall anomalies determined by SPI values. This test is widely used for the analysis of trends in climatology. The significance of trends was determined by the approximated Z value (Zs) of the Mann Kendall (MK) test statistic.

The results of the trend analysis for the 1st Inter monsoon period are given in Table 6. During this period; significant increasing trends for SPI were observed in the Wet Zone in 3 out of 9 locations; in Kegalle, Katugastota and Nuwara-Eliya. In the Intermediate Zone, no trends were observed except for Wellawaya which exhibited a significant increasing trend signifying positive anomalies (wet conditions). Among the locations in the Dry Zone, Anuradhapura, Jaffna and Trincomalee reported significant increasing trends.

Table 6. *Statistics of the locations which exhibited significant trends in rainfall anomalies (SPI values) in the First Inter Monsoon period*

Location	Climatic Zone	AER	MK test statistic	Zs	Trend
Kegalle	Wet	WL2b	134	2.06	Increasing
Katugastota	Wet	WM2b	195	3.01	Increasing
Nuwara-Eliya	Wet	WU3	132	2.03	Increasing
Jaffna	Dry	DL3	177	2.73	Increasing
Anuradhapura	Dry	DL1b	184	2.84	Increasing
Wellawaya	Intermediate	IL1c	139	2.14	Increasing
Trincomalee	Dry	DL2b	134	2.06	Increasing

Zs = Z approximation, Zs>1.96= significant increase, Zs<1.96= Significant decrease
AER = Agro Ecological Region

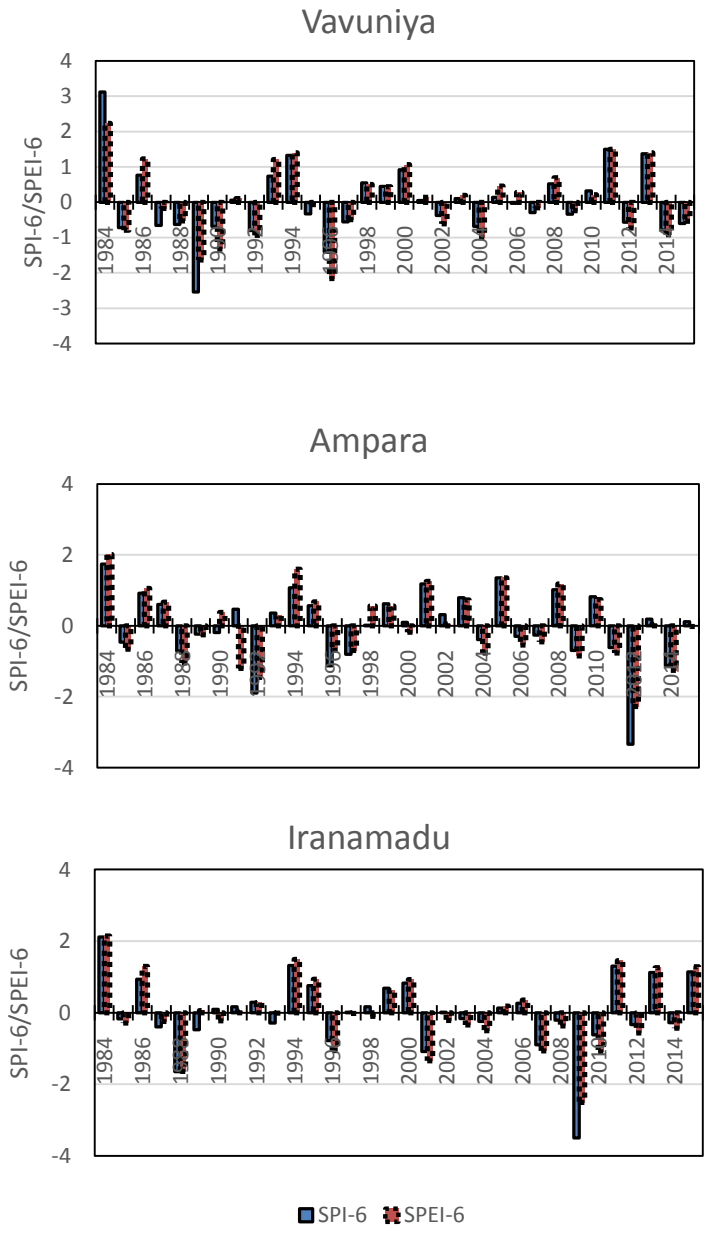


Fig. 1. Temporal variation in 6-month SPI and SPEI for October – March in the Dry Zone of Sri Lanka

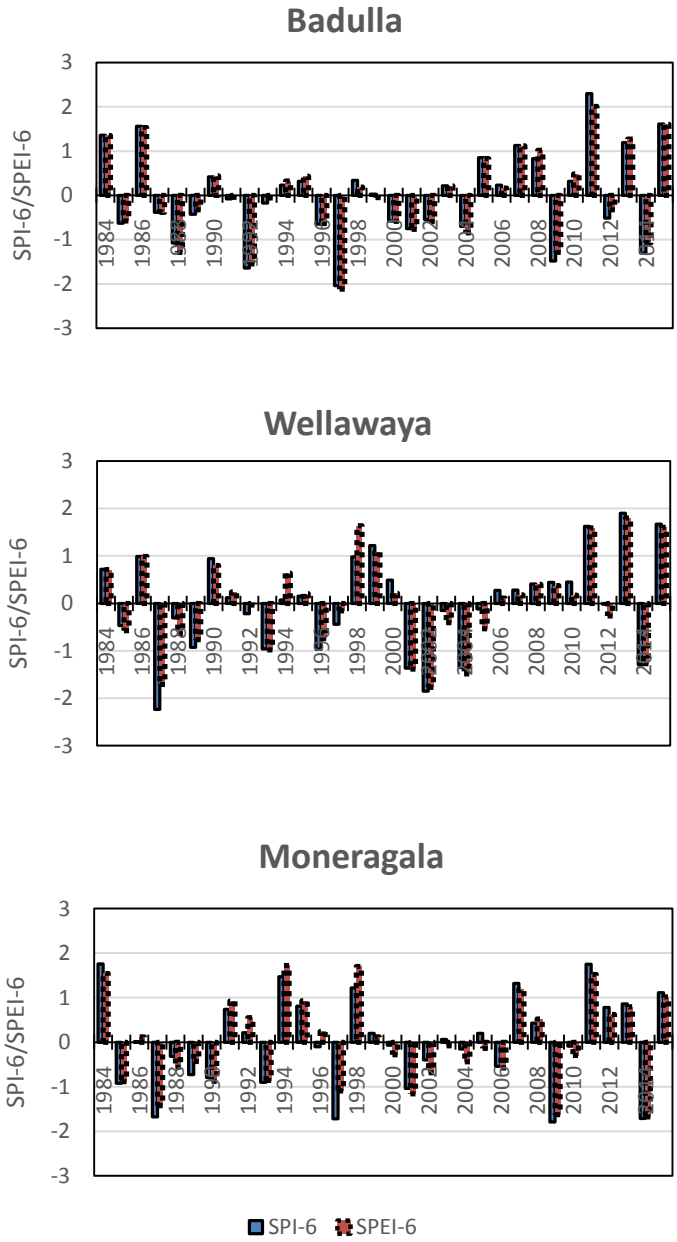


Fig. 2. Temporal variation in 6-month SPI and SPEI for October – March in the Intermediate Zone of Sri Lanka

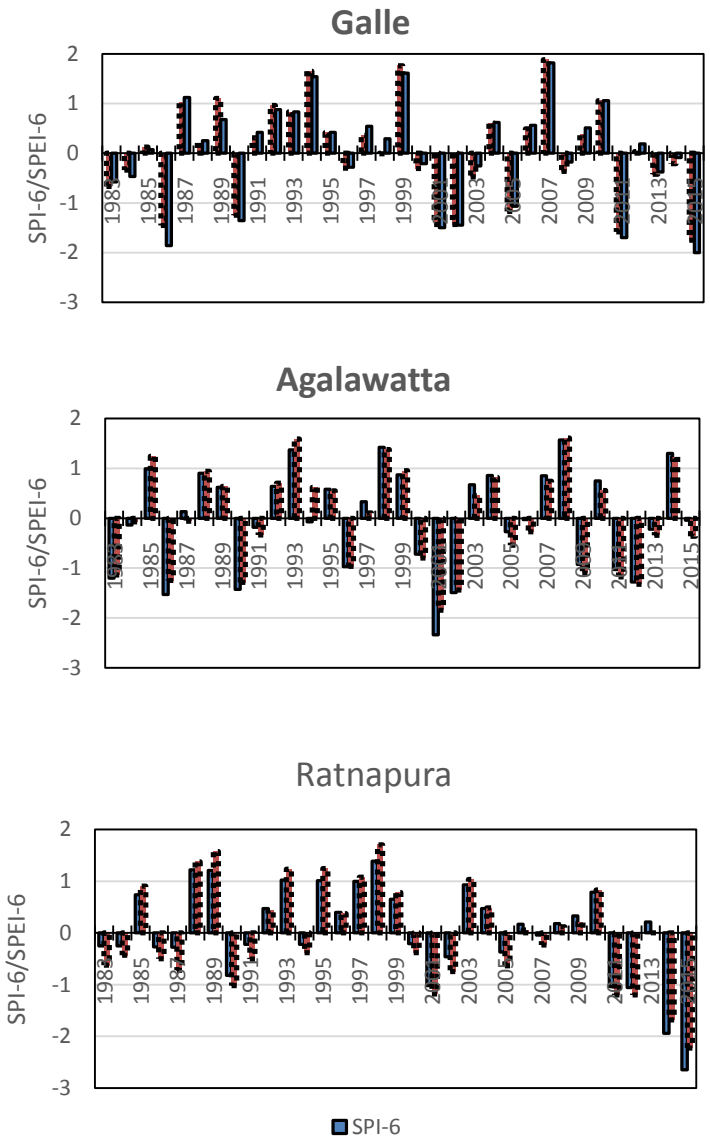


Fig. 3. Temporal variation in 6-month SPI and SPEI for May to October in the Wet Zone of Sri Lanka

Nuwara-Eliya in the Wet Zone reported a significant decreasing trend in SPI for the SW period (Table 7). Although not significant, the Mann Kendall test statistic was negative in the other stations, except Kegalle and Colombo in the Wet Zone. As in the 1st inter monsoon period, only Wellawaya exhibited a significant increasing trend in the locations of intermediate zone.

Table 7. *Statistics of the locations which exhibited significant trends in rainfall anomalies (SPI values) in the South West Monsoon period*

Location	Climatic zone	AER	MK test statistic	Zs	Trend
Nuwara-Eliya	Wet	WU3	-181	-2.79	Decreasing
Jaffna	Dry	DL3	148	2.28	Increasing
Ampara	Dry	DL2b	210	3.24	Increasing
Sangaman Tank	Dry	DL2b	-133	-2.05	Decreasing
Wellawaya	Intermediate	IL1c	151	2.32	Increasing

Zs = Z approximation, Zs>1.96= significant increase, Zs<1.96= Significant decrease
AER = Agro Ecological Region

As given in Table 8, only increasing trends were observed for the Second Inter Monsoon. Significant increasing trends were observed for Kegalle and Katugastota (Wet Zone), Matara and Wellawaya (Intermediate Zone) and Anuradhapura and Ampara (Dry Zone). Rainfall anomalies measured by SPI did not indicate any trend except for Matara in the Intermediate Zone (Table 9). A graphical representation of the results of trend analyses of rainfall anomalies in different locations is given in Figure 4.

Table 8. *Statistics of the locations which exhibited significant trends in rainfall anomalies (SPI values) in the Second Inter Monsoon period*

Location	Climatic zone	AER	MK test statistic	Zs	Trend
Kegalle	Wet	WL2b	153	2.36	Increasing
Katugastota	Wet	WM2b	141	2.17	Increasing
Matara	Int.	IL1a	144	2.22	Increasing
Anuradhapura	Dry	DL1b	151	2.32	Increasing
Ampara	Dry	DL2b	132	2.03	Increasing
Wellawaya	Intermediate	IL1c	147	2.26	Increasing

Zs = Z approximation, Zs>1.96= significant increase, Zs<1.96= Significant decrease
AER = Agro Ecological Region

Table 9. *Statistics of the locations which exhibited significant trends in rainfall anomalies (SPI values) in the North East Monsoon period*

Location	Climatic Zone	AER	MK test statistic	Zs	Trend
Matara	Intermediate	IL1a	149	2.40	Increasing

Zs = Z approximation, Zs>1.96= significant increase, Zs<1.96= Significant decrease
AER = Agro Ecological Region

Out of the total 25 locations studied, significant increasing trends in rainfall anomalies were observed in seven locations in the First Inter Monsoon season. In the SW monsoon season, significant increasing trends were observed in three locations and decreasing trends were observed in two locations. Only significant increasing trends were observed in the Second Inter Monsoon period. During the North East monsoon period, the only location exhibited a significant increasing trend, was Matara, which belongs to the Intermediate Zone. When considering all four monsoon seasons in all 26 locations, both the Inter Monsoon seasons and the South West Monsoon showed more significant trends. Seventeen out of 19 changing trends were increasing in the selected locations. Anomalies observed in the NE periods were comparatively low. This study provides valuable outputs for future predictions of rainfall anomalies and spatial mapping can be employed to represent past rainfall events and distribution of SPI values for better expression of results.

Collaborative research

1) 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 and funded by the National Science Foundation under National Thematic Research Programme (NTRP).The project commenced in 2013 and completed in December, 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. The final report preparation is in progress.

2) 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). 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 – Research Assistant : Sangeeth Liyanaarachchi).

3) 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.

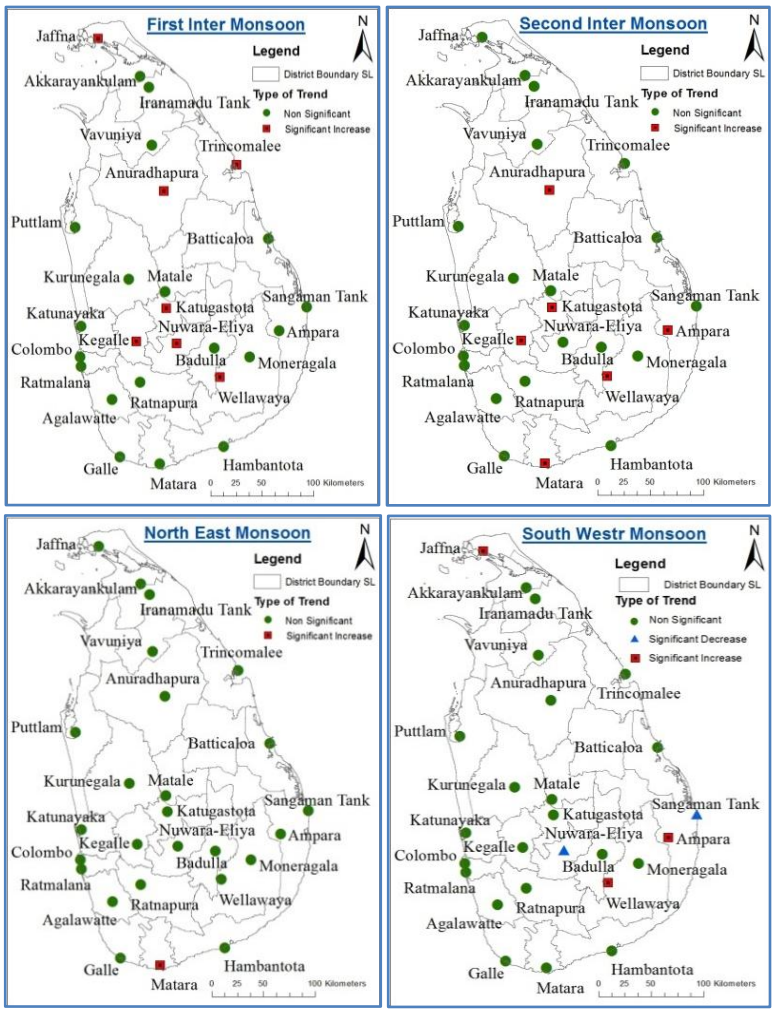


Fig. 4. Graphical Representation of types of trends in rainfall anomalies in different rainfall seasons

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 and O V Abeywardene).

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.

A database is maintained on rainfall experienced in rubber growing areas of Sri Lanka. Monthly rainfall values experienced in rubber growing areas is given in Table 10 (W Wijesuriya, C Munasinghe and V Abeywardene).

Maintenance and establishment of meteorological and agro-meteorological stations

New recording type rain gauges were installed at the meteorological stations in the premises of Kuruwita and Moneragala Sub-stations was established and data collection was started during this year (W Wijesuriya and V Abeywardene).

Table 10

Table 10. *Monthly rainfall in rubber growing areas - 2016*

Month	Location										
	Hanwella	**Ratnapura**	**Agalawatte**	**Galle**	**Kekanadura**	**Nittambuwa**	**Kurunegala**	**Moneragala**	**Uhana**	**Matale**	**Badulla**
	WL 1a	**WL 1a**	**WL 1a**	**WL 2a**	**IL 1a**	**WL 3**	**IL 1a**	**IL 1c**	**DL 2a**	**WM 3b**	**IM 1a**
January	124.6	139.7	198.3	40.7	0	4.4	1.7	26.2	216.4	11.1	64.9
February	59.6	88.9	106.3	250.1	15.1	14.6	28.7	101.9	111.6	32.1	80.9
March	93	193.7	126.4	39.4	14.5	45.8	150.7	129.2	93.7	33	47
April	337.7	396.5	240.3	76	39.7	204.5	306.5	66	29.4	104.2	35.7
May	1021.3	811.3	977.8	440.8	225.2	944.3	737.6	238.8	212.7	549.4	276.7
June	200.6	220.4	159.4	119.1	82.9	115.1	133	0	0	79.3	5.2
July	183.2	193.4	157.7	128.2	98.9	65.4	85.2	37.6	91.5	46.9	162.6
August	49.2	131.9	128	76.8	36	24.2	14.9	153.5	124.5	11.5	51.3
September	89.6	101.7	51.1	43.9	13.6	29	2.3	53.3	111.2	4.8	0.5
October	177.7	156.2	266.5	370.5	189.2	190.4	123.1	111.2	80.4	58.9	68.2
November	374.5	235	365.1	332.5	379.6	217.1	305.9	90.6	235	135.1	137.1
December	120.7	163.9	189.2	63.4	69.9	43.5	26.9	99	70.8	52.4	104.6
Total rainfall (mm)	2831.7	2832.6	2966.1	1981.4	1164.6	1898.3	1916.5	1107.3	1377.2	1118.7	1034.7
No. of rainy days	179	203	210	168	82	139	120	97	57	96	109

AGRICULTURAL ECONOMICS

J K S Sankalpa

DETAILED REVIEW

Staff

Mr J K S Sankalpa, Research Officer (Agricultural Economist) was on duty throughout the year. Miss P G N Ishani has joined to the AEU as a Research Officer (Agricultural Economist) from May, 2016.

Seminars/Conferences/ Meetings/Workshops attended

Name of the Officer	Activity	Organization
JKS Sankalpa	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
	Wayamba International Conference	Wayamba University, Sri Lanka
PGN Ishani	Training on Arc GIS 10.4 Tools & Functionality	Esri License holder, Geo Solutions (Pvt) Ltd.
JKS Sankalpa PGN Ishani	Scientific Committee Meeting	Rubber Research Institute of Sri Lanka
	Workshop on Coping Mechanisms for Low Rubber Price	Rubber Research Institute of Sri Lanka & International Rubber Research Development Board
	Plantation Crop Research Symposium	Crop Research Institutions

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.285, recorded in December. Prices of all grades of RSS were lower than that of the previous year (2015) up to month of April and prices were higher than the previous prices from April to December except September and October months. Prices of all RSS grades have increased at the end of year by 13% from 2015 to 2016 due to higher demand prevailed for all grades of RSS at the international market.

(a) **(b)**

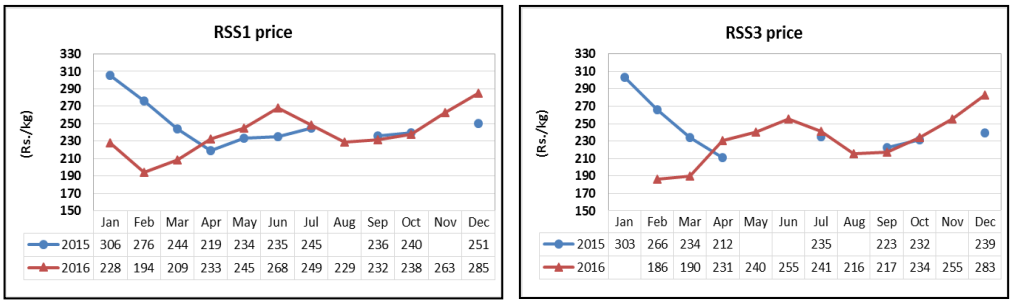
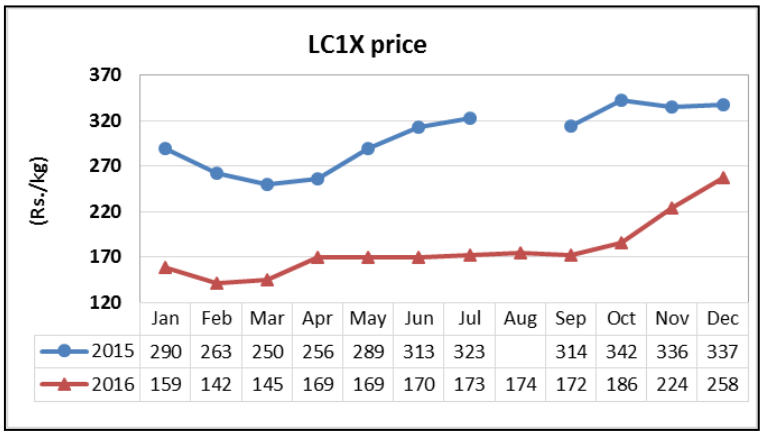


Fig.1. Monthly average prices of RSS 1 (**a**) and RSS 3 (**b**) in 2015 & 2016

Prices of Latex Crepe (LC)

Prices of Latex Crepe1X for 2015 and 2016 are shown in Figure 2. LC1X prices has increased during the latter part of 2016. However, LC prices were below the average price of previous year. Against the previous year, the gap in prices was

higher during the first half of the year than the latter part of the year. The average LC1X price ranged from Rs.230 (October) to Rs.289 (February) during 2016. The average price of LC1X was Rs.261 which was a 13% reduction compared to the previous year.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015	290	263	250	256	289	313	323		314	342	336	337
2016	159	142	145	169	169	170	173	174	172	186	224	258

Fig. 2. Monthly average of nominal LC1X price in years 2015 & 2016

Monthly changes of RSS 1 and LC1X from 2013 to 2016 are depicted in Fig.3. Monthly average of LC1X and RSS1 reached the highest in November 2013. The price differences between the LC1X and RSS1 were higher in year 2015.

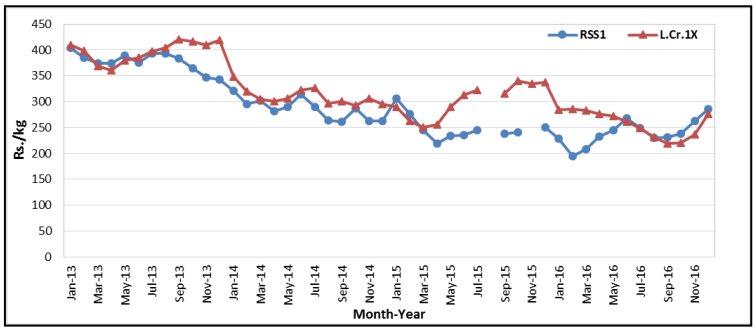


Fig.3. Monthly nominal average prices of LC1X and RSS 1

RESEARCH

The following studies were conducted in the year 2016.

Analysis of driving forces and the spatial variability of productivity in smallholder rubber lands in Sri Lanka (AE/01/a)

The goal of this study was analyzes the productivity variation in smallholder rubber lands in in Sri Lanka and spatial relationship of key drivers to the productivity variation. Low productivity has been a major challenge in rubber plantations in the country in recent years. In this study, it has been used spatial modelling tools available in geographic information science to explore the spatial variability of the rubber productivity and explore the key drivers of it in spatial context. Geostatistical kriging analysis is the simple type of prediction method which was include the cross validation of prediction and error terms in the forecasting techniques. The productivity of smallholder rubber lands in Kalutara District varied from 767 to 1463 kg/ha/year. Local variation of driven forces behind the Average productivity was explored using Geographically Weighted Regression (GWR) method. GWR explored the spatial variability of the relationship among the productivity and Fertilizer usage, Weeding, Soil conservation, Tapped trees and Age of tapping trees. All the variables were found to present significant spatial variability. Apart from generating global significant value model resulted the local variation of each parameter estimates with respect to the projected coordinates of the area. Emerge of sign change of local parameters observed in some areas that cannot be observed in globally. Average productivity variation has shown in Table 2.

Table 2. *Summary statistics of productivity of different DS divisions in Kalutara district*

DS Division	Mean	Max	Minimum	Standard deviation
Agalawatta	1137	1310	992	69
Bandaragama	1078	1124	1031	19
Beruwala	1199	1352	1011	42
Bulathsinghala	1172	1311	950	48
Dodangoda	1174	1375	943	67
Horana	1106	1181	912	38
Ingiriya	1102	1166	767	72
Kalutara	1190	1395	1044	84
Madurawala	1121	1203	955	56
Mathugama	1083	1242	870	71
Millaniya	1112	1317	843	74
Palindanuwara	1190	1385	945	49
Panadura	1089	1152	975	41
Walallawita	1157	1463	892	58

The GWR model results were given in the Table 3. Global t-value explain the how the direction of relationship behave in the area and the statistical significance level change in the GR. Second column of the table shows those variable that have spatial variability at the 95% and 90 % confidence intervals. Variables selected in the analysis were signicant in the global model and there were spatial variability in the area.

Table 3. *Results of GWR*

Variables	Global t-value	GR estimate	GR SE	DIFF C
Intercept	624.54	1146.84	1.83	-1229.68
Fertilizer	2.66	5.43	2.03	-129.49
Weeding	4.48	10.77	2.40	-165.05
Soil conservation	11.02	26.41	2.39	-73.86
Age of plant	-9.21	-18.89	2.05	-139.88
Tapped trees	5.55	11.53	2.07	-122.50
n	1337			
AICGR	15,051			
AICGWR	12,934			
GR adjusted R^2	0.23			
GWR- adjusted R2	0.85			
GWR F value	49.71			

GR: Global regression; GWR: Geographically weighted regression, AIC: Akaike information criterion, DIFF C: Difference of criterion, n= number of samples selected. GR SE: Global regression standard error of estimate (J K S Sankalpa, Wasana Wijesuriya and Senani Karunaratne).

Analysis of technical efficiency and its determinants of latex harvesting in Dartonfield Estates, Rubber Research Institute of Sri Lanka (AE/02/a)

The goal of this study was analyzes the relationship between technical efficiency of latex harvesters in Rubber Research Institute's estates of Sri Lanka (RRISL). A total of 70 latex harvesters were selected and served with a structured interview using questionnaire. Data Envelopment Analysis was used to estimate technical efficiency of latex harvesting in the estates. Labour, fertilizer, chemical and tapped trees were used as inputs in technical efficiency analysis and double censored Tobit regression model was estimated to assess the impact of harvester specific socio-economic variables in harvesting. Findings revel that, mean technical efficiency of latex harvesting is 53% in RRISL estates while 26% of harvesters were recorded 41% -50% of efficiency score.

Tobit regression coefficients and probability values estimated are shown in Table 4. Positive regression coefficients indicates that variable values will positively impact on increase of technical efficiency of harvesters while increase of negative values decrease the efficiency of harvester. Harvester's gender shows a negative coefficient in the regression results. 55% of harvesters are female in the population. This indicates that female harvesters are more efficient than male harvesters. (Dummy variable, Male=1, Female=0). Harvester's education level which was measured as number of years spent in the school has positive impact on technical efficiency of the harvesting. If the harvester is spent additional one year in the school, it will be impacted by 0.01 of technical efficiency increase.

Table 4. *Tobit regression model results*

Variable	Coefficient	P value
Constant	0.2834	0.192
Age of harvester	-0.0033	0.228
Gender of harvester (Dummy variable)	-0.0251	0.532
Family members of harvester	-0.026	0.076**
Educational years	0.0098	0.156
Training (dummy variable)	0.0029	0.944
Experience in years	0.0089	0.006*
Total Payment	0.0004	0.043*

*Significance level: * Significance at 5 % level while ** is significant at 10 % level.*

(J K S Sankalpa, Wasana Wijesuriya and O V Abeywardana)

Rubber based farming systems and sustainable livelihood development: A case study in Moneragla district Sri Lanka (AE/01/b)

Overall aim of this study is to provide a guideline to improve the smallholder rubber sector in the Moneragala District and give sustainability indicator as a guideline in further expansion of NR in non-traditional areas Sri Lanka. To achieve this goal, it was designed to explore the suitable farming systems for socio-economic development of people in Moneragala district, Identify the spatial variability of socio-economic condition in terms of impact of farming system on livelihood development & identifying the issues and perspectives of them to rectify inadequacies in knowledge on environmental, social, economic, technological and institutional aspects which appear in different magnitudes.

Data collection was completed through a primary survey carried out in the Moneragala district. Based on the number of smallholders who are currently involving in a rubber based farming system, survey sample is proportionately selected and 228 primary data samples were collected. Data analysis was in progress as an exploratory data analysis and a spatial analysis. Figure 4 depicts the different farming systems available in the Moneragala district (J K S Sankalpa, Wasana Wijesuriya and O V Abeywardana).

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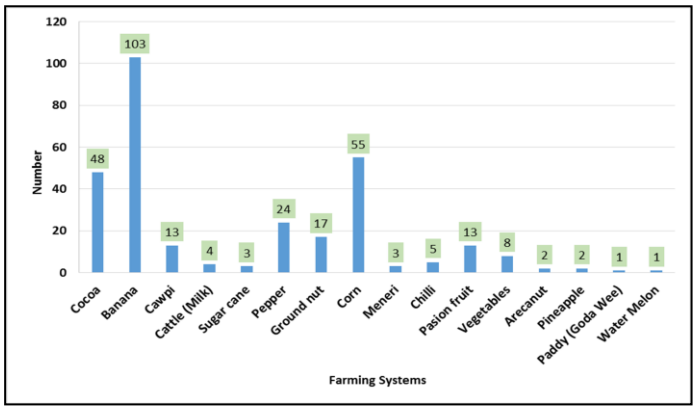


Fig. 4. Different farming systems observed in Moneragala district

Analysis of rubber based farming systems in traditional rubber growing areas Sri Lanka (AE/01/c)

Overall aim of this study is to provide a guideline to improve the smallholder rubber sector in the traditional rubber growing areas in Sri Lanka. It was designed to achieve objectives similar to study (AE/01/b). However, farming systems and suitability of implications are different from non-traditional rubber growing areas. Physical, geographical, land resources, climatic conditions are varied from non-traditional rubber growing areas. Primary data collection was in progress in Kalutara district (P G N Ishani, O V Abewardana and Wasana Wijesuriya).

Analysis of impact of CESS tax policy changes on raw rubber exports in Sri Lanka (AE/04/a)

Government of Sri Lanka has been introducing and changing the CESS tax rate on agricultural commodities with the aim of development of value added products rather than exporting raw agricultural materials from the country. This study

attempts to analyze the impact of natural rubber CESS tax policy changes happened during the last few years in the country. This will be analyzed based on the custom data which was collected during the period of 2010 to 2015 and natural rubber CESS income generation. CESS income data was collected from the Ministry of Plantation Industries. The study will help to provide a guideline in policy making in the tax rate formulation in the country. Secondary data collection was completed and Analysis was in progress during the year (P G N Ishani and Wasana Wijesuriya).

Worthiness of investing on rainguards in rubber estates: Case study on estates owned by the Rubber Research Institute (AE/04/b)

Majority of the rubber growing areas in Sri Lanka are located in South Western region. These areas are subjected to heavy monsoon periods starting from May to September and December to February. Rain interference is a serious issue in the rubber estates as it leads to crop loss through nil tapping, late tapping or washouts. Rubber production is in a declining trend since 2011. The unfavorable weather condition prevailed in those years is contributed to this decline in production.

Financial analysis was conducted to measure the profitability of using rain guards considering one hectare of land based on actual data available at Dartonfield estate. Data were collected from the Dartonfield estate for the year 2015. The data collected included extent, no of rainguarded trees, rainguard cost, tapping cost, and Net Sales Average (NSA). Further rain fall data and number of tapping days in Dartonfield gathered from the year 2005 to 2015. Pay back periods of the investment on rainguards were calculated with the assumptions of 0.035 kg latex yield per tree per tapping (kg/t/t) and plant density of 300 trees per hectare. Table 5 depicts the results obtained from the financial analysis of use rainguards in the Dartonfield estate.

Table 5. *Financial analysis of use of rainguards at three estates in 2015*

	Dartonfield	Gallewatta Division	N' Division	Total
Hectare	18	55	24	96
No of Rainguard fitted	4,611	15,610	7,283	27,504
Yield	26,878	109,247	25,545	161,670
Yield advantage kg	3,383	18,953	5,516	27,852
N.S.A Rs/kg	255	255	255	255
Revenue due to rainguards (Rs.)	863,545	4,837,943	1,408,014	7,109,502
Revenue due to rainguards (Rs/ha)	49,121	88,510	58,255	73,742

	Dartonfield	Gallewatta Division	N' Division	Total
Rainguard cost (Rs/tree)	46	46	46	46
Tapping cost (Rs/kg)	113	113	113	113
Cost of manufacturing Rs/kg	36	36	36	36
Total cost Rs/kg	203	182	189	186
Additional profit Rs/kg	53	74	68	70
Additional expenditure for the application of rainguards only (Rs) (Cost per tree*total no of trees)	212,106	718,060	335,018	1,265,184
Additional expenditure for the application of rainguards only (Rs/ha)	12,065	13,137	13,861	13,123
Additional profit from rainguard	178,487	1,368,259	373,819	1,935,993
Additional profit per hectare	5,541	11,284	13,442	10,680
Net profit from yield advantage (Rs) (NSA-COP)*yield Advantage	178,487	1,394,751	362,787	1,935,993
Net profit from yield advantage (Rs/ha)	10,153	25,517	15,010	20,081
Payback period (Days)	5	5	5	5

(P G N Ishani and Wasana Wijesuriya**)**

Table 1. *Monthly Auction Prices of Rubber in year 2016*

Month	RSS Prices (Rs.)					Latex Crepe prices (Rs.)					Scrap Crepe Prices (Rs.)				
	RSS1	RSS2	RSS3	RSS4	RSS5	LC-1X	LC-1	LC-2	LC-3	LC-4	1Xbr	2Xbr	3Xbr	4Xbr	Flat Bark
Jan	228	189				286	284	267	226	161	159	158	156	150	150
Feb	194	189	186	179		289	286	268	227	145	142	141	142	140	
Mar	209	205	190	182	182	287	283	258	242	147	145	140	147	143	138
Apr	233		231		212	278	277	255	227	179	169	163	166	158	153
May	245	239	240			273	272	237	211	179	169	160	166	159	137
Jun	268		255		231	268	262	227	206	178	170	165	162	158	135
Jul	249	246	241		233	250	249	223	210	209	173	170	169	160	143
Aug	229	228	216	214	215	235	231	209	200	190	174	172	175	167	152
Sep	232	222	217	217		223	219	206	194	176	172	171	171	163	153
Oct	238	235	234	234		230	221	212	205	193	186	181	179	173	164
Nov	263	261	255	252		235	237	232	231	229	224	222	206	205	175
Dec	285	283	283	297	288	280	276	270	265	265	258	253	243	240	220
2016 Average	239	230	232	225	227	261	258	239	220	188	178	175	173	168	156

LIBRARY AND PUBLICATION

S U Amarasinghe

DETAILED REVIEW

Mr S U Amarasinghe, Librarian, Mrs R M Amaratunga, Library Assistant and Assistant Publication Officer, Mr P M Prema Jayantha, Management Assistant, 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 Annual General Meeting of the Sri Lanka Library Association
- One AGRINET Advisory Committee Meeting 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 2015
- Annual Report 2015
- Annual Review 2014

Advisory Circulars

- Production of Budded Plants
- ලපටි බද්ධ පැළ නිපදවීම
- කිරි කැපීම හා වැහි ආවරණ භාවිතය
- Field Establishment
- රබර් කිරි එකතු කිරීම හා සුරක්ෂණය
- Tapping & Use Rainguards
- Fertilizer to Rubber
- Manufacture of Latex Crepe Rubber
- Collection & Preservation of Latex
- Manufacture of Balloons
- Manufacture of Cast Products

- Manufacture of Rubberized Coir Mattresses
- නිරෝගී රබර් පැළ තවානක් පවත්වා ගැනීම

- Frequently Asked Questions (Sinhala & English)
- Binding of Advisory Circulars Collection
- සැමට සෙත සලසන නැගෙනහිර ප්‍රදේශයේ රබර් වගාව

List of books purchased during the year

No	Title	Publisher	Year of the published
01	Standard methods for the examination of water and waste water	American Public Health Association	2012
02	Phytophthora diseases of plantation crops	Kerala : Rubber Research Institute of Sri Lanka	2015
03	Physico-mechanical and processability studies of skim natural rubber	Nugegoda : University of Sri Jayawardanapura	2016
04	Statistical Information on Plantation crop – 2014	Colombo : Ministry of Plantation Industries	2014
05	Polymer lattices and their applications	London : Applied Science Publishers	1982
06	Synthetic rubber latex examination for micro-organisms ISO/DIS 2085	Colombo : SLSI	2016
07	A systematic approach to soil fertility evaluation and improvement	Modern Agriculture and Fertilizers	2014
08	Proceedings of 15th Agriculture Research Symposium 28th June, 2016	Wayamba University of Sri Lanka	2016
09	Proceedings of CRRI & IRRDB International Rubber Conference, 2016	IRRDB & CRRI	2016
10	ඵලදායීතා වර්ධනය සඳහා අසිරිමත් පංචවිධ සංකල්පය, 5S	උපාලි මාරසිංහ	2006
11	ඵලදායීතා වර්ධනය සඳහා තත්ත්ව කව හා තත්ත්ව පාලන මෙවලම්	උපාලි මාරසිංහ	2010
12	විශිෂ්ඨත්වය උදෙසා ඵලදායීතා වර්ධනය: ඩෙමිංගේ කළමණාකරන මූලධර්ම 14	උපාලි මාරසිංහ	2014
13	විශිෂ්ඨත්වය උදෙසා ඵලදායීතා වර්ධනය තුලනාත්මක පාලන සටහන්	උපාලි මාරසිංහ	2010
14	ශ්‍රී ලංකාවේ දැව ශාක : දැව ගති ලක්ෂණ සහ දැව භාවිතය: දැව අත්පොත	නිමල් රුවන් පතිරණ	2016

Information services

Computerized bibliographic data up to the year 2016 were sent to the National Library of Sri Lanka and the CARP Library for compilation of the National Union Catalogue and the National Agricultural Bibliography respectively. The resource sharing activities were continued among the AGRINET Libraries.

Six literature searches 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 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 K K P Gunawardana Acting Chief Clerk of Estate Office retired on 28th February 2016.

The Group cadre stood as follows at the end of the year.

Senior staff	01
Assistant staff	09
Minor staff	03
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	28.18	15.13	47.45
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	-	9.82	12.69	22.51
Streams	-	-	2.17	2.17
Grand total	**74.29**	**184.35**	**73.24**	**331.88**

Rainfall

The annual rainfall recorded for the year was 2,682.1 mm with 181 wet days.

Table 2. *Annual rainfall and wet days of the group for last five years*

	2012	2013	2014	2015	2016
Rainfall (mm)	3,622.6	3,565.4	4,568.6	4,014.5	2,682.1
Wet days	195	207	199	210	181

Crop

A total crop of 176,136 kg has been harvested against the estimated crop of 197,474 kg (89.2%) which is a decrease of 21,338 kg.

Table 3. *The crop and YPH (kg) of Dartonfield group from 2012 to 2016*

Hect.	2012		2013		2014		2015		2016	
	174.85		169.03		179.32		181.28		181.28	
Division	Crop	YPH	Crop	YPH	Crop	YPH	Crop	YPH	Crop	YPH
Dartonfield	34,092	891	29,451	770	28,885	897	26,878	834	23,635	734
Gallewatta	125,789	1,091	130,425	1,043	115,248	952	109,247	901	123,207	1,016
N'kele	31,709	1,488	24,720	1,355	28,682	1,101	25,545	919	29,294	1,053
Group total	191,590	1,096	184,596	1,016	172,815	964	161,670	892	176,136	972
Group estimate	187,150	1,070	190,000	1,046	199,296	1,111	200,688	1,107	197,474	1,089

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 2012 to 2016*

	2012	2013	2014	2015	2016
Dartonfield	6.2	6.2	5.5	5.6	5.7
Gallewatte	9.1	8.7	6.9	7.2	7.9
Nivitigalakele	8.1	7.6	7.0	7.2	7.3
Group average	**8.3**	**8.0**	**6.6**	**6.9**	**7.4**

Tapping days

Annual break down of Normal tapping (NT), Late tapping (LT), Double tapping (DT) and No tapping of Dartonfield estate is given in Table 5.

Table 5. *Actual number of tapping days of Dartonfield group during last five years*

	2012	2013	2014	2015	2016
Normal tapping	229	216	219	204	258
Late tapping	14	28	11	12	07
Cash/Double tapping	(13)	(18)	(21)	(23)	(29)
No tapping	54	56	55	70	39
Rainguard tapping	68	61	80	79	62
Slight Rain	01	01	-	-	-
Total no of tapping days	312	306	310	295	327

Rainguards

Total of 150.70 hectares were rainguarded during the year and an additional crop of 24,994 kg was harvested which amounts to 17% of total harvested crop. Additional tapping days done due to rainguards during the year were 46, 75 and 62 from D/F, G/W and N/K respectively. Profit generated due to rainguards was Rs.433,895.84 and profit per hectare Rs.2,879.20.

Table 7. *Additional income generated by fixing rainguards (Rs/kg)*

	Dartonfield Division	Gallewatta Division	Nivithigalakale Division	Total
Area (ha)	28.66	93.24	28.80	150.70
No. of rainguards fitted	7240	29835	7505	44580
Additional crop (kg)	2423	17176	5395	24994
Rainguard cost per kg.	88.53	61.94	81.16	68.67
Tapping cost per kg.	116.46	116.46	116.46	116.46
C.O.M. Rs/kg	32.35	32.35	32.35	32.35
Total cost Rs/kg	237.34	210.75	229.97	217.48
N.S.A. Rs./kg	234.84	234.84	234.84	234.84
Additional profit Rs./kg	(2.50)	24.09	4.43	17.36
Additional profit from rainguards (Rs.)	(6,057.50)	42,783.84	23,899.85	433,895.84
(Additional profit per hectare (Rs.)	(211.36)	458.86	829.85	2879.20

***** Low crop harvested from rainguard due to dry period of October to December cost of production has increased than previous year.

Total profit and profitability per hectare

The total loss and loss per hectare were (Rs.1,107,895.44) and Rs.6,111.52) for the year under review.

Table 8. *Comparative statement of the revenue profit per kg and profit per hectare*

	Years				
	2012	**2013**	**2014**	**2015**	**2016**
Mature area (ha)	174.85	169.03	179.32	181.28	181.28
Total profit (Rs.)	32,020,436.70	15,071,788.05	1,987,373.99	(2,475,167.70)	(1,107,895.44)
Profit per ha. (Rs.)	183,130.89	89,166.35	11,082.83	(13653.84)	(6,111.52)

Cost of production and productivity

Table 9. *Labour rates and break down of cost of production from 2012 to 2016 (Rs./kg.)*

	2012	**2013**	**2014**	**2015**	**2016**
1. Labour wages	572.00	572.00	687.50	687.50	687.50 up to Sept. 805 from Oct.
2. Cost of production	216.33	262.39	245.06	270.57	241.13
2.1 Tapping	84.64	100.94	118.61	113.94	116.46
2.2 Manufacture	35.66	35.68	35.82	36.43	32.35
2.3 General charges	75.02	102.26	74.49	103.07	74.43
2.4 Mature/area upkeep	20.91	23.51	16.14	17.13	17.89
3. N.S.A.	383.36	348.74	256.56	255.26	234.84
4. Profit per kg	167.13	86.35	11.50	(15.31)	(6.29)

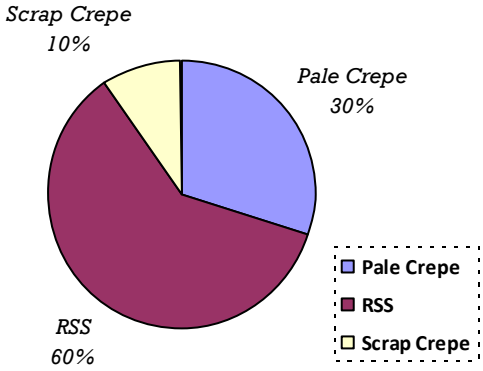
Manufacture

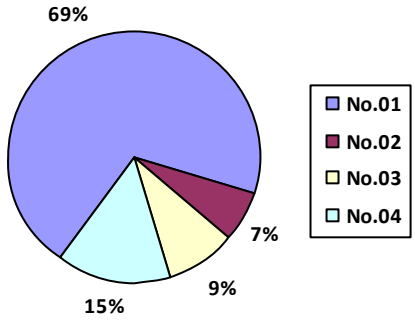
Out of the latex crop of 176,136 kg harvested, 36,776 kg has been sent as Latex Crepe No.1 which is 70% and 93,550 kg as RSS No. 01 which is 88%. Details are given in Table 10 and Fig. 1.

Table 10. *Summary of grades manufactured during the year*

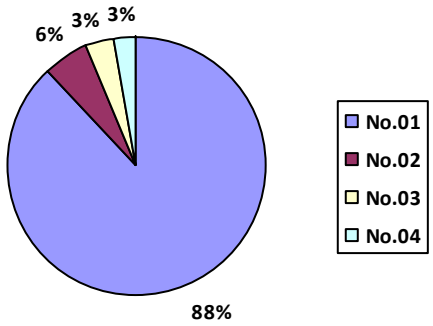
Grade	**Quantity (kg.)**	**Percentage %**
Latex crepe No.1	36,776	69
Latex crepe No.2	3,479	07
Latex crepe No.3	4,759	09
Latex crepe No 4	7,759	15
Total	**52,773**	**100**
RSS No.01	93,550	88
RSS No.02	6,293	06
RSS No.03	3,475	03
RSS No.04	2,918	03
Total	**106,236**	**100**

Grade	Quantity (kg.)	Percentage %
Scrape crepe No.1	12,656	74
Scrape crepe No.2	3,829	22
Scrape No.3	642	04
Total	**17,127**	**100**
Grand total	**176,136**	





Pale Crepe Manufacturing percentage



RSS Manufacturing percentage

Fig. 1.

SUB STATION - KURUWITA

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

Hectarage

A summary of the hectarage is given in Table 1.

Table 1. *Land distribution (ha.) in Kuruwita Sub station*

Land type	Extent (ha.)
Mature area	75.66
Immature area	6.50
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 104,651kg was harvested during the year, recording an increase of 4,481 kg on previous year's crop.

The actual yield per hectare (YPH) was 1,383.17 kg which is an increase of 15.85 kg when comparing with previous year's crop.

The yield per hectare (YPH) for the past five years are given in the Table 2.

Table 2. *Yield per hectare for the past five years*

YPH (kg)	Year				
	2012	**2013**	**2014**	**2015**	**2016**
Estimated	1,474.26	1,366.26	1,419.82	1,378.65	1,339.54
Actual	1,403.03	1,410.77	1,378.34	1,367.32	1,383.17

The yield per hectare recorded (kg) for each month during the year is given in Table 3.

Table 3. *Actual yield per hectare (kg) recorded for each month during the year*

Month	YPH (kg)
January	156.43
February	110.03
March	122.66
April	72.36
May	84.43
June	92.78
July	127.54
August	144.13
September	120.67
October	124.02
November	81.25
December	145.82

Tapper productivity

The average intake per tapper at the end of the year was 9.1 kg. The average IPT during the last five years are given in Table 4.

Table 4. *The average intake per tapper (IPT) (kg) for the last five years*

IPT (kg)	Year				
	2012	**2013**	**2014**	**2015**	**2016**
Intake per tapper	8.9	8.7	8.9	8.9	9.1

Rainfall

The annual rainfall recorded during the year was 3,342.8 mm with 251 wet days (Table 5).

Table 5. *Annual rainfall figures and the number of wet days of the estate for the past 5 years*

	Year				
	2012	**2013**	**2014**	**2015**	**2016**
Rainfall (mm)	4,411.40	3,817.80	5,093.10	4,002.14	3,342.80
Wet days	150	174	239	251	222

Tapping days

There were 352 tapping days recorded during the year (Table 6). This was possible merely due to the use of rainguards.

Table 6. *The Average number of tapping days of the Kuruwita Sub Station for the past five years*

	Year				
	2012	**2013**	**2014**	**2015**	**2016**
01.Total tapping days	**342**	**338**	**335**	**348**	**352**
1.1 Normal	320	327	282	314	344
1.2 Late	22	11	38	32	08
1.3 Rain Interference	-	-	15	02	-
1.4 Rainguarded Tapping	(77)	(95)	(131)	(140)	(84)
02 Recovery Tapping	(05)	(12)	(08)	(08)	-
03 No tapping	24	27	30	17	14

When compared with the last year there was an increase in normal tapping days from 314 to 344 days during the year.

Rainguards

Due to the use of rainguards an additional 84 tapping days were recorded during the year. This contributed to 20% of the total crop yielding an additional profit of Rs.1,719,158.70.

An analysis of the use of rainguards for the years 2014, 2015 and 2016 are given in Table 7.

Table 7. *An analysis of the use of rainguards (Rs./kg)*

	Year		
	2014	**2015**	**2016**
Hectarage (ha.)	62.34	71.00	73.41
No. of raiguards fitted	18,421	21,890	22,262
Additional tapping days	131	140	84
No. of kilos harvested	36,275	36,837	20,454
Raiguard cost per (kg.)	27.65	25.65	43.41

	Year		
	2014	**2015**	**2016**
Tapping cost (Rs./kg.)	87.81	87.77	89.65
Total cost (Rs./kg.)	115.46	113.42	133.06
N.S.A (Rs./kg.)	251.92	207.86	217.11
Additional Profit (Rs./kg.)	136.46	94.44	84.05
Additional profit from rainguards (Rs.)	4,950,086.50	3,478,886.28	1,719,158.70
Additional profit per hectare (Rs.)	79,404.65	48,998.39	23,418.59

Total profit and profitability per hectare

The total profit and profit per hectare were Rs.3,959,993.84 and Rs.52,339.33 respectively for the year 2016. This is an increase of Rs.2,292,163.34 and Rs. 29,573.42 respectively when compared with the last year.

Table 8 gives a comparative statement of the mature extent, total profit and profit per hectare for the past five years.

Table 8. *Comparative statement of the mature extent, total profit and profit per hectare for the past five years*

	Year				
	2012	**2013**	**2014**	**2015**	**2016**
Mature extent (ha.)	71.29	74.29	71.84	73.26	75.66
Total profit (Rs.)	18,760,063.36	15,975,578.58	5,339,158.40	1,667,830.50	3,959,993.84
Profit per hectare (Rs.)	263,151.40	215,043.46	74,320.13	22,765.91	52,339.33

Cost of production and profitability

The cost of production has decreased by Rs.11.94 per kg when comparing with the previous year (Table 9).

Labour rate and the breakdown of the cost of production (Rs/kg) for the past five years are given in Table 9.

Table 9. *Labour rate (Rs.) and the break down of the cost of production from 2012 to 2016 (Rs./kg.)*

	Year				
	2012	**2013**	**2014**	**2015**	**2016**
Labour rate	572.00	687.50	687.50	687.50	Jan. - Nov. 687.50 From December 805.00
Cost of production	178.69	187.19	198.00	191.21	179.27
Tapping cost	79.49	90.44	96.70	87.77	89.65
Manufacturing	-	-	-	22.14	21.49

	Year				
	2012	**2013**	**2014**	**2015**	**2016**
General chargers	77.13	74.55	79.58	64.72	54.48
Field & cultivation cost	22.07	22.20	21.72	16.58	13.65
N.S.A	366.21	339.62	251.92	207.86	217.11
Profit per kg.	187.52	152.43	53.92	16.65	37.84

Other crops

Cinnamon

281 kg of Cinnamon were sold during the year from Rubber/Cinnamon inter cropping area and the total income and the profit were Rs.505,214.63 and 32,087.12 respectively.

POLGAHAWELA SUB STATION

P A Lukshaman

DETAILED REVIEW

Mr P A Lukshaman, Senior Estate Manager overlooked the activities of the Sub station and Dr S M M Iqbal coordinated the research activities. Mrs Chandrani Weeramanthrie, Management Assistant was on duty throughout the year.

Crop

A total crop for 13,753 kg have been harvested against the estimated crop of 11,756 kg which is an increase of 1,997 kg. The total crop, YPH and IPT for 2015 and 2016 are given in Table 1.

Table 1. *Total crop, YPH and IPT for 2015 & 2016*

Year	Hectare	Crop (kg)	YPH (kg)	IPT (kg)
2015	10.75	12,206	1,136	9.2
2016	11.75	13,753	1,170	10.1

Total number of 495 trees died from 2005 to 2012 replanting and the details and given in Table 2.

Table 2. *The age wise breakdown of the dead trees affected by the server drought in 2016*

Field	Age (y)	No. of dead trees due to drought
2005	11	30
2006	10	57
2007	9	99
2008	8	23
2009	7	82
2010	6	39
2011	5	144
2012	4	21
Total		**495**

Meteorological Summary
Dartonfield Station

Wasana Wijesuriya

During the last 17 years, an average annual rainfall of 4069 mm was observed in the Dartonfield meteorological station located in the Agro Ecological Region, WL_{1a}. Out of the 17 years since 2000, a total rainfall of less than 3000 mm has been recorded only during 2016 (Fig. 1) which was 2966 mm. The rainfall recorded in 2016 accounted for a decline of 29% compared to the previous year.

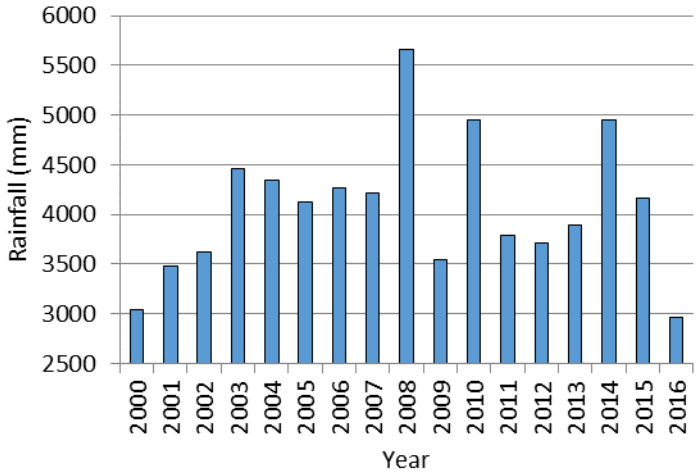


Fig. 1. Variation in annual rainfall at Dartonfield

As indicated in Fig. 2 the rainfall distribution at Dartonfield during this year departed from the usual pattern. Above average monthly rainfall values were observed in January and May while below average values were recorded in the rest of the months, except for November which was very close to the long term average. The minimum monthly rainfall of 51 mm and the maximum monthly rainfall of 978 mm were recorded in September and May, respectively.

Distribution of rainfall in different seasons at Dartonfield is given in Fig. 3. Rains during the South West season (May – September) decreased by 436 mm compared to the previous year. Rainfall during IM1 (March & April) in 2016 is about 248 mm lower than 2015. During North East and IM2 seasons, 2016 recorded lower values; *viz.* 84 mm and 434 mm, respectively compared to 2015.

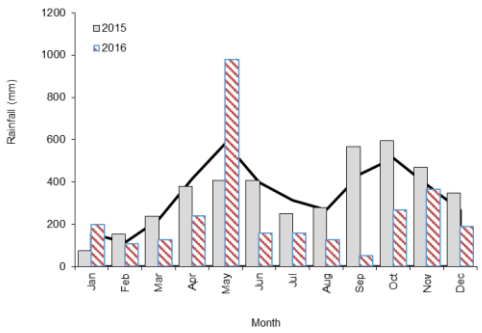


Fig. 2. Distribution of monthly rainfall in 2015 and 2016 at Dartonfield (The line chart indicates the long-term average)

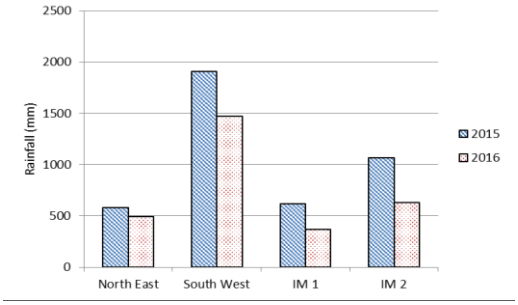


Fig. 3. Seasonal distribution of rainfall at Dartonfield in 2016

The distribution of weekly rainfall is illustrated in Fig. 4. Ten dry weeks (weeks having a total rainfall less than 10 mm) were observed during this year. The highest weekly rainfall of 304 mm was observed in the 20th standard week, which coincided with the 2nd week of May.

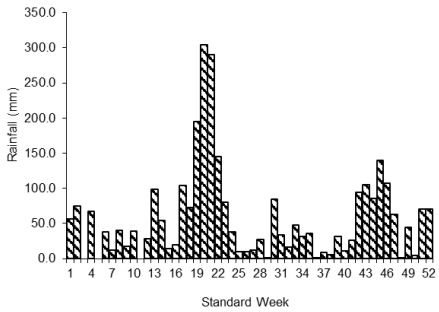


Fig. 4. Weekly variation in rainfall in 2016

There were 2 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 210, which was below the long term average (222) by 12 days. A dry spell lasted over a month or more can have adverse impacts on rubber plantations. There were only 5 dry spells greater than or equal to 7 days; the longest being 13 days, from 12th to 24th March. The details of the dry spells are given below.

Details of dry spells at Dartonfield

Period	**No. of days**
12th to 21st January	10
27th January to 6th February	11
01st to 07th March	07
12th to 24th March	13
19th to 25th September	07

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 3420 mm, 1948 mm, 1158 mm and 2313 mm were recorded respectively, in Kuruwita, Narampola, Moneragala and Nivithigala Kele stations during 2016.

Distributions of monthly rainfall at Kuruwita, Narampola. Moneragala and Nivithigala Kele are illustrated respectively in Fig. 5 (a), (b), (c) and (d). The rainfall received in these stations recorded decreases of nearly 18%, 31%, 40% and 46% in annual rainfall compared to the previous year, respectively.

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^{0}C in 4 days; 1 day in February and 3 days in December.

The daily average temperature pattern was fairly steady with a mean annual temperature of 27.3^{0}C and a standard deviation of 0.9, which could be a favourable condition for rubber plantations. The lowest mean minimum temperature of 22.2^{0}C was observed in December while the highest mean maximum temperature of 34.1^{0}C was observed in March. However, any signs of adverse conditions with respect to the temperature regime at Dartonfield were not reported during the year.

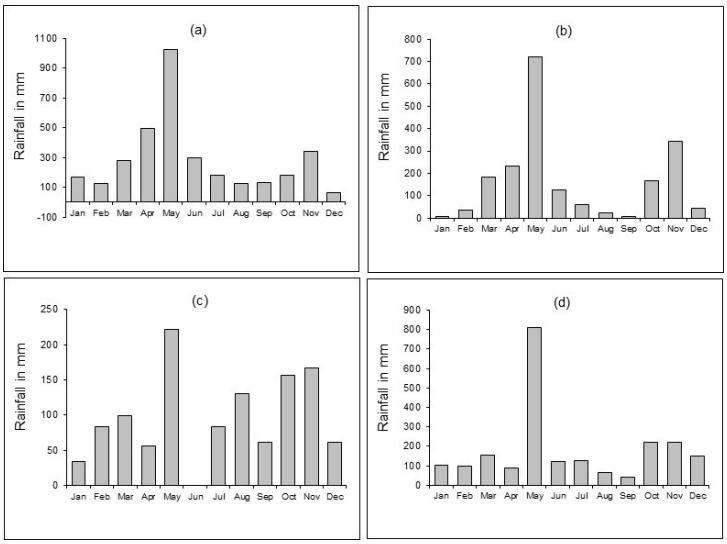


Fig. 5. Distribution of monthly rainfall in (a) Kuruwita and (b) Narampola (c) Moneragala and (d) Nivithigala Kele

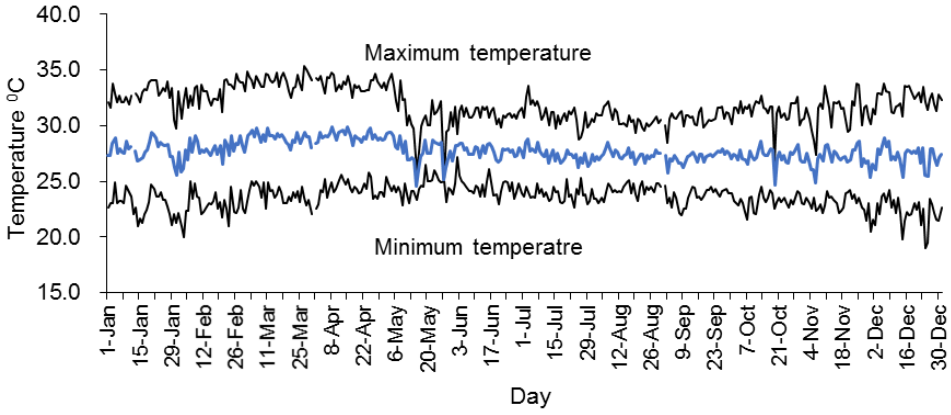


Fig. 6. Daily minimum, maximum and average temperature distributions

A total of 1962 bright sunshine hours was received at an average rate of 5.4 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 47% of the days, while in 28% 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 2016 was observed in the range, 71 % to 96 %. The mean RH values recorded at 08:30 and 15:30 were 86% (SD=6.9) and 78 % (SD=10.8), respectively.

Monthly values of soil temperatures recorded at 08:30 and 15:30 hrs in 4 different depths are depicted in Fig. 8 and Fig. 9.

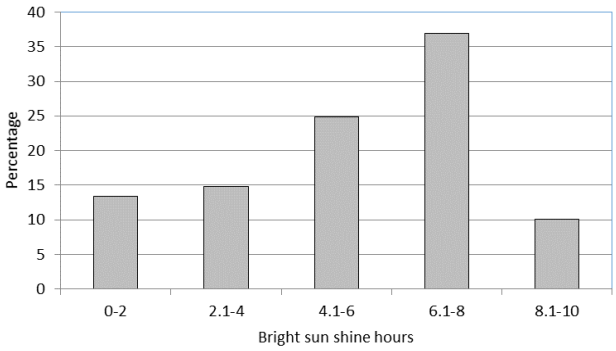


Fig. 7. Distribution of bright sunshine hours in 2016

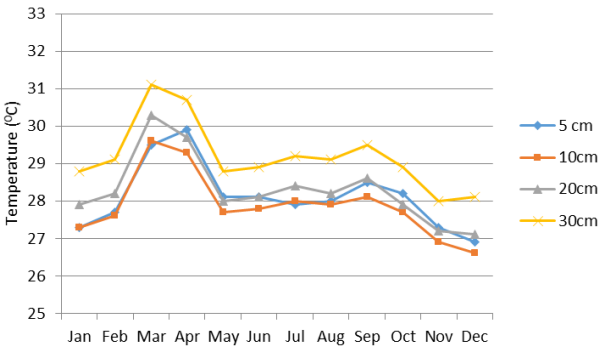


Fig. 8. Distribution of soil temperature at 4 different depths at 08:30 hrs during 2016

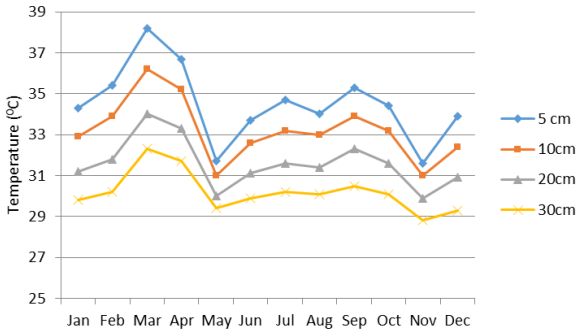


Fig. 9. Distribution of soil temperature at 4 different depths at 15:30 during 2016

Table 1. *Monthly variation of rainfall and rainy days in 2016*

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	198.3	(156)	13	(11)	5	7	1	90
February	106.3	(114)	09	(09)	2	7	-	96
March	126.4	(222)	09	(13)	7	9	-	127
April	240.3	(415)	20	(18)	-	13	-	111
May	977.8	(584)	29	(24)	6	25	4	87
June	159.4	(398)	21	(23)	4	15	-	84
July	157.7	(313)	18	(22)	7	14	-	87
August	128.0	(268)	22	(20)	8	15	-	90
September	51.1	(436)	14	(22)	10	6	-	87
October	266.5	(513)	23	(23)	14	11	2	96
November	365.1	(387)	18	(20)	4	13	1	81
December	189.2	(266)	14	(15)	6	8	-	93
Total	2,966.1	(4,072.0)	210	(220)	59	143	8	1129

* 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 – 2016*

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	32.7	22.9	27.8 (26.7)	-	5.4	89 (88)	20	79 (68)	1.1
February	32.9	22.8	27.9 (27.1)	01	3.2	88 (86)	14	74 (65)	1.3
March	34.1	23.7	28.9 (27.6)	-	7.0	84 (85)	16	72 (68)	1.7
April	33.8	24.3	29.1 (27.8)	-	6.7	92 (88)	4	72 (75)	1.6
May	31.0	24.5	27.8 (27.6)	-	2.7	87 (89)	18	83 (77)	1.5
June	31.0	24.5	27.8 (26.9)	-	5.1	88 (89)	12	74 (77)	2.4
July	30.9	23.8	27.4 (26.7)	-	5.4	88 (88)	13	73 (75)	2.1
August	30.6	24.2	27.4 (26.6)	-	6.9	85 (88)	14	80 (74)	2.5
September	30.7	23.7	27.2 (26.7)	-	6.0	88 (86)	9	82 (75)	2.5
October	31.3	23.2	27.3 (26.6)	-	5.6	86 (86)	8	79 (77)	1.8
November	31.2	22.9	27.1 (26.6)	-	3.1	87 (85)	11	84 (77)	1.2
December	32.4	22.2	27.3 (26.7)	03	4.7	86 (85)	12	78 (73)	1.7

** Average values for 1980-2005 are shown in parentheses

List of Publications

Scientific Journals
(Bold type - Employees of Rubber Research Institute of Sri Lanka)

Dissanayake, D.M.A.P., Gunarathna, P.K.K.S. and **Wijesuriya**, **W.** (2016). Evaluation of farmer awareness on rubber cultivation and production technologies in major rubber-growing areas of Sri Lanka. *Sri Lanka Journal of food and agriculture*, **1** (1). 39-50.

Sampath, W.D.M. and **Edirisinghe, D.G.** (2016). Effect of waste LDPE on properties of maleic anhydride treated NR/LDPE/waste LDPE composites. *The Journal of the Plastics and Rubber Institute of Sri Lanka* 1**5**, p.31-41.

Bulletin/Conferences/Seminars/Workshops/Reports

Dissanayake, W.M.S.L. and **Sampath, W.D.M.** (2016). Effect of blend composition on physical, chemical and morphological properties of natural rubber/Low density polyethylene blends. *Proceedings of the Winc 2016 Wayamba International Conference*, 19-20th August, 2016.

Fernando, T.H.P.S., Seneviratne, P., Siriwardena, D., Wijayaratne, C., Tennakoon, B.I., Peiris, P. and **Wijewardhana, A.N**. (2016). Efficacy of native anatagonistic microflora with special reference to *Trichoderma* sp. in the biological control of white root disease of rubber. *Proceedings of the Sixth Symposium on Plantation Crop Research,* Sri Lanka. 109-118.

Gayan, M.W.H., **Wijesuriya, B.W.**, **Sankalpa, J.K.S.,** Punyawardene, B.V.R., Premalal, S., Herath, H.M.L.K., Karunaratne, S.B., Peiris, B.L. and Amarasekera, N. (2016). Comparing the use of Standardized Precipitation Index (SPI) and Standardized Precipitation Evapotranspiration Index (SPEI) for Identifying Rainfall Anomalies in the Wet Zone. Wayamba International Conference 2016: 241p.

Hettiarachchi, R.P., Samarappuli, L., **Mithrasenea, U., Edirimanna, V., Thewarapperuma, A. Chandrasiri, J.A.S., Gunathilake, T.** and **De Silva, K.E.** (2016). Availability of plant nutrients from encapsulated fertilizers based on rubber latex and coir dust. *Proceedings of the Sixth Symposium on Plantation Crop Research,* Sri Lanka. 173-183.

Iqbal, S.M.M., Rodrigo, V.H.L., Munasinghe, E.S., Balasooriya B.M.D.C., Kudaligama, K.V.V.S., Jayathilake, P.M.M. and **Randunu, R.P.S.** (2016). Growth performance of young rubber (*Hevea brasiliensis*) in the Dry Zone of Sri Lanka; an investigation in Vavuniya district. *Proceedings of the Sixth Symposium on Plantation Crop Research,* Sri Lanka. 101-111.

Jeewanthi, P.W., **Wijesuriya, B.W.** and Sarath Kumara (2016). Application of response surface method for optimizing the efficiency of a process: A case study from centrifuge latex manufacturing process. *Wayamba International Conference* 2016: 297p.

Jeewanthi P.W., **Wijesuriya W**. and **Sankalpa J.K.S.** (2016). Changes Observed in Rainfall Patterns in Three Major Rubber Growing Areas. *Annual Research Colloquium on Agrarian Studies in Sri Lanka* 2016: 25p.

Kirushanthi, T., **Edirisinghe**, **D.G.** and **Jayasinghe, C.K**. (2016). Investigation on suitability of Banana fiber as a filler material in natural rubber latex-based household gloves. *Proceedings of the Research Symposium of Uva Wellassa University,* 28th January, 2016.

Kumara, P.R., **Munasinghe, E.S., Rodrigo, V.H.L**. and Karunaratna, A.S. (2016). Carbon footprint of rubber/sugarcane intercropping system in Sri Lanka; a case study. *Procedia Food Science* **6** (2016), 298-302.

Lakshman, R.G.N., **Kudaligama, K.V.V.S., Rodrigo, V.H.L., Iqbal, S.M.M., Attanayake, A.P., Randunu, R.P.S., Perera, M.K.P., Madushani, P.D.T.L.** and **Nadeeshani, A.A.A.** (2016). Effectiveness of S/2 d4 harvesting system in the rubber smallholder sector of Eastern province of Sri Lanka. *Proceedings of the Sixth Symposium on Plantation Crop Research,* Sri Lanka. 181-188.

Munasinghe, E. and **Rodrigo, V.H.L**. (2016). Effect of land productivity on the economic lifespan of rubber plantations; a situation analysis in Sri Lanka. *Proceedings of the International Rubber Conference 2016, International Rubber Research and Development Board*, Siem Reap, Cambodia. 21st – 22nd December 2016. 136-142.

Nayanakantha, N.M.C., Madhushani, K.D., Amarathunga, L.A.R., Wijesekera, G.A.S., Pathirana, P.D., Karunathilaka, W., De Zoysa, D.L.N., De Alwis, M.N., Handapangoda, R. and **Seneviratne, P.** (2016). Treatment with nitric oxide and seed coat removal improve germination dynamics and growth attributes of rubber (*Hevea brasiliensis*). *Proceedings of the Sixth Symposium on Plantation Crop Research,* Sri Lanka. 59-75.

Padmathilake M.A.V.N., Withanage, N.S., Dharmadasa, R.A.P.I.S., **Wijesuriya, W.** and Jeewanthi, P.W. (2016). Interference for tapping due to rainfall and effectiveness of rainguards under different rainfall scenarios: A case study in the Dartonfield Rubber Estate. *Wayamba International Conference* 2016: 138p.

Rodrigo, V.H.L. and **Munasinghe, E.S.** (2016). Competitive crops for rubber plantations; a comparative financial analysis under Sri Lankan conditions. *Proceedings of the International Rubber Conference 2016, International Rubber Research and Development Board*, Siem Reap, Cambodia. 21st – 22nd December 2016. 128-135.

Rupasinghe, P.V.S., Withanage, N.S., **Munasinghe, E., Rodrigo, V.H.L., Iqbal, S.M.M**. and Jayasinghe, H.A.S.L. (2016). Effect of anti-transpirant in sustaining rubber leaf physiology under dry climatic conditions. *Proceedings of the Sixth Research Symposium of Uva Wellassa University of Sri Lanka.* 79.

Sampath, W.D.M., Edirisinghe, D.G. and Egodage, S.M. (2016). Property improvements of natural rubber and low density polyethylene blends through dynamic vulcanization. *Proceedings of the Sixth Symposium on Plantation Crop Research,* Sri Lanka. 55-64.

Silva, M.K.R., Wjesundera, R.L.C., **Fernando, T.H.P.S.**, **Tennakoon, B.I.** and **Wijekoon, W.M.S.P.** (2016). Association of forest-origin tree species on the development of Brown root disease in Sri Lankan rubber plantations. *Twenty first International Forestry & Environment Symposium*, Sri Lanka.

Silva, M.K.R., Fernando, T.H.P.S. and **Tennakoon, B.I.** (2016). Potential use of lower concentrations of currently-used fungicides for the control of black stripe disease of rubber. Fifth Symposium of the Young Scientists Forum, National Science and Technology Commission, Sri Lanka.

Silva, S.P.P., **Nayanakantha, N.M.C**., **Seneviratne, P**. and Nugawela, A. (2016). Influence of selected clonal seedling rootstocks on growth of young budded rubber (*Hevea brasiliensis*). *Proceedings of 15th Agricultural Research Symposium.* 28th – 29th June 2016. Wayamba University of Sri Lanka.

Silva, T.U.K., Senevirathne, A.M.W.K., Seneviratne, P., De Costa, W.A.J.M., **Samarasekera, R.K.** and **Deshapriya, H.A.U.** (2016). Impact of different latex harvesting systems on bark consumption, yield and economic lifespan of rubber plantations in Sri Lanka. *Proceedings of the Sixth Symposium on Plantation Crop Research,* Sri Lanka. 125-133.

Weerakoon, W.M.T.H., **Attanayake, A.P., Gamage, H.V.K., Lokuge, C., Vitharana, L.P.** and Withanage, N.S. (2016). Effect of processing conditions on raw rubber properties of natural rubber. *Proceedings of the Sixth Symposium on Plantation Crop Research,* Sri Lanka. 43-47.

Wijesuriya, B.W., Sankalpa, J.K.S., Liyanaarachchi, L.A.T.S. and Gayan, M.W.H. (2016). Drought Indices to Identify Rainfall Anomalies in Rubber Growing Areas of Sri Lanka. *CRRI & IRRDB International Rubber Conference*, Siem Reap, Cambodia, 21-25 November 2016. 415-427.

Awards

Ratnayake, U.N., Edirisinghe, D.G., Sampath, W.D.M. and **Abeywardena**, **D.G.M.J.** (2016). Technology Award (Technology Award of Excellence) (2016). from the National Science Foundation for the project titled "High Performance Lighter Weight Prosthetic Foot based on Hybrid Nano-material Filled Natural Rubber Nano-composite".

Patents

Edirisinghe, D.G., Mahanama, **M.K.,** Rathnawardhana, M.K.N.N. and Gunathilaka, R.P.D. (2016). Patent was granted for "A Mechano-chemical Reclaiming Process (Oreclaim) for Ground Rubber Tyre" (Patent No. 17588).

GENETICS AND PLANT BREEDING

The annual hand pollination programme was carried out at Neuchatel breeding garden and one hundred and twenty one new genotypes were raised. The clone RRISL 201, RRISL 203 and RRISL 208 were used as female parents. Few male parents used from Non Wickham genetic collection other than promising clones.

Twenty two selections were made from 1990, 1991, 1996 and 1997 hand pollination progenies. Some of genotypes in year 2000 hand pollination progeny evaluating at Elston Estate were showed very good yield performance. The existing small scale and estate collaborative trials performed well. However, the recording of yield data was disturbed due to frequent rainfall.

Existing smallholder RRI collaborative trials in traditional and non-traditional rubber growing areas are performed well where few trials were given up due to poor support received from the smallholders. The trial established at Kataragama in 2015 was badly affected by dry weather and not in the position to continue.

Thousand eight hundred and sixty five number of accessories from 1981 IRRDB germplasm collection were selected for this year multiplication and establishment. All these were subjected to preliminary characterization before pollard them.

The procedure of total RNA isolation from rubber Latex was optimized. Ten genotypes selected from 1995 hand pollination programme were characterized and fifteen molecular markers tested were showed good genetic distance among them. Polymorphism was found among parents, grandparents and moderately susceptible control clones in year 2005 hand pollination progeny which is screening for Corynespora leaf fall disease resistance using SSR molecular markers.

PLANT SCIENCE

Seed survey revealed that there was a marked reduction in seed production in 2016 when compared to that in 2015 irrespective of clones and areas. Seeds treated with a botanical formula [using drumstick/ "Murunga" (Moringa oleifera) leaf extract] resulted in improved germination and growth of seedlings and budded plants. Two large scale sprinkler and drip irrigation systems were designed for rubber nurseries and fields in Padiyathalawa nursery site. Exogenous salicylic acid as a soil drench improved the growth of polybagged plants under both normal and restricted irrigation conditions and under glass house and nursery conditions. Growth and physiological data obtained from plants in Kilinochchi showed significant differences for clones. Test tapping yields obtained from young budded plants of RRIC 121 were better than those obtained from bare root plants of the same clone at 9th year of tapping.

Rubber x Agarwood intercropping experiment revealed that, among three Agarwood species [(Aquilaria crassna, Aquilaria subintegra and Gyrinops walla (walla patta)], a significantly higher girth and height was recorded from A. subintegra. G. walla showed the lowest values for growth under different shading and spacing conditions. Cinnamon and tea performed well when intercropped under rubber with wider inter row systems when compared to fruit crops such as rambutan, durian and jak with high stature at Kuruwita substation. Overall yield performance of the plants under high densities improved after converting the tapping system from conventional (S/2 d2 without stimulation) to low frequency harvesting with stimulation (S/2 d3 + 2.5%ET).

Modified tapping experiment at Pitiyakanda revealed that there was no significant difference in yield obtained through S/4 d3 + 5% ET 12/y and S/3 d3 + 2.5%ET 12/y systems with less bark consumption when compared to S/2 d/3 + 2.5% ET 5/y. Crop estimation experiments at Moneragala and Sapumalkanda revealed that the bark thickness at highest girth class was higher as compared to other two girth classes. A new stump budding experiment was commenced in Moneragala for evaluating performance among selected clones. A new experiment was commenced to reduce TPD incidence by using chemical and botanical formulas. All rubber nurseries in the country were inspected for quality assurance and reports were submitted. Post evaluation was done for the home garden project in Kalutara, Ampara, Moneragala and Polonnaruwa. Issuing technically specified tapping knives and marking plates, testing polythene were attended/ done by the department staff.

PLANT PATHOLOGY AND MICROBIOLOGY

Incidence of the secondary leaf fall diseases, Powdery mildew and Colletotrichum leaf disease was mild during the refoliation period except for a few disease vulnerable sites. According to the Corynespora disease screening programme, there were no new reports from the field plants in 2016. Incidence of Phytopthora disease was also at a mild condition during the year. The studies on the biology of the population of Rigidoporus spp. the causative agent of white root disease of rubber, were completed. Experiments were in progress to test the effectiveness of tree injection in white root disease management. The effectiveness of antagonistic plants against Rigidoporus identified in vitro conditions were being tested in the field. As the incidence of Brown root disease was high in the non traditional rubber growing areas, studies on the biology of the pathogen were under taken. The clonal screening programme for the 2016 was partially completed due to the lack of transport facilities. Imidacloprid was introduced to control cockchafer grub infestations in rubber plantations as a substitute for chlorophyrofos. Antagonistic fungi were identified from rubber growing areas to control the white root disease biologically. A compost based medium was used to prepare the biopesticide. A serum based medium to formulate a liquid biopesticide was tested in collaboration of Biochemistry and Physiology Department. Fungi and bacteria from different environments were isolated in view of developing bioremediation. Studies on microbes which are useful in waste water, treatments, fixation of heavy metals like cadmium and biological degradation of chlorophyrofos were in progress. Extraction of antifungal and antibacterial compounds from rubber latex is also in progress. A culture collection consisting beneficial fungi and bacteria was done for commercial purposes. A programme on identification of pest and diseases in non-traditional areas of the country was commenced with the funds received from the Ministry of Plantation Industries. Sites were selected to establish clonal screening trials in nontraditional rubber growing areas viz. Padiyathalawa, Kandakaduwa and Vavuniya. For the same purpose, nurseries consisting of fifty recommended and potential rubber clones were established in Monaragala.

SOILS AND PLANT NUTRITION

Improved nitrogen mineralization and K fertility, increased soil pH from extremely acidic levels was observed with Biofilm biofertilizer (BFBF). Improved root growth combined with high microbial activity in BFBF treatment enhanced the nutrient uptake efficiency. Although major nutrients in soils showed no increased concentrations with BFBF treatments, it has yielded a high plant dry matter production and major plant nutrients N, P, K and Mg uptake of nursery plants. Immature field plants showed a higher growth rate and leaf nutrient contents with combined use of chemical fertilizer with BFBF treatment when compared to those with only use of chemical fertilizers. Application of weedicides, Glyphosate, Glufosinate ammonium did not show any harmful effect on soil microbial population and available soil nutrient levels of N and P during the incubation period of 3 months. Application of commercially available slow release fertilizers for rubber nursery plants showed comparable growth parameters to recommended fertilizer applications at biweekly intervals. . Introduction of locally produced coir and rubber based slow release fertilizer for immature field plants had given promising results compared to conventional fertilizer applications. Degraded soil fertility under immature clearings was found to be enhanced by combine use of environmental friendly agro management practices. Site specific fertilizer recommendation programme provided 36 fertilizer recommendation reports for 3600 ha of mature rubber. Seven land suitability reports were issued for 500 ha under land selection programme. Analytical reports were sent for approximately 1100 samples (5000 parameters) including 170 fertilizer samples for outside organizations to assure application of good quality fertilizers to rubber lands.

BIOCHEMISTRY AND PHYSIOLOGY

Recently recommended S/2 d4 low frequency harvesting system has been adopted in about 20 ha of rubber land in both smallholdings and estates. In order to identify best genotypes for the sub-optimal climatic conditions in non-traditional rubber growing areas, new experiments were established at Vauniya, Kandakadu, Padiyathalawa and Mahaoya with 10 clones.

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 Nivithigalakele division of Dartonfield estate was also selected to investigate the adaptability of S/2 d4 system at commercial scale. In addition, a weekend harvesting system was also being tested in Kuruwita RRISL substation at commercial scale. Testing of S/2 d4 harvesting system in the Intermediate Zone was continued at RRISL Substation, Polgahawela.

Testing of physical properties and biochemical composition of rubber wood with respect to clone and age has been continued. A new experiment on identification of effect of non-rubber components on quality of raw rubber was commenced in view of developing a system to screen best clones which produce quality raw rubber, at the early stages of the breeding and selection programme.

ADVISORY SERVICES

Seven hundred and fifty eight (758) rubber smallholdings were inspected in the Monaragala district by REOo and necessary corrections in agronomic aspects were attended for improvements under the Smallholders Plantation Entrepreneurship Development Programme (SPEnDP). Under this, awareness programmes were also conducted for the benefit of 543 rubber farmers on general aspects of rubber cultivation, maintenance and processing. In addition, farmer training programmes were conducted to educate 2267 rubber growers on general cultivation and processing aspects of rubber. Also, sixty selected youth were trained on value addition of rubber. A special focus was made on tapping related training programmes and introduced 550 new rubber tappers. As a noval approach in technology transfer, sixty village youth in Monaragala district were trained as para extension service providers.

As a farmer participatory approach, 185 rubber lands in different REO divisions in traditional rubber growing areas were developed as model rubber holdings. Status of 81 immature substandard rubber holdings and 89 mature substandard rubber holdings were improved successfully. Thirty eight rubber processing centers were developed as models and construction of 18 new RSS processing centers and rehabilitation of 9 substandard centres were attended. As a solution to the tapper shortage, 357 new harvesting assistants were introduced through Tapping Training Schools (TTS) and 1407 semi skilled harvesting assistants were trained to improve their technical quality in tapping.

Group extension programme called "Vihidum Sathkara" was effectively conducted providing advisory and extension services for 1942 and 54 rubber smallholdings and medium scale rubber lands, respectively in traditional rubber growing areas for necessary improvements. Nearly seven hundred advisory visits were carried out to solve problems in technology adoption on requests made by rubber smallholders. Basic data and information were collected to develop selected villages as model rubber villages. Preliminary works to establish two technology transfer centres at Kegalle and Ratnapura were attended for effective technology transfer to rubber growers.

RUBBER TECHNOLOGY AND DEVELOPMENT

Rubber composites using fibres of Pandanas (Watakeiya) and powdered dried leaves of Water Hyacinth (Japan Jabara) were developed with the aim of producing green rubber composites. Six crepe rubber based vulcanizates were produced with the aim of producing an infant play item and the sheets were handed over to the manufacturer to test for nitrosamines. A natural rubber (NR) based compound suitable for roofing sheets was developed on request. Also, a NR compound with good adhesion was developed for a glove manufacturer. Further, a rubber compound was prepared with the aim of manufacturing a bat grip with a textured surface on a request made by a cricket coach and physico-mechanical properties were evaluated. A NR latex based adhesive for shoes was developed at the request of a rubber small holder cum entrepreneur.

A series of NR/low density polyethylene (LDPE) simple blends were prepared by varying the NR:LDPE blend ratio and physico-mechanical properties were evaluated. NR/nitrile rubber (NBR)/polyvinyl chloride (PVC) blend was produced on a request made by an automobile component manufacturer.

NBR glove waste was reclaimed using an environmental friendly, novel reclaiming agent and the properties of virgin NR/reclaimed NBR blend composites developed were found to be comparable to those of composites prepared with virgin NR and NBR glove waste reclaimed with TMTD. This work was conducted on a request made by a leading glove manufacturer. Patent was granted for "Oreclaim - A mechano-chemical reclaiming process for ground rubber tyre (GRT)".

Conducted twenty five workshops on "Rubber based products manufacture" for SMEs/rubber farmers in collaboration with Thurusaviya Fund/RDD/ NIPM/SPEnDP. Further, the staff was involved in transferring knowledge on rubber based products manufacture to the public at four exhibitions. Tested 657 samples of raw rubber, rubber compounds and products at the request of the rubber industry.

POLYMER CHEMISTRY

The study of introduction of a plant based preservative system for natural rubber latex that helps to replace the harmful TMTD/ZnO preservative system used in the centrifuged latex industries was continued throughout the year. Trials were commenced to evaluate raw rubber properties of RSS made out from blends of Skim Natural Rubber Latex (SNRL) and Field Natural Rubber Latex (FNRL).

A manufacturing technology for the manufacture of Coir pith encapsulated slow releasing fertilizer blocks was developed at the request of Soils and Plant Nutrition Department. A latex based adhesive was developed for footwear industry at the request of a medium scale rubber state owner. Trials were carried out to develop a water-proofing cement using commercially available low cost polymer solutions. More than thousand samples of polymer materials were analyzed using a Fourier transform infrared spectroscopy (FTIR) spectrophotometer.

RAW RUBBER AND CHEMICAL ANALYSIS

The department is 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 four hundred dry rubber samples two hundred seventy nine latex samples, thirty one rubber processing chemicals, thirty two bleaching agent samples. Three hundred and eighty six 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.

Effects of ethephon stimulation for dynamic mechanical properties were studied for stimulated rubber. New test method for the determination of dirt content was established to replace highly toxic chemical used in previously used method. Registration of TSR manufacturing factories was started and registration offered to a one TSR manufacturer. Trouble shooting activities were carried out regarding quality issues raised for Vietnam latex.

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

Two natural rubber types namely skim natural rubber which is a byproduct of natural rubber latex centrifugation process containing high proportions of non-rubbers and unfractioned and unbleached crepe rubber (UFUB) were used to prepare thermoplastic natural rubber blends (TPNR). They were melt blended with polyethylene (PE) at 1:1 ratio by weight. The Physico-mechanical and processability studies of these blends were carried out. The performance of these blends was compared with the Standard Lanka Rubber (SLR) and polyethylene plastic blends prepared at the same weight ratio.

It has found that high non rubber content present in the skim rubber has not influenced the preparation and processing characteristics of skim/PE blends. The study also confirmed that all the skim/PE (50/50) blends vulcanised at different sulphur concentrations poses the thermoplastic elastomer characteristics. Physical and mechanical properties of skim/PE blends types did not exhibits significant inferior properties compared to that of SLR/PE blends. However, it was found that onset vulcanization time becomes faster in skim/PE blends. EPDM could be used as a potential compatibilizer for skim/PE blends as evident from the improved properties such as tensile strength, hardness, swelling resistance of compatibilized blends. The optimum EPDM content for the skim/PE blends was found to be 10%.

Linear Low Density Polyethylene (LLDPE) blended with Un-fractioned and Unbleached Crepe Rubber (UFUB) and TSR separately. In these systems also, rubber phases were dynamically vulcanized at different sulphur concentrations. The results showed that UFUB/LLDPE blends show lower onset vulcanization times than TSR/LLDPE blends. The tensile strength and elongation at break percentage of UFUB/LLDPE blends reported to be higher than that of SLR/LLDPE blends. However, Hardness of both blend systems did not show a significant difference at all sulphur concentration studied. It was also revealed that latter has the higher aging resistance than the formed blend.

The project on use of natural rubber (NR) latex sludge as filler for natural rubber compounds was continued. In an attempt to improve the adhesion between processed sludge filler particles and NR, surface modification of filler following three chemical surface treatments using three surface modifiers were carried out. Three surface modifiers used were stearic acid, Triethoxy vinyl silain (TEVS) and zinc stearate and straric acid was found to be the best among the three, candidates as assed intern of processing safety and tensile properties of the composites.

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

ADAPTIVE RESEARCH

Rubber cultivation in Vavuniya under smallholder conditions showed a reasonable growth with an average annual girth expansion rate of 8.6cm. As the first record for the Dry Zone in the country, the growth curve for the immature phase of rubber was established. Rubber was successfully established at Vishwamdu in Killinochchi District. Financial analyses on lifespan of rubber cultivation indicates that at present market price and existing tree densities, life cycle of about 20 years could be adopted for high level of profitability.

BIOMETRY

Development, modification of statistical methods, research support and studies on climatology are the three major research and development focuses of the Biometry section. 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 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. New recording type rain gauges were installed in the Meteorological Stations in the sub-stations, Moneragala and Kuruwita.

AGRICULTURAL ECONOMICS

Agricultural Economics Unit (AEU) was conducting a survey to find out the sustainability of rubber based farming systems of the small holder sector in Moneragala District. AEU has examined the resource quality for rubber farming in Nuwara-eliya district of Sri Lanka in collaboration with Biometry section using multi criteria and GIS approach. The studies conducted during year were focused on analysis of productivity and their driven forces in the smallholder sector in Kalutara district. AEU has involved in various economic analyses and collaborative research with the Biometry section and Advisory Services Department throughout the year. A Few analyses were focused on technical efficiency on latex harvesting at Dartonfield estate. GIS databases preparation was done on estates own by the RRI which is flexible and effective mechanism to the decision makers for efficient planning and management in rubber. Also AEU has completed analyses on rubber industry performance.

LIBRARY AND PUBLICATION

The Library and Publication Section continued with its regular services in collecting and disseminating information on natural rubber and related subject areas and processing and publishing of its regular publications.

Fifteen text books were added to the reference section of the Library bringing the total collection up to 6050.

While eight Journals were purchased, 30 titles were received on exchange basis.

DARTONFIELD GROUP

A total crop of 176,136 kg has been harvested during this season. The actual crop harvested was 89% of the estimated crop. But when comparing with the previous year's crop, this is an increase of 8%. The crop harvested from the rainguard area was 24,994 kg which amount to 14% of total harvested crop.

The YPH for the year was 972 kg and compared with the same period last season, it has increased by 80 kg.

The average intake per tapper recorded during the year was 7.4kg from a tapping task of 232 trees. Highest intake per tapper of 10.2kg was recorded from the 1990 clearing with a tapping task of 302 trees of clone RRIC 130/121 tapped on 1/2S d3 tapping system of Gallewatta division.`

The total number of Normal, Late, Rain guard & No tapping days recorded during the year were 258, 07, 39 and 62 respectively.

Total rainfall recorded for the year was 2,682.1mm with 181 wet days. When compared with the same period last year, it is less by 1,332.4mm and wet days less by 29 respectively.

The COP and NSA achieved for the year were Rs.241.13 and Rs.234.84 respectively, giving a loss of Rs.6.29 per kg and a total loss of Rs.1.1 million. Deficit per hectare recorded for the year was Rs.6,111.52 .

Latex Crepe No.01 manufactured during the year was 70% and RSS No.01 was 88% of the total Crepe and RSS.

KURUWITA SUB - STATION

The mature and immature extents of the Kuruwita Sub Station were 75.66 and 6.50 hectares respectively during the year.

A total crop of 104,651 kg was harvested during the year recording an increase of 4,481 kg on previous years crop.

The actual yield per hectare (YPH) was 1,383 kg. The average intake tapper (IPT) of the estate was 9.1 kg and this is an increase of 0.2 kg when compared with the previous year.

The total number of Normal, Late, Rainguarded and No tapping days recorded during the year were 344, 08, 84 and 14 respectively.

The annual rain fall recorded during the year was 3,342.8 mm with 222 wet days as against 4,002.14 mm with 251 wet days during the previous year.

The cost of production (C.O.P.) and the net sale Average (N.S.A) for the year were Rs.179.27 and Rs.217.11 per kg respectively. The profit made for the year was Rs.3.9 million and the profit per hectare recorded for the year was Rs.52,339.33.

POLGAHAWELA SUB - STATION

A total crop of 13,753 kg, has been harvested during this season and it was 117% of the estimated crop. This was 12% increase wit compared to the previous year's crop.

The YPH for the year was 1,170 kg (Months of October and November were not tapped due to heaver drought condition prevailed). This was an increase of 34 kg over the last year's value recorded for the same period.

The average intake per tapper recorded during the year was 9.6 kg. The highest intake per tapper of 10.1 kg was recorded from the 2005 clearing with a tapping task of 216 trees of clone RRIC 121 tapped on S2D2, S2D3 and S2D4 systems.

The total number of Normal, Late, No tapping days during the year were 240, 24 and 101 respectively.

Total rainfall recorded for the year was 1,947 mm with 24 wet days. Out of the total manufactured RSS, the share for No.01 grade is 83%.

METEOROLOGICAL REPORT

The total annual rainfall at Dartonfield was 2,966 mm which accounted for a decline of 29% compared to the previous year. This was the lowest during the last 17 years recorded at the Dartonfield meteorological station located in the Agro Ecological Region, WL_{1a}. The monthly rainfall distribution at Dartonfield during this year departed from the usual pattern. Above average monthly rainfall values were observed in January and May while below average values were recorded in the rest of the months, except for November which was very close to the long term average. The minimum monthly rainfall of 51 mm and the maximum monthly rainfall of 978 mm were recorded in September and May, respectively. Rains during the South West season (May September) decreased by 436 mm compared to the previous year. Rainfall during IM1 (March & April) in 2016 is about 248 mm lower than 2015. During North East and IM2 seasons, 2016 recorded lower values; viz. 84 mm and 434 mm, respectively compared to 2015.

There were 2 rainfall events that exceeded the hazardous limits for land slides (100 mm of rainfall during a day) reported during the year under review. The observed total number of rainy days of the year was 210, which was below the long term average (222) by 12 days. A dry spell lasted over a month or more can have adverse impacts on rubber plantations. There were only 5 dry spells greater than or equal to 7 days; the longest being 13 days, from 12^{th} to 24^{th} March.

The daily average temperature pattern was fairly steady with a mean annual temperature of 27.3^0C and a standard deviation of 0.9, which could be a favourable condition for rubber plantations. The lowest mean minimum temperature of 22.2^0C was observed in December while the highest mean maximum temperature of 34.1^0C was observed in March.

A total of 1,962 bright sunshine hours was received at an average rate of 5.4 hours/day which was comparatively higher than the respective figures observed during the last year. Bright sunshine hours exceeded 6 in 47% of the days, while in 28% of the days it was below 4 hours. The mean RH values recorded at 08:30 and 15:30 were 86% and 78%, respectively.