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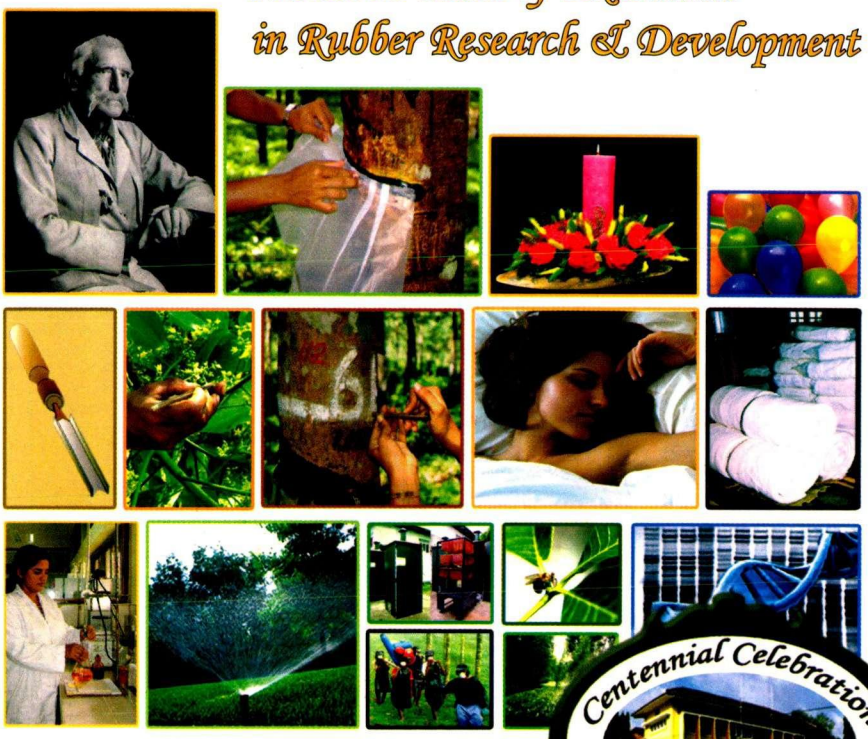
RUBBER RESEARCH INSTITUTE OF SRI LANKA

Hundred Years of Excellence in Rubber Research & Development



Annual Review 2009

RUBBER RESEARCH INSTITUTE OF SRI LANKA ANNUAL REVIEW 2009

United -Moratuwa

Cover Story

Hundred Years of Excellence in Rubber Research and Development

Rubber Research Institute of Sri Lanka, the oldest of its nature in the world commemorated 100 years of excellence in Research and Development during the year.

The origin of the Institute goes back to 1909 when a group of British planters agreed to engage a Chemist to study the coagulation of rubber. From that small beginning the Rubber Research Institute has grown into a well equipped research station providing a valuable service to both the rubber growers as well as the industrialists.

The steady growth of the RRISL in its research and development activities contributed significantly to enhance the land productivity in the country and won the recognition as an International Centre for Excellence on NR research. Among many of the internationally recognized innovations, development of high yielding clones tolerant to diseases is one of the milestones led to revolutionize the NR industry in our motherland.

As a world leader in natural rubber related R & D activities we assure all stakeholders the fullest support to meet the ever increasing challenges for a sustainable rubber industry in Sri Lanka.

Rubber Research Institute of Sri Lanka

Annual Review – 2009

1st January 2009 to 31st December 2009

Editors
R C W M R A Nugawela, PhD (Essex)
W M G Seneviratne, PhD (Sussex)
C K Jayasinghe, PhD (Sri Lanka)

Head Office & Laboratories
Dartonfield
Agalawatta

Board Office & Laboratories
Telewela Road
Ratmalana

CONTENTS

RUBBER RESEARCH BOARD OF SRI LANKA

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Members appointed by the Hon Minister of Plantation Industries

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Mr T M J Bandara, Asst. Director, National Planning, General Treasury
Mr S S Poholiadda, Director Operations, Kegalle Plantation Ltd.
Mr R C Peiris, Executive, Lankem Tea & Rubber Plantation Ltd.
Mr Anura Edirisinghe, Representative, Colombo Rubber Traders Association
Mr Justin Seneviratne, Director, Lalan Rubbers (Pvt.) Ltd.

Ex-Officio Members

Dr A Nugawela, Director, Rubber Research Institute
Mr W Rubasinghe, Director General, Rubber Development Department (up to 18.09.2009)
Mr G D V Perera, Chairman, Planters Association of Ceylon

STANDING COMMITTEES

Estates Committee

Mr J Y Peries, Chairman, Rubber Research Board
Dr A Nugawela, Director, RRI
Dr C K Jayasinghe, Deputy Director - Research (Biology), RRI
Miss W K V de Silva, Deputy Director (Administration), RRI
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Mr S A R Samarasekera, Assistant Superintendent, RRI Sub-station, Kuruwita
Mr S B Dissanayake, Manager, Dalkeith Estate, Baduraliya & Visiting Agent for Dartonfield Estate
Mr Salinga Dissanayake, Deputy General Manager, Peenkanda Estate, Nivitigala & Visiting Superintendent for Kuruwita Sub-station
Mr N B Seneviratne, Manager, Eladuwa Estate, Matugama
Mr S Eriyagama, Director, Agalawatta Plantations Ltd., No 10, Gnanartha Pradeepa Mawatha, Colombo 8 (from 22.06.2009)
Mr S Doranegama, Superintendent, Pallegoda Estate, Dharga Town (from 22.06.2009)
Mr W Kularatne, Accountant, RRI (In attendance)

Audit and Management Committee

Mr T M J Bandara, Asst. Director, National Planning, General Treasury
Mr W Rubasinghe, Director General, Rubber Development Department (up to 18.09.200)
Dr A Nugawela, Director, Rubber Research Institute

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Dr A Nugawela, Director, RRI
Dr W M G Seneviratne, Deputy Director Research (Technology), RRI
Dr C K Jayasinghe, Deputy Director Research (Biology), RRI
Dr (Mrs) L Samarappuli, Head, Soils and Plant Nutrition Dept., RRI
Dr (Mrs) P Seneviratne, Head, Plant Science Dept., RRI
Dr Anura Dissanayake, Head, Advisory Services Dept., RRI
Dr V H L Rodrigo, Head Biochemistry Dept., RRI
Dr R S Dharmakeerthi, Soil Chemist (Principal Research Officer) Soils & Plant Nutrition Dept., RRI
Dr (Mrs) Wasana Wijesuriya, Biometrician, RRI
Dr Susantha Siriwardena, Head, Raw Rubber Process Development and Chemical Engineering Dept., RRI
Dr S M M Iqbal, Agronomist, RRI
Mrs D G Edirisinghe, Acting Head, Rubber Technology and Development Dept., RRI
Mrs S P Withanage, Geneticist and Plant Breeder, RRI
Mr Sarath Kumara, Rubber Chemist, RRI
Mrs A P Attanayake, Assistant Rubber Chemist, RRI
Dr A M W K Seneviratne, Botanist, RRI
Mr N M C Nayanakantha, Botanist, RRI
Mrs T H P S Fernando, Assistant Plant Pathologist, RRI
Mrs K V V S Kudaligama, Assistant Biochemist, RRI
Mrs Nilmini Liyanage, Assistant Rubber Chemist, RRI
Mr H N K K Chandralal, Assistant Rubber Chemist, RRI
Mrs D Seneviratne, Assistant Rubber Chemist, RRI
Mr H M L K Herath, Assistant Biometrician, RRI
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Mr J Perera, Superintendent, Dartonfield Group, RRI
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Mr R C Peries, Director/CEO, Kotagala Plantations Ltd., No.53 1/1, Sir Baron Jayathilaka Mawatha, Colombo 1
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Mr Gunendra Sellahewa, Supplies Manager, Dipped Product, No.400, Deans Road, Colombo 10

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Mr M R Fernando, Superintendent, Malaboda Estate, Matugama

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Mr T H Gamage, Superintendent, Madampe Estate, Rakwana

Mr M P H Gunaratne, Manager, Bentota Estate, Elpitiya

Mr S F Fernando, Manager, Dewalakanda Estate, Dehiowita

Mr J N Hettiarachchi, Manager, Padukka Estate, Padukka

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Mr Rolly Duglus, Manager, Opatha Estate, Kahawatta
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Mr A Rajasinghe, Superintendent, Galatura Estate, Kiriella
Mr A F Peries, Group General Manager, Pitiyakanda Group, Mawathagama
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Mr D M D B Daswatte, Manager, Geekiyanakanda Estate, Neboda
Mr C U Pallegama, Senior Manager, Rayigam Estate, Ingiriya
Mr Athula Rajasinghe, Superintendent, Galatura Estate, Galatura
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Mr Jeewantha Senarathne, Manager, Palmadulla Estate, Kahawatta
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Mr N B Seneviratne, Deputy General Manager, Namunukula Plantations, Eladuwa Estate, Matugama
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Mr R T Tennakoon, Manager, Sorana Estate, Horana
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Mr S Doranegama, Superintendent, Pallegoda Estate, Yatadola
Mr C Seneviratne, Manager, Udabage Estate, Deraniyagala
Mr S C T Fernando, Manager, Uskvalley Estate, Baduraliya
Mr R A Alahakoon, Superintendent, Yatadola Estate, Matugama
Mr R Seneneviratne, Group Manager, Halpe Estate, Tummodera
Mr C A Amarathunga, Deputy General Manager, Edarapola Estate, Bulathkohupitiya
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Mr Y N Samarasinghe, Manager, Poranuwa Estate, Kahawatta
Mr K G Thilakaratne, Group General Manager, Mahaoya Group, Lalan (Pvt) Ltd., Dehiowita
Mr Mr N D Madawala, Manager, Udabage Estate, Deraniyagala

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Dr A Nugawela, Director, Rubber Research Institute
Miss W K V de Silva, Deputy Director (Administration)
Mr W D Wimaladasa, Elected Committee Member
Mr H H Jayasinghe, Elected Committee Member
Mr W Kularatne Accountant, RRI (In-attendance)

Chairman's Office & Board Secretariat

Chairman	- Mr J Y Peiris
Deputy Director (Administration)	- Miss W K V de Silva
Confidential Clerk/Stenographer	- Mrs B H P Balasooriya

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Attorney General's Department
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Auditor General
Auditor General's Department
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e-mail: rrigpb@sltnet.lk

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e-mail: rrikuruwita@sltnet.lk

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Director	011 - 2635142
Deputy Director Research (Technology)	011 - 2633351
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RUBBER RESEARCH INSTITUTE OF SRI LANKA

STAFF

DIRECTORATE

Director	R C W M R A Nugawela, BSc (SL), MSc (Lond.), PhD (Essex)
Deputy Director - Research (Biology)	C K Jayasinghe, BSc (SL), MSc (SL), MSc (Agric) (Aust.), PhD (SL)
Deputy Director - Research (Technology)	W M G Senevirante, BSc (SL), PhD (Sussex)
Deputy Director (Administration)	Miss W K V de Silva, BA (SL), LLB, Attorney at Law

RESEARCH DEPARTMENTS

Genetics and Plant Breeding

Geneticist and Plant Breeder	**Mrs S P Withanage, BSc Agric (SL), MSc (India)
Assistant Geneticist and Plant Breeder	K K Liyanage, BSc Agric (SL)
Development Officer	K B A Karunasekera
Experimental Officers	K W Rupatunga
	I D M J Sarath Kumara
	L S Kariyawasam
	T M S K Gunasekera
	H P Peries, Dip. Agric (Kundasale)
	Mrs A K Gamage, BSc (SL)
Clerk/Typist	Mrs S D P K L Peiris

Plant Science

Head of Department	Mrs G P W P P Seneviratne, BSc (SL), PhD (Bath)
Botanist (Principal Research Officer	A M W K Senevirathna, BSc (SL), MSc (SL), PhD (Wales)
Botanist (Senior Research Officer)	N M C Nayanakantha, BSc (SL), MSc (India) (up to 13.12.2009)
Assistant Botanists	N A A D Wickramaratna, BSc Agric (SL), PhD (Canada) (from 12.10.2009)
	Mrs D S A Nakandala, BSc Agric (SL)
	K A G B Amaratunga (from 01.02.2009)
	T U K Silva, BSc Agric (SL), MPhil (SL) (from 01.02.2009)

Experimental Officers	R P Karunasena
	Mrs G A S Wijesekera
	Mrs R K Samarasekera
	M K P Perera, BSc (SL)
	W D M N de Alwis, BSc (SL)
	D L N de Zoysa
	P D Pathirana, BSc (SL)
	P K W Karunathilake, Dip. Agric (Ratnapura)
Technical Officer	R Handapangoda, BSc Agric (SL) (from 01.02.2009)
Clerks	Mrs H D D E Jayawardena
	Mrs Aruni de Almeida

Plant Pathology and Microbiology

Head of Department	**Miss W P K Silva, BSc (SL), MSc (SL), MPhil (Aust.), PhD (SL)
Assistant Plant Pathologist	Mrs T H P S Fernando, BSc (SL), MPhil (SL)
Experimental Officers	E B Fernando
	Mrs B I Tennakoon, Dip. Agric (Kundasale)
	Mrs E A D D Siriwardene, BSc (SL)
	S C P Wijayaratne, NDT Agric (Hardy)
	Mrs N Jayawardene, Dip. Agric. (Bibile)
	S R D P C Peiris, BSc (SL)
	E A D N Nishantha, Dip. Agric. (Ratnapura)

Audio Visual Aids and Photographic Unit

Audio Visual Aids Production Officer	L W Amaratunge

Soils and Plant Nutrition

Head of Department	Mrs M L A Samarappuli, BSc Agric (SL), MSc (California), PhD (SL), F I Biol. (SL)
Soils Chemist (Principal Research Officer)	R S Dharmakeerthi, BSc Agric (SL), MSc (SL), PhD (Canada)
Assistant Soils Chemist	Mrs R P Hettiarachchi, BSc (SL), MPhil (SL)
Experimental Officers	H D S P Perera, BSc (SL), MSc (SL)
	Mrs S D C K Maheepala
	S N Silva
	P Karunadasa, BSc (SL), MSc (SL), M I Biol. (SL)
	A H U Mitrasena

Experimental Officers	A N Yakandawala
	T B Dissanayake
	Miss V U Edirimanne, BSc (SL)
	Miss A P Thewarapperuma
	P A C R Puhambugoda, NDT Agric (Hardy)
	P D T C Gunatilleke
Technical Officers	J A Sarath Chandrasiri (from 01.07.2009)
English Stenographer	Mrs K A D L Rupasinghe Perera

Biochemistry and Physiology

Head of Department	V H L Rodrigo, BSc Agric (SL), MSc (Essex), PhD (Wales)
Assistant Biochemists	* Mrs G V L Nilmini, BSc (SL)
	Mrs K V V S Kudaligama, BSc (SL), MPhil (SL)
Experimental Officers	D Ramawickrema (up to 03.11.2009)
	P D J Rodrigo
Technical Officer	R P S Randunu, BSc (SL) (from 01.02.2009)

Polymer Chemistry

Rubber Chemist	Mrs C J Wellappili, BSc (SL), MSc (SL), PhD (Cardiff) (up to 27.04.2009)
Assistant Rubber Chemists	Mrs A H R Nilmini, BSc (SL), PhD (Cardiff) (from 24.08.2009)
	H N K K Chandralal, BSc (SL), MSc (SL) (from 01.02.2009)
Experimental Officers	Mrs D I R Denawaka, Dip. Rubber Tech. (PRI)
	Mrs W C M Kuruppu, Dip. Rubber Tech. (PRI), Certificate Rubber Tech. (Moratuwa)
	S S Warnapura
	S L G Ranjith, Dip. Rubber Tech (PRI)
	S M A Samarakoon, Dip. Agric. (Kundasale)
	Miss D M S Wijesekera, Dip. Rubber Tech. (PRI)

Raw Rubber and Chemical Analysis

Assistant Rubber Chemist	Mrs A P Attanayake, BSc (SL)
Experimental Officers	Mrs H S Weeraman, Certificate, Rubber Tech. (PRI)
	Mrs L Wanigatunga
	Mrs H V K Gamage

Experimental Officers	Mrs C S Lokuge
	L P P Vitharana
	K R N Karunatilleke, Dip. Rubber Tech. (PRI)
	B Gunasiri
	W D Wimaladasa
Clerk	Mrs I Wijesinghe

Electronic Instruments Repair Unit

Instrument Technician	L G P Lelwela

Rubber Technology and Development

Acting Head of Department	Mrs D G Edirisinghe, BSc (SL), MSc (SL), MPhil (UK)
Assistant Rubber Chemist	Mrs G D D Seneviratne, BSc (SL) (from 18.08.2009)
Experimental Officers	Mrs M K Mahanama, Dip. Rubber Tech. (PRI)
	Mrs S I Yapa, Dip. Rubber Tech. (PRI)
	Mrs P C Wettasinghe
	P L Perera
	T A A I Siriwardene
	Mrs G M Priyanthi Perera, BSc (SL), MSc (SL)

Raw Rubber Process Development and Chemical Engineering

Head of Department	S Siriwardene, BSc (SL), MSc (Australia), PhD (Malaysia)
Rubber Chemist (Senior Research Officer)	**R M U Ratnayake, BSc (SL), PhD (Loughborugh) (up to 01.04.2009)
Assistant Rubber Chemist	P H Sarath Kumara, DPRI, MSc (SL)
Experimental Officers	Mrs W K C Nalinie, Dip. Rubber Tech. (PRI)
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	E C D Senanayake
	Mrs U M S Priyanka, BSc (SL), MSc (SL)
	Miss V C Rohanadeepa
	A K D W Prasad
Store Keeper	Mrs L Rukmanie
Clerk	Mrs S A Paranavithana

Biometry Section

Biometrician	Mrs B W Wijesuriya, BSc Agric (SL), MPhil (SL), PhD (SL)

Assistant Biometrician	H M L K Herath, BSc Agric (SL), MSc (SL) MSc (USA) (from 12.01.2009)
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

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Research Assistants	W A D D S Wettasinghe
	Mrs E S Munasinghe, BSc Agric (SL)
	Mrs B M D C Balasooriya, BSc Agric (SL)

Polgahawela Sub-Station

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Accounts Clerk	Mrs W A C Weeramanthree

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Clerk/Typist	P M P Jayantha

ADMINISTRATION DEPARTMENT

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Administrative Assistant	Mrs M D P Mandalawatta
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	Mrs P W Neelamanie
	Mrs S K Hadunge
Clerk/Typists	Mrs J A D Wijayanthi
	Mrs B D Niranjala
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Translator	Mrs D N Senevirathna, BSc (SL)
Telephone Operator	Mrs J A D C Preethika
Pharmacist	S Lankeshwara

Internal Audit Unit

Internal Auditor	Mrs M S I Senadeera, AFA, IIPF, IRCA, LICA

Internal Audit Officer	K C Fernando
Clerk/Typist	Mrs S N Munasinghe

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Electrical Foreman	W D Ratnasinghe
Building Foreman	M A D K Jayasumana
Transport Officer	U L D R L Gunasinghe
Chief Clerk	Miss M G Silva
Clerk/Typists	Mrs K C S Wickremasinghe
	Mrs J A S Dharshanie (Dip. in Management)
Work Supervisor (Electrical)	T M R P Tennakoon

Accounts Section

Accountant	W Kularatne
Accounting Assistant	D D R Lankatilaka, BCom (SL)
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	Mrs M Gunawardene
	Mrs K Kapuge
	Mrs R Handungoda
	Mrs G P Kukulewithana
Clerks	A V Nandasena
	Mrs K J M C R Fernando
Cashier	Mrs G A D D Jayawardena
Junior Assistant Clerks	Mrs C Dissanayake
	A K D A Wickremasinghe
Store-Keeper	D C P Pothmitiyage (up to 03.02.2009)
Assistant Purchasing Officer	K D Sumanasena

DARTONFIELD GROUP

Estate Superintendent	Jehan Perera
Senior Clerk	K K P Gunawardena
Junior Assistant Clerks	Mrs S I K Pathirage
	Mrs O W D Namalie Udayanthi
Factory Officer	D S K Ranaweera

Kurkwita Sub-Station

Visiting Superintendent	Salinga Dissanayake
Assistant Estate Superintendent	S A R Samarasekera

Junior Assistant Clerk	D S Jayasinghe

ADVISORY SERVICES DEPARTMENT

Head of Department	D M A P Dissanayake, BSc Agric (SL), PhD (Aberdeen)
Regional Advisory Officers	A H Kularatne, BSc Agric (SL), MSc (Reading), MSc (SL)
	P K K S Gunartne, BSc Agric (SL)
Divisional Rubber Extension Officers	D Podimahattaya
	R A D Ranawaka
	I Kiridena
	L L A Samarawickrama, BSc (SL)
	U L R A Perera
	R L R U S Bandara
	H H Jayasinghe
	M G N Gunaratne
Rubber Extension Officers	D Weerasekera
	W D T C Muniratne, Dip. Plant Ex Mangt.
	K V Nandanakumara
	D R A M G Abeydissanayake
	R M S Ratnayake, NDT Agric (Hardy)
	D E P M Nanayakkara, Dip. Agric. (Aquinas)
	W D Chandrasiri
	M Dharmadasa, BSc (SL), MSc (SL)
	J A J Perera
	E G U Dhanawardena
	Nihal Gamage, Dip. Agric. (Angunakolapelessa)
	U N Jayasuriya
	G D N Seneviratne
	K P Jayasinghe
	W C Siriwardena, Dip. Plant Ex. Mangt.
	S G G Wijesinghe
	N G Yasaratne
	D M Mahindapala
	I P L Kithsiri
	W M A S L Wanigasuriya, Dip. Agric (Aquinas)
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	N L Dharmasena

Clerk (Special Grade)	Mrs M A P P Seneviratne
Clerks	Mrs M K Wijetilleke
	Mrs L Somawathi
	Mrs C Gunatilleke
	Mrs J N R Jayasinghe
Clerk/Typist	Mrs S Nakandala
	Mrs S M Kaluarachchi

* On study leave overseas
** On no pay leave

National Science and Technology Awards – 2008

Dr S Siriwardena, the Head and Principal Research Officer, Mr T A S Siriwardena and Mr A K D Warnajith, Experimental Officers of the Raw Rubber Process Development and Chemical Engineering Department jointly won the National Science and Technology Awards – 2008 in the category of Development and Adaptation of Technologies for SMEs at the national competition organized by the Ministry of Science and Technology of Sri Lanka. We congratulate them for their achievement and bringing credit to the institute.

General Research Committee Award - 2009

Dr V.H.L. Rodrigo, Head/Department of Biochemistry and Physiology was adjudged the winner of the General Research Committee (GRC) Award – 2009, offered by General Research Committee of the Sri Lanka Association for the Advancement of Science. This highly prestigious award was offered considering his research in the fields of rubber based farming systems, harvesting latex, carbon fixation of rubber towards the mitigation option of climate change and expansion of rubber cultivation to non traditional areas. He has also been the winner of the award for excellence in scientific research – 2006, offered by the Young Scientists Forum of the National Science and Technology Commission. We congratulate Dr V.H.L. Rodrigo on his achievements and bringing honour to institute.

RUBBER RESEARCH INSTITUTE OF SRI LANKA

DIRECTOR'S REVIEW

A Nugawela

The Rubber Research Institute of Sri Lanka celebrated 100 years of Research and Development work on natural rubber in the country during the year. The programme designed to commemorate this significant achievement was initiated with religious activities, *i.e.* all night pirith ceremony, sermons from different religions and an almsgiving held on the 5th and 6th of March. This was followed by a press conference held at the Ministry of Plantation Industries chaired by the Minister Hon. D M Jayaratne. The objective of the press conference was to disclose the significance of the event, research and development activities carried out over the past 100 years and the events scheduled to celebrate the event. The inauguration ceremony of the centennial activities was held at the Presidential Secretariat under the auspices of the Prime Minister Hon. Ratnasiri Wickramanayake. During this event canceling of a first day cover and releasing of publications and videos done for the benefit of the industry were performed by the

Religious activities held on 5th & 6th March at Agalawatta Head Quarters

The inauguration ceremony at Presidential Secretariat

Hon. Prime Minister. Five high yielding rubber clones bred by the Rubber Research Institute of Sri Lanka were also released by the Hon. Prime Minister to mark the centennial year. Further, the services of the most senior employees were appreciated by presenting them with a souvenir. A newspaper supplement was published on the same day comprising of messages from the President Hon. Mahinda Rajapaksha, Prime Minister Hon. Ratnasiri Wickramanayake, Minister of Plantation Industries Hon. D M Jayaratne, Secretary, Ministry of Plantation Industries Mrs. Indrani Sugathadasa and also the Chairman and the Director of the Institute.

Centennial Rubber Conference was held on the 12th & 13th of May at Hilton Colombo under the theme "Development of Natural Rubber Industry through Empowerment of Stakeholders". The Secretary General of the International Rubber Research and Development Board, Dr. Abdul Aziz and the Head of Economics and Statistics Division, International Rubber Study Group, Mr. Gerard Stapleton delivered the key note addresses. Twenty five papers were presented, 16 by the scientists of the Rubber Research Institute and 9 by eminent personal representing the industry on their Research and Development needs. Over 350 delegates participated at the conference.

Centennial Rubber Conference

Crop Clinics and Exhibitions with the objective of technology transfer were held during the year covering all major rubber growing areas including Monaragala. Each crop clinic had a stall from every Department/Section of the institute demonstrating its recommendations to the industry and also depicting the current Research and Development programmes. Further seminars and demonstrations were conducted for the participants on some selected currently important topics. Apart from the institute, the Rubber Development Department and the Thurusaviya Fund had stalls to educate the growers on the services provided by them. Dealers of agro-chemicals and utensils connected to the rubber industry also had stalls at the crop clinics. In average around 3000 participants comprising of Rubber Smallholders, Managers, Field Staff and Workers of Plantation Sector and School Children attended each Crop Clinic and Exhibition.

Crop Clinics in progress

Finally the services of all employees of the institute were appreciated by hosting them for a lunch and by presenting them with a memento at a get together held at Wadduwa Holiday Resort, Kalutara.

Appreciation of the services of employees: final event

The Research and Development programme of the Rubber Research Institute was carried out simultaneously with the activities connected to the centennial celebrations of the institute. A brief summery of some Research and Development highlights of the year are given below.

Five new clones with high yield potential, growth vigor and disease resistance, *i.e.* RRISL Centennial 1,2,3,4 and 5 were released to the industry during the year. Further, clone RRISL 2001 recommended to the plantation sector was released to the rubber smallholders as well. Two new clones in the pipeline, *i.e.* 95-13 and 95-55 continued to give high latex yields. Based on data collected from a survey, guidelines were issued to rubber nursery owners on how best they could collect their seed requirement during the seed fall period to establish nurseries. Planting distances were revised to give 515-520 trees/hectare. A successful repellent was developed to protect rubber

plantations from damages caused by mammalian pests. Though mealy bug *Paracocus marginatus* invaded rubber plantations and nurseries, it was efficiently managed using both cultural and chemical methods. Growth of young budding plants could be significantly improved by using soil and coir dust at a ratio of 3: 1 by volume. During the first six weeks after cut back root activity is at a very low level and hence precautions to protect young budded plants need to be taken during this period. A new user friendly computer programme was developed for site specific fertilizer recommendation for mature rubber. Site specific fertilizer recommendations were given for 4000 ha of mature rubber whilst land suitability reports were provided for 250 ha. More then 500 fertilizer samples were analyzed for quality. A tentative recommendation for d/4 system of tapping with stimulation was issued for the industry. Skill development and awareness programmes together with demonstration plots were utilized to uplift the performance of rubber smallholders.

A method to improve the quality of high Volatile Fatty Acid (VFA) containing centrifuged latex was recommended. New limits were introduced for Fe and Ca ions in crepe rubber processing water. A low cost rainguard sealant with relatively better physical properties was developed using waste engine oil and waste rubber. A lab scale two roll mill was developed and introduced for accurate determination of DRC. A titrimetric method was introduced to accurately determine the strength of DAHP. This would prevent use of low quality DAHP in the centrifuged latex industry. Natural and nitrile rubber blend based rice huller rollers were developed in response to a request from the industry. A low cost environmentally and a user friendly bag to replace conventional polybags was developed using empty cement bags and a modified latex compound. Testing and issuing reports on raw rubber, rubber compounds and products, processing and effluent water, protein analysis were done on the request of the industry.

Trends in the Sri Lankan rubber industry

The natural rubber production in the country increased up to 136.88 thousand metric tons during the year. This is a 6.1% increase over the 2008 production of 129.0 thousand metric tons. As per the latest figure reported on the total rubber extent of the country, *i.e.* 124,300 hectares and assuming 80% of the total extent as mature rubber the national productivity level had been around 1,376 kg per hectare during the year. This is a 4.1% increase over the 2008 national productivity level of 1,322 kg of rubber per hectare per annum.

The national productivity level has been increasing steadily with the increase in natural rubber prices. Tapping of abandoned areas, use of fertilizer and rainguarding technology, improvements in quality of tapping and adopting correct tapping systems are possible changes that would have led to increased productivity levels.

Extent of rubber has increased up to 124,300 hectares in 2009 from the figure 122,000 hectares in the previous year showing an increase of 1.9%. This is even

higher than the previous year's increase of 1.6% despite of the poor trading period that prevailed during the latter part of 2008.

Nevertheless, it needs to be emphasized that a census on the rubber extent in the country is an urgent need to ensure the accuracy of the same and productivity levels.

Trends in the global rubber industry

The world Natural Rubber production declined to 9,602 million tones from the previous year's production figure of 10, 031 million tones. This is a 4.5% drop in the production as compared to a 0.5% growth in production during the previous year. The world natural rubber consumption for the years 2008 and 2009 were 10,154 and 9,547 million tones respectively. Hence the world natural rubber consumption in 2009 has decreased by 6%. It is evident that 99.4% of the world natural rubber production in 2009 has been consumed during the year indicating that there is no over supply situation.

The world synthetic rubber production decreased to 12,168 million tones from the previous year's production of 12,784 million tones. This is a 4.8% drop in production when compared with the previous year. The world synthetic rubber consumption decreased to 11,878 million tones from the previous year's consumption of 12,619 million tones. This is a 6.2% drop in the synthetic rubber consumption from the previous year. Accordingly, both natural and synthetic rubber consumption has declined in 2009 when comparing with 2008 and the biggest drop is in the synthetic rubber. Drop in rubber consumption could be attributed to the world economic melt down, which resulted in a drop in demand for rubber goods.

OVERSEAS VISITORS

Mr Pham Van Hang, Deputy Director, Vietnam Rubber Group, Vietnam
Mr Le Cuong, Senior Officer, Vietnam Rubber Group, Vietnam
Mr Nguyen Quoc Viet, Deputy Director, Dau Tieng Rubber Company, Vietnam
Mr Tran Van Ranh, Deputy Director, Tay Ninh Rubber Joint Stock Co., Vietnam
Mr Vo Nhat Duy, Director, Son La Rubber Join Stock Co., Vietnam

GENETICS AND PLANT BREEDING

P Seneviratne

SUMMARY

Five new clones were registered and released under the label "RRISL Centennial 1,2,3,4 and 5" to commemorate the centennial year of RRISL. These clones were first issued for the plantation sector. Clone RRISL 201 was released for the Small Holder sector too. High g/t/t values were recorded throughout the year for clones 95-13 and 95-55 in ECT trials carried out at Kuruwita sub station.

Clones RRISL 203, RRISL 206, RRISL 208, RRISL 211 and RRISL 2000 continued to give high yield values measured as grams per tree per tapping (g/t/t) in all Estate x RRI Collaborative (ECT) trials proving their suitability in commercial planting.

Annual hand pollination programme was not carried out in the year under review due to severe dry weather condition that prevailed throughout the flowering season. However, the higher success rate achieved in the previous year yielded enough material to multiply in budwood nurseries for testing in Small Scale Clone trials.

Monthly Test Tapping and data collection in most of the small scale clone trials was low due to rain interferences and also due to recovery tapping practices on estates.

DETAILED REVIEW

Staff

Dr (Mrs) P Seneviratne Acting Head of the department, Assistant Geneticist and Plant Breeder Mr K K Liyanage, Research Assistant, Mr K B Karunasekera, Experimental Officers Mr K W Rupatunga, Mr L S Kariyawasam, Mr I D M J Sarath Kumara, Technical Officers Mr T M S K Gunasekera, Mr H P Peiris and Mrs S D P K L Peiris, Clerk/typist were on duty throughout the year.

Geneticist and Plant Breeder Mrs S P Withanage continued her postgraduate training abroad. Mrs A K Gamage was on maternity leave from 21.05.2009 to 18.09.2009 and continued to be on leave till 18.11.2009 with no pay.

Seminars/Training Programmes/Workshops/Exhibitions conducted

The department staff provided necessary training for the NIPM, Universities and stake holders of various categories. Crop Clinics organized by Advisory Services Department were also attended.

Meetings/Seminars and Workshops attended

Officer	Subject	Organization
K K Liyanage	Seminar on the identification and monitoring of infectious pathogens by Real Time PCR (Quantitative analysis)	Eppendorf India Ltd
P Seneviratne K K Liyanage K B Karunaekara	Centennial Rubber Conference Sri Lanka 2009 on 12th and 13th of May	Rubber Research Institute of Sri Lanka

Visits

Advisory	- 4
Experimental	- 567
Miscellaneous	- 20
Total	- 591

LABORATORY INVESTIGATIONS

Molecular biology of *Hevea* GPB/MM/97

Investigations on polymorphism of recommended *Hevea* clones using RAPD techniques were continued. Attempts were made to identify pairs of seedling plants of same origin multiplied through rooting of cuttings, using RAPD techniques with little success.

FIELD EXPERIMENTS

Hand pollination (HP) programme – 2008(GPE/BST/HP/01)

The annual hand pollination programme was not carried out this year due to severe dry weather that prevailed throughout the flowering season and also due to spread of *Oidium* disease which infected the flowers.

Evaluation of hand pollinated progenies

Small Scale Clone Trials

The list of the Small Scale Clone Trials maintained and monitored by the Department during the year under review is given in Table 1.

Table 1. *Details of Small Scale Clone Trials*

HP year	Site	Planting date	Current status
1987	Clyde- Kethhena	May 1993	11th year of tapping
1990	Kuruwita sub station	July 2002	1st year of tapping
1991	Pallegoda	August 2000	3rd year of tapping
	Vogan	November 2000	3rd year of tapping
1996	Kuruwita sub station – I & II	May 1999	4th year of tapping
1997	Clyde – I & II	June 2000	3rd year of tapping
1998	N'kele I,II & III	June 2001	2nd year of tapping
	Kuruwita sub station I,II & III	July 2001	2nd year of tapping
1999	Kuruwita sub station I,II & III	June 2002	Immature
2000	Arappalakande I-III	May 2003	Opened for tapping
	Delkeith IV & V	June 2003	Immature
	Elston VIII & IX	July 2003	Immature
	Nivithigalakele VI & VIII	July 2003	Immature
2001	Paiyagala I	June 2006	Immature
	Kuruwita sub station II	July 2006	Immature
2002	Pallegoda I	July 2007	Immature
2002	Eladuwa II	July 2008	Immature
2004	Eladuwa Trial I	August 2008	Immature
	Neuchatel Trial II	August 2008	Immature
2007	Kuruwita sub station (seedlings)	July 2008	Immature

Evaluation of 1987 H.P. selections - Clyde estate (GPB/BST/HPS/87/1)

Data collection of this trial was temporally stopped due to changing the panels far too earlier than the recommended time as a result of continuous high intensity tapping practices adopted by the estate.

Evaluation of 1990 H.P. clones at Kuruwita estate (GPB/BST/HPS/90/01)

The 7th year girth measurements and 1st year yield data based on three test tappings were analyzed and HP entries which performed better than the control clones in growth and yield are listed in Table 2.

Table 2. *Mean girth and yield of selected HP entries of the 1990 HP progeny planted at Kuruwita Sub station in 2002*

Mean girth (cm)		Mean yield (g/t/t)	
Clone	**Girth**	**Clone**	**Yield**
90-10	60.25^{a}	90-6	54.57^{a}
90-20	59.43^{ab}	90-7	51.89^{ab}
90-7	57.68^{ab}	90-1	51.28^{abc}
90-11	56.75^{ab}	90-9	43.57^{abcd}
90-21	56.00^{ab}	90-17	43.07^{abcd}
90-27	54.06^{abc}	90-10	41.56^{abcde}
90-19	54.00^{abc}	90-21	37.90^{abcdef}
90-29	52.71^{abcd}	90-4	$35.19^{abcdefg}$
90-6	52.56^{abcd}	RRIC 130	$33.90^{abcdefgh}$
RRISL 205	52.15^{abcd}		

(P Seneviratne, K K Liyanage, H P Peris and K B Karunasekera).

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

DMRT grouping of 9th year girth and 3rd year yield based on 11 and 13 test tappings respectively are given in Tables 3a and 3b.

Table 3a. *Mean girth and the DMRT grouping of selected HP entries of the 1991 HP progeny planted at Pallegoda and Vogan estates in 2000*

Mean girth (cm) of 91-01 trial (at Pallegoda estate)		Mean girth (cm) of 91-02 trial (at Vogan estate)	
Clone	**Girth**	**Clone**	**Girth**
RRISL 205	74.7^{a}	97-62	75.96^{a}
RRIC 121	71.92^{ab}	RRISL 205	72.46^{a}
91-29	70.66^{abc}	91-79	71.36^{ab}
91-19	68.95^{bcd}	RRIC 121	69.36^{abc}
91-1	66.33^{bcde}	91- 71	65.14^{bcd}
91-13	64.85^{cdef}	91- 63	64.27^{bcd}
91-5	64.66^{cdef}	91- 57	64.00^{cd}
91-2	64.32^{cdeg}	97 – 58	62.86^{cde}
91-4	63.46^{defg}	91-58	62.50^{cdef}

Table 3b. *Mean yield and the DMRT grouping of the HP entries of the 1991 H.P. progeny planted at Pallegoda and Vogan estate*

Mean yield (g/t/t) of 91-01 trial (at Pallegoda estate)		Mean yield (g/t/t) of 91-02 trial (at Vogan estate)	
Clone	**Yield**	**Clone**	**Yield**
91-21	51.26^{a}	RRIC 121	60.74^{a}
91-19	44.98^{ab}	91-57	53.50^{ab}
RRIC 121	41.16^{abc}	91-58	48.72^{abc}
91-24	40.0^{abc}	91-73	46.15^{abcd}
91-4	38.45^{abcd}	91-62	43.43^{abcde}
91-29	38.32^{abcd}	91-71	43.39^{bcde}
RRISL 205	37.42^{abcde}	91-58	41.04^{bcde}
91-16	36.72^{abcdef}	91-86	39.00^{bcdef}
91-2	34.93^{bcdef}	91-65	38.05^{bcdef}

(P Seneviratne, K K Liyanage, K W Rupatunge, L Kariyawasam and K B Karunasekera)

Evaluation of 1996 H.P. seedlings - Kuruwita estate (GPB/BST/HPS/96 -1 and 96-2)

In both trials 10^{th} year girth measurements were grouped using DMRT and some of the superior genotypes are given in table 4a. Mean yields and the DMRT grouping of some selected clones based on seven test tapings in the 4^{th} year of tapping are given in Table 4b along with control clones.

Table 4a. *Mean girth and the DMRT grouping of HP selections of the 1996 HP progeny planted in 1999*

Mean girth (cm) of 96-1 trial		Mean girth (cm) of 96-2 trial	
Clone	**Girth**	**Clone**	**Girth**
96-59	80.53^{a}	RRIC 121	75.42^{a}
96-14	74.66^{ab}	96-37	72.85^{ab}
96-15	74.35^{ab}	96-45	71.41^{abc}
RRIC 121	72.42^{bc}	96-41	69.98^{abcd}
96-17	71.43^{bcd}	96-47	69.84^{abcd}
RRISL 205	68.07^{bcde}	96-54	68.96^{abcde}
96-58	67.53^{bcdef}	96-39	66.00^{abcdef}
		96-20	$65.61^{abcdefg}$
		96-40	$64.16^{abcdefgh}$
		96-28	$62.76^{bcdefghI}$
		RRISL 205	$62.30^{cdefghI}$

Table 4b. *Mean yield (third year tapping) and the DMRT grouping of some of the HP selections of the 1996 HP progeny planted in 1999*

Mean yield (g/t/t) of 96-1 trial		Mean yield (g/t/t) of 96-2 trial	
Clone	**Yield**	**Clone**	**Yield**
96-58	52.294^{a}	96-54	44.03^{a}
96-14	46.75^{ab}	96-45	42.02^{ab}
96-65	45.63^{bcd}	96-20	41.72^{abc}
96-18	41.79^{bcd}	RRIC 121	39.30^{abcd}
RRIC 121	40.84^{bcde}	96-43	36.72^{abcde}
96-15	39.45^{bcdef}	96-39	36.22^{abcde}
96-59	36.76^{bcdefg}	96-47	35.11^{abcdef}
96-3	35.31^{cdefgh}	96-32	34.33^{abcdef}
96-8	$35.17^{cdefghI}$	96-33	33.02^{abcdef}

(P Seneviratne, K K Liyanage, H P Peris and K B Karunasekera)

Evaluation of 1997 H.P. clones at Clyde estate (GPB/BST/HPS/97/01 & 91/2)

Table 5a shows the ninth year girth measurements and their DMRT grouping for two trials. Mean yields of the third year of tapping and the DMRT grouping of some selected clones based on 12 test tapings are given in Table 5b along with control clones.

Table 5a. *Mean girth (Ninth year) of the 1997 HP progeny planted at Clyde estate in 2000*

Mean girth (cm) of 97-01 trial		Mean girth (cm) of 97-02 trial	
Clone	**Girth**	**Clone**	**Girth**
97-5	66.56^{a}	RRISL 205	65.17^{a}
97-2	65.13^{ab}	97-67	63.80^{ab}
RRISL 205	63.60^{abc}	97-55	62.92^{ab}
97-10	63.13^{abc}	97-61	62.67^{abc}
97-40	60.82^{bcd}	97-60	60.50^{abcd}
97-19	60.50^{bcd}	97-66	60.28^{abcd}
97-23	59.96^{cde}	97-79	59.83^{abcde}
RRIC 121	59.46^{cde}	97-64	59.66^{abcde}
97-26	59.10^{cde}	97-56	59.20^{abcde}

Table 5b. *Mean yield (third year) of the 1997 HP progeny planted at Clyde estate in 2000*

Mean yield (g/t/t) of 97-01 trial		Mean yield (g/t/t) of 97-02 trial	
Clone	**Yield**	**Clone**	**Yield**
97-42	46.13^{a}	97-74	60.78^{a}
97-25	43.46^{ab}	97-60	53.457^{ab}
97-10	39.06^{abc}	97-66	52.80^{abc}
97-3	37.169^{abcd}	97-70	52.29^{abc}
97-36	35.76^{abcde}	97-56	48.24^{abcd}
97-26	35.65^{abcde}	97-83	41.24^{bcde}
97-9	35.40^{abcde}	97-55	40.83^{bcdef}
97-21	34.95^{abcdef}	97-67	38.15^{bcdefg}
97-19	34.43^{abcdef}	RRIC 121	37.73^{cdefgh}
RRIC 121	34.30^{abcdef}		

(P Seneviratne, K K Liyanage, T M S K Gunasekera and K B Karunasekera)

Evaluation of 1998 H.P. clones at Nivithigalakele (GPB/BST/HPS/98/01,02,03) and Kuruwita substations (GPB/BST/HPS/98/04,05,06)

Eighth year girth measurements and second year yield data based on eight test tappings were analysed using Duncan's multiple range test for each trial separately. Some of the promising HP entries and control clones are given in Tables 6a, 6b, 6c and 6d.

Table 6a. *Mean girth of selected HP entries of the 1998 HP progeny planted at Nivitigalakele Sub station in 2001*

Trial 98-01 Mean girth (cm)		Trial 98-02 Mean girth (cm)		Trial 98-03 Mean girth (cm)	
Clone	**Girth**	**Clone**	**Girth**	**Clone**	**Girth**
98-88	64.96^{a}	98-132	68.89^{a}	RRISL 205	63.12^{a}
98-147	64.48^{ab}	98-96	62.57^{b}	RRIC 121	61.65^{ab}
98-180	60.20^{bc}	RRIC 121	61.06^{b}	98-133	61.28^{ab}
98-134	59.40^{bc}	98-53	60.65^{b}	98-280	61.28^{abc}
RRIC 121	59.03^{bc}	98-159	58.68^{bc}	98-225	58.30^{abcd}
RRISL 205	58.03^{bcd}	98-129	58.42^{bc}	98-151	58.25^{abcd}
98-112	57.68^{bcde}	98-85	55.62^{cd}	98-197	57.60^{abcd}
98-108	56.13^{cdef}	98-259	55.34^{cd}	98- 228	57.40^{abcd}
98-115	55.78^{cdef}	RRISL 205	54.93^{cde}	98-281	57.102^{bcde}

Table 6b. *Mean girth of selected HP entries of the 1998 HP progeny planted at Kuruwita Sub station in 2001*

Trial 98-04 Mean girth (cm)		Trial 98-05 Mean girth (cm)		Trial 98-06 Mean girth (cm)	
Clone	**Girth**	**Clone**	**Girth**	**Clone**	**Girth**
98-276	68.86^{a}	98-68	67.69^{a}	98-224	89.42^{a}
98- 230	66.25^{ab}	98-58	64.85^{ab}	RRISL 205	70.19^{ab}
98- 98	63.96^{abc}	98-51	62.31^{abc}	98-223	68.8^{ab}
98- 84	63.34^{abcd}	RRISL 205	62.06^{abcd}	RRIC 121	64.88^{b}
RRISL 205	62.84^{abcd}	98-58	61.62^{bcde}	98-154	63.46^{b}
98-219	61.39^{bcde}	98-50	60.86^{bcdef}	98-19	60.43^{b}
98-11	61.03^{bcde}	RRIC 121	59.86^{bcdefg}	98-30	$59..68^{b}$
RRIC121	60.09^{bcdef}	98-73	58.73^{bcdefg}	98-278	58.13^{b}
98- 207	59.93^{bcdef}	98-41	$57.43^{cdefghi}$	98-196	58.04^{b}

Table 6c. *Mean yield (g/t/t) of selected HP entries of the 1998 HP progeny planted at Nivitigalakele Sub station in 2001*

Trial 98-01 Mean yield (g/t/t)		Trial 98-02 Mean yield (g/t/t)		Trial 98-03 Mean yield (g/t/t)	
Clone	**Yield**	**Clone**	**Yield**	**Clone**	**Yield**
98-88	57.99^{a}	98-132	65.23^{a}	RRIC 130	46.18^{a}
98-168	45.89^{b}	98-262	56.26^{b}	98-133	39.54^{ab}
98-100	45.06^{b}	RRIC 130	52.39^{bC}	98-118	36.72^{bc}
98-123	41.36^{bc}	98-259	49.209^{bcD}	98-138	36.04^{bcd}
RRIC 130	41.30^{bc}	98-96	44.86^{cde}	98-228	34.78^{bcde}
98-112	40.91^{bc}	98-85	40.38^{de}	98-269	33.26^{bcdef}
98-137	40.04^{bcd}	RRIC 121	40.34^{de}	98-225	31.80^{bcdefg}
98-134	39.37^{bcd}	98-159	38.73^{ef}	98-281	30.33^{cdefgh}
98-108	39.16^{bcd}	98-117	37.54^{def}	98-151	$29.56^{cdefghi}$

Table 6d. *Mean yield (g/t/t) of selected HP entries of the 1998 HP progeny planted at Kuruwita Sub station in 2001*

Trial 98-04 Mean yield (g/t/t)		Trial 98-05 Mean yield (g/t/t)		Trial 98-06 Mean yield (g/t/t)	
Clone	**Yield**	**Clone**	**Yield**	**Clone**	**Yield**
98-105	57.667[a]	98-80	43.67[a]	RRIC 130	46.182[a]
98-237	50.34[ab]	98-70	40.08[ab]	98-133	39.54[ab]
98-230	45.67[abc]	98-78	39.71[ab]	98-118	36.72[bc]
98-219	45.64[abc]	98-58	37.55[abc]	98-138	36.04[bcd]
98-98	45.62[abc]	98-44	37.54[abc]	98-228	34.78[bcde]
98-164	44.82[bc]	RRIC 121	36.92[abc]	98-269	33.26[bcdef]
RRIC 130	43.71[bcd]	RRIC 130	36.13[abc]	98-225	31.80[bcdefg]
98-143	43.65[bcd]	98-51	35.62[abcd]	98-281	30.33[cdefgh]
98-124	43.14[bcd]	98-62	33.78[abcde]	98-151	29.56[cdefghi]
RRIC 121	42.59[bcde]	98-73	33.19[abcde]	98-157	27.24[defghi]

(P Seneviratne, K K Liyanage, H P Peris and K B Karunasekera)

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

The seventh year girth measurements taken from each trial. Results of the best control clone and those performed better than the best control clone are given in Table 7a. In table 7b first year yield data based on three test tappings are given for some of the promising HP entries.

Table 7a. *Mean girth of selected HP entries of the 1999 HP progeny planted at Kuruwita Sub station 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**
99-67	59.31[a]	99-157	67.56[a]	99-189	67.01[a]
99-55	56.43[ab]	99-47	60.28[ab]	99-216	61.87[ab]
99-73	56.00[abc]	99-167	60.18[ab]	99-166	58.12[bc]
99-61	55.37[abcd]	99-159	57.56[bc]	99-230	56.49[bc]
99-139	54.50[abcde]	99-272	56.87[bcd]	99-63	55.26[bcd]
99-74	54.14[abcde]	99-178	55.75[bcde]	99-64	54.62[cde]
99-43	53.37[abcde]	99-265	55.18[bcdef]	RRIC 121	53.42[cde]
99-48	53.06[abcde]	99-137	52.85[bcdefg]	99-44	53.31[cde]
99-81	52.68[abcde]	99-194	52.43[bcdefgh]	99-92	52.50[cdef]
99-71	51.50[abcdef]	RRISL 205	52.18[bcdefghi]	99-192	52.37[cdef]
99-58	51.4[abcdef]	99-242	52.00[bcdefghi]	99-78	52.35[cdef]
99-72	50.87[abcdefg]				

Table 7b. *Mean yield of selected HP entries of the 1999 HP progeny planted at Kuruwita Sub station in 2002*

Trial 99-01		Trial 99-02		Trial 99-03	
Clone	**Mean yield (g/t/t)**	**Clone**	**Mean yield (g/t/t)**	**Clone**	**Mean yield (g/t/t)**
99-55	79.18^{a}	99-157	60.71^{a}	99-230	86.87^{a}
99-42	52.08^{b}	99-161	60.54^{a}	99-166	65.95^{b}
99-67	49.22^{bc}	99-272	53.78^{abc}	RRIC 130	56.20^{bc}
99-90	48.78^{bc}	99-180	48.95^{abcd}	99-234	55.32^{bcd}
99-61	48.74^{bcd}	99-265	48.16^{abcde}	99-216	51.83^{bcde}
99-73	47.00^{bcd}	99-193	44.73^{abcdef}	99-201	45.30^{bcdef}
99-106	46.21^{bcde}	99-132	$44.46^{abcdefg}$	99-184	44.25^{cdefg}
99-102	45.71^{bcde}	99-167	$43.94^{abcdefg}$	99-93	43.49^{cdefgh}
99-108	42.08^{bcdef}	99-178	$43.10^{abcdefgh}$	99-64	42.96^{cdefgh}
99-43	41.82^{bcdef}	99-194	$42.92^{abcdefgh}$	99-120	$41.81^{cdefghi}$

(P Seneviratne, K K Liyanage, H P Peris and K B Karunasekera).

Evaluation of 2000 HP clones at Arrapalakande Estate (GPB/BST/HPS/2000/01, 02, 03), Dalkeith estate (GPB/BST/HPS/2000/04,05), Nivithigalakele substation (GPB/BST/HPS/2000/06,07) and Elston Estate (GPB/BST/HPS/2000/08,09)

Arrapalakande estate Trial I (GPB/BST/HPS/2000/01)

In this trial each block contained 364 genotypes derived from 11 families planted as completely randomized single tree plots. Sixth year girth measurements and DMRT grouping are given in Table 8 with the families.

Arrapalakande Trial II (GPB/BST/HPS/2000/02)

Total of 258 genotypes derived from ten families were tested in a completely randomized single tree plot design. Family means derived from sixth year girth measurements are given in Table 9.

Table 8. *Mean girth and DMRT grouping of families of 2000 HP progeny Trail I planted at Arrapalakande estate in 2003*

Family	Mean girth (cm) and DMRT grouping
PB 235 × PB 260	58.22[a]
PB 235 × RRIC 121	56.17[ab]
RRIC 121 × PB 235	55.90[ab]
BPM 24 × PB 260	55.31[abc]
BPM 24 × PB 235	54.48[abc]
PB 260 × RRIC 121	51.80[bcd]
RRIC 121 × PB 260	48.16[bc]
BPM 24 × RRIC 121	48.41[bcd]
RRIC 121 × GP 36-104	47.93[cd]
BPM 24 × GP 36-104	47.65[cd]
PB 260 × PB 260	43.55[d]

(P Seneviratne, K K Liyanage, T M S K Gunasekera and K B Karunasekera).

Table 9. *Mean girth of families of the 2000 HP progeny Trial II planted at Arrapalakande estate in 2003*

Family	Mean girth (cm)
BPM 24 × PB 235	51.0
BPM 24 × PB 260	50.5
BPM 24 × RRIC 121	48.7
PB235 × PB 260	49.3
PB 235 × RRIC 121	49.6
PB 260 × PB 260	44.5
PB 260 × RRIC 121	48.5
RRIC 121 × GP 36-147	47.4
RRIC 121 × PB 235	50.7
RRIC 121 × PB 260	51.3

(P Seneviratne, K K Liyanage, K W Rupatunge and K B Karunasekera).

Arrapalakande Trial III (GPB/BST/HPS/2000/03)

This trial contained 90 genotypes derived from a single family BPM 24 × PB 235 planted in a completely randomized design with four single tree plots per clone. Sixth year girth measurements were taken and some of the genotypes and their DMRT rankings are shown in Table 10.

Table 10. *Mean girth of vigorous genotypes and their DMRT ranking in 2000 HP progeny Trial III planted at Arrapalakande estate in 2003*

Clone	Girth (cm)
2000-48	68.00^{a}
2000-103.	64.66^{ab}
2000-27	63.50^{abc}
2000-150	63.00^{abc}
2000-149	62.62^{abcd}
2000-109	62.62^{abcd}
2000-42	62.00^{abcde}
2000-59	61.12^{abcdef}
2000-105	61.00^{abcdef}
2000-130	60.87^{abcdef}

(P Seneviratne, K K Liyanage, I D M J Sarathkumara and K B Karunasekera)

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, Variance, Minimum and Maximum derived from the sixth year girth measurements are given in Table 11.

Table 11. *Mean, minimum, maximum and variance of two families at Dalkith estate (2000 hand pollination progeny) trial IV planted in 2003*

	Family	
	RRIC 121 × PB 235	**PB 235 × RRIC 121**
Mean (cm)	43.36	45.5
Minimum (cm)	24.0	25.0
Maximum (cm)	64.5	67.5
Variance	62.32	72.0

(P Seneviratne, K K Liyanage, K W Rupatunge and K B Karunasekera)

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, Variance, Minimum and Maximum derived from the sixth year girth measurements of two families are given in Table 12.

Table 12. *Mean, minimum, maximum and variance of two families at Dalkith estate (2000 hand pollination progeny) trial V planted in 2003*

	Family	
	BPM 24 × PB 260	**RRIC 121 × PB 260**
Mean (cm)	42.0	39.1
Minimum (cm)	23.0	20.0
Maximum (cm)	59.0	60.0
Variance	83.0	72.6

(P Seneviratne, K K Liyanage, I D M J Sarathkumara and K B Karunasekera)

Nivithigalakele substation - (GPB/BS/HPS/2000/06, GPB/BST/HPS/2000/07) Trial VI and Trial VII planted in 2003

In trial VI, 46 genotypes from one family with three single tree plots are tested in a completely randomized design. In Trial VII, 193 genotypes are tested from a single family with three single tree plots, in a completely randomized design. Family mean, Variance, Minimum and Maximum derived from the sixth year girth measurements are given in Table 13.

Table 13. *Mean, minimum, maximum and variance of two families at Nivitigalakele (2000 hand pollination progeny) trial VI and VII planted in 2003*

	Results of the trial VI (BPM 24 × RRIC 121)	**Results of the trial VII (PB 260 × RRIC 121)**
Mean (cm)	49.69	52.2
Minimum (cm)	27.0	28.5
Maximum (cm)	66.5	77.5
Variance	79.8	76.2

(P Senaviratne, K K Liyanage, T M S K Gunasekera and K B Karunasekera)

Elston estate - (GPB/BS/HPS/2000/08, GPB/BST/HPS/2000/09)- Trial VIII and Trial IX planted in 2003

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. In Trial IX, 52 genotypes have been included from 11 families with six single tree plots per genotype in a completely randomized design. Results of the sixth year girth measurements show that most of the genotypes have not achieved the tappable girth. Table 14 shows the family means calculated from the fifth year girth measurements in trial IX.

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

Parentage (Family)	Mean girth (cm)	Variance
BPM 24 × GP 36-104	44.0	63.1
BPM 24 × PB 235	52.5	46.2
BPM 24 × PB 260	48.8	137.6
BPM 24 × RRIC 121	50.23	27.1
PB 235 × PB 260	51.6	77.1
PB 235 × RRIC 121	48.6	47.5
PB 260 × PB 260	45.9	66.6
PB 260 × RRIC 121	50.2	60.4
RRIC 121 × GP 36-147	46.6	65.3
RRIC 121 × PB 235	53.0	41.8
RRIC 121 × PB 260	52.0	57.6

(P Seneviratne, K K Liyanage, H P Peiries and K B Karunasekera)

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

The mean girth of clones calculated from third year girth measurements were grouped using the Duncan's Multiple range test for each trial and some of the promising HP entries are given in Table 15.

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

Payagala estate		Kuruwita sub-station	
Clone	Girth (cm)	Clone	Girth (cm)
2001-249	28.5^{a}	2001-89	23.9^{a}
2001-257	28.2^{ab}	RRISL 203	22.8^{ab}
2001-110	28.1^{ab}	2001-179	22.1^{abc}
2001-127	27.65^{abc}	2001-185	21.8^{abcd}
2001- 115	27.6^{abc}	2001-207	21.1^{bcde}
2001- 99	27.36^{abcd}	2001-183	20.75^{bcde}
2001- 126	27.35^{abcd}	2001-205	20.7^{bcde}

(P Seneviratne, K K Liyanage, T M S K Gunasekera and H P Peiries)

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

The second year girth measurement was taken and the mean girth of clones were grouped using the Duncan's Multiple range test and the results are given in Table 16.

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

Clone	Mean girth (cm)
2002-24	16.72^{a}
2002-17	16.44^{ab}
2002-11	15.73^{abc}
2002- 18	15.66^{abc}
2002-43	15.5^{abc}
2002-14	15.45^{abcd}
2002-69	15.38^{abcd}
2002-26	15.20^{abcde}
2002-96	15.15^{abcde}

(P Seneviratne, K K Liyanage, K W Rupatunge and K B Karunasekera).

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

First year girth data were collected for the seedling progeny and family means are given in Table 17.

Table 17. *Family means of 2007 HP progeny at the Kuruwita sub station planted in 2008*

Family	Girth (cm)
RRIC130 × GP 22-137	6.5
RRIC130 × GP 21-163	7.0
RRIC130 × GP 1-2	7.0
RRIC 130 × GP 10-54	6.5
PB 260 × IAN 45/710	6.0
IAN 45/710 × PB 260	6.2

(P Seneviratne, K K Liyanage, K B Karunasekera and H P Peiris)

Performance of Multi-clonal stands (GPB/MCS/99/KU)

The ninth year girth measurements were taken during the year. Table 18a shows the mean girth for each treatment, *i.e.* control monoclonal plots and plots of Bi – and Tri - clones. According to the girth data control monoclonal plot of RRIC 121 shows the highest growth (Table 18a). Third year yield data were also collected during the year and are given in Table 18b.

Table 18a. *Mean girth of monoclonal, bi-clonal and tri- clonal plots planted at Kuruwita Subs station in 1999*

Treatment	Mean girth (cm)
RRIC 121	72.45
RRIC 133	71.36
RRIC 121/RRIC 133	71.17
RRIC 102/RRIC 121	68.64
RRIC 102/RRIC 121/RRIC 133	67.03
RRIC 102/ RRIC 133	67.0
RRIC 100/ RRIC 133/RRIC 121	66.68
RRIC 100/RRIC 102/RRIC 121	66.16
RRIC 100/RRIC 133	65.81
RRIC 100/RRIC 121	65.26
RRIC 100/RRIC 102/RRIC 133	64.9
RRIC 100	63.1
RRIC 102	62.8
RRIC 100/RRIC 102	61.5

Table 18b. *Mean yield (g/t/t) of third year tapping of monoclonal, bi-clonal and tri- clonal plots planted at Kuruwita Subs station*

Treatment	Mean yield (g/t/t)
RRIC 100/RRIC 121	34.5
RRIC 121	31.95
RRIC 133/RRIC 121	29.9
RRIC 102/RRIC 121	29.2
RRIC 100/RRIC 121/RRIC 133	27.9
RRIC 100/RRIC 102/RRIC 121	27.3
RRIC 102	26.4
RRIC 102/RRIC 121/RRIC 133	24.8
RRIC 100/RRIC 102	22.0
RRIC 100	21.8
RRIC 133	21.7
RRIC 102/RRIC 133	21.1
RRIC 100/RRIC 102/RRIC 133	20.9
RRIC 100/RRIC 133	20.2

(P Seneviratne, K K Liyanage, K B Karunasekera and H P Peiris in collaboration with Plant Science Dept.)

Open pollinated seedling progenies from commercial clones (GPB/BST/SP/2000)

Ninth year girth measurements were collected for this trial and mean girth values are shown in Table 19a. Girth was measured 150 cm above the bud union in budded plants and 150 cm above the ground level in seedlings. As far as girth is concerned there is no significant difference among selected and unselected seedlings. Variation is minimum for yield among three types as shown in Table 19b.

Table 19a. Mean *girth measurements obtained for selected and unselected seedlings and for budded plants*

Budded plants	Girth (cm)	Selected seedlings	Girth (cm)	Unselected Seedlings	Girth (cm)
PB 86	64.2	PB 86	63.5	PB 86	63.6
RRIC 121	62.8	RRIC 121	60.7	RRIC 121	63.7
PB 28/59	56.3	PB 28/59	58.2	PB 28/59	59.6
RRIC 100	59.4	RRIC 100	67.0	RRIC 100	66.1
PB 260	58.6	PB 260	66.3	PB 260	66.8

Table 19b. *Mean yield for third year tapping (g/t/t) recorded for selected and unselected seedlings and for budded plants*

Treatment	Yield (g/t/t)
PB 260 unselected seedlings	27.6
RRIC 100 selected seedlings	26.2
PB 86 selected seedlings	26.1
PB 28/59 budded stumps	26.1
RRIC 100 unselected seedlings	26.0
PB 28/59 unselected seedlings	25.7
PB 260 budded stumps	25.4
RRIC 121 selected seedlings	25.4
PB 28/59 selected seedlings	24.1
RRIC 100 budded stumps	23.6
RRIC 121 budded stumps	23.5
PB 86 unselected seedlings	23.0
RRIC 121 unselected seedlings	23.0
PB 86 budded stumps	22.7
PB 260 selected seedlings	22.5

(P Seneviratne, K K Liyanage, K W Rupatunga and K B Karunasekera)

Estate/RRI collaborative clone trials (ECT's) GPB/BST/ECTs

Annual girth measurements were taken from all the trials. Table 20a (registered clones) and 20b (unregistered clones) show the girth measurements for the year under review and for the previous two years with the information on planting sites.

Table 20a. *Mean annual girth measurements for registered clones of ECTs (Estate/RRISL Collaborative Trials)*

Clone	Site	Year of planting	Girth in cm		
			2007	2008	2009
RRISL 201	Tempo	1996	70.82	71.65	72.9
	Kuruwita	1994	72.0	72.90	75.5
	Salawa	1999	68.15	73.15	77.1
RRISL 203	Galewatta	1987	73.87	75.0	76.4
RRISL 205	Pallegoda	1995	72.58	75.0	75.3
RRISL 206	Pallegoda	1995	66.42	69.3	71.4
	Salawa	1999	58.00	61.65	64.5
RRISL 207	Dosert division*	2004	21.86	34.4	43.0
RRISL 208	Dartonfield	1994	67.48	68.8	69.4
RRISL 210	Payagala*	2006	9.25	16.25	27.4
RRISL 211	Dartonfield	1994	65.59	66.5	67.0
RRISL 212	Kuruwita*	2006	8.6	13.7	21.0
RRISL 214	Dosert division*	2004	21.16	33.5	42.3
	Kuruwita*	2006	7.0	11.3	17.6
RRISL 216	Dartonfield	1994	64.21	65.85	67.5
RRISL 217	Kuruwita	1995	59.0	60.05	61.4
RRISL 219	Dartonfield	1994	67.20	69.1	70.2
	Kuruwita	2008			6.0
RRISL 223	Galewatte	1994	64.77	66.2	67.6
RRISL 225	Nivitigalakele	2002	52.10	53.5	62.1
RRISL 2000	Pallegoda	1998	65.13	70.0	69.2
	Nivitagalakele	2001	58.90	60.10	62.5
	Dosert division*	2004	24.28	38.00	46.2
	Kuruwita	2005	12.9	19.7	30.5
RRISL 2001	Pallegoda	1995	65.34	66.3	66.0
	Nivitigalakele	2001	55.13	56.65	59.2
	Dosert division*	2004	24.31	34.4	42.4
RRISL 2002	Dosert division*	2004	20.96	34.3	41.7
	Nivitigalakele	2001	55.2	57.4	60.6
RRISL 2003	Dosert division*	2004	21.70	33.4	41.1
RRISL 2004	Dosert division*	2004	23.30	34.3	42.5
RRISL 2005	Dosert division*	2004	27.40	40.23	48.2
RRISL 2006	Dosert division*	2004	24.15	35.5	45.6
RRII 105	Pallegoda	1998	54.10	55.6	56.4

* Immature fields

Table 20b. *Mean annual girth measurements for un-registered clones of ECTs (Estate/ RRISL Collaborative Trials)*

Clone	Site	Year of planting	Girth in cm		
			2007	2008	2009
78-140	Eladuwa	2006	8.0	15.0	25.6
78-150	Nivitigalakele	2006	9.3	18.9	33.7
78-158	Eladuwa	2006	7.0	13.9	24.3
78-260	Eladuwa	2006	7.0	12.7	21.5
78-278	Kuruwita	2006	7.7	13.4	22.0
78-334	Eladuwa	2006	8.3	17.8	32.5
78-341	Eladuwa	2006	8.1	16.2	30.0
78-510	Kuruwita	2006	7.8	13.8	23.3
78-534	Kuruwita	2006	7.7	13.6	22.0
78-689	Eladuwa	2006	7.5	15.1	27.3
78-759	Kuruwita	2006	8.3	14.5	23.7
78-770	Kuruwita	2006	7.0	12.2	20.9
78-873	Kuruwita	2006	6.9	10.1	17.5
87-182	Kuruwita	2008	-	-	6.0
87-235	Kuruwita	2008	-	-	4.6
87-290	Kuruwita	2008	-	-	5.2
87-370	Kuruwita	2008	-	-	6.4
92-124	Pallegoda	2007	-	7.5	13.3
	Kuruwita	2007	-	7.1	12.4
92-129	Pallegoda	2007	-	7.8	13.5
	Kuruwita	2007	-	6.6	11.5
92-250	Pallegoda	2007	-	6.6	12.9
92-279	,,	2007	-	7.8	14.0
92-132	,,	2007	-	6.6	11.6
	Kuruwita	2007	-	7.4	12.0
92-358	Payagala	2006	9.8	17.6	29.9
GP 12-93	Kuruwita	2006	-	11.9	19.0
GP 22-137	Payagala	2006	7.5	13.6	22.4
GP 44-24	,,	2006	9.0	16.0	26.8
RRIC 100 seedlings	Kuruwita s.s.	2005	12.7	20.8	32.7

Yields from ECTs (Estate/RRISL Collaborative Trial) - *GPB/BST/ECT/95/01*

The estate yields and other data obtained from ECT trials are given in Table 21.

Table 21. *Clone, year of tapping, number of tapping days, average yield (g/t/)t and yield/tree/year of ECT trials*

Clone	Year of tapping	No. of tapping days	Average g/t/t	Yield/tree/year (Kg)
RRISL 201	6	130	33.6	4.3
RRISL 203	15	99	45.8	4.5
RRISL 205	8	100	40.7	4.0
RRISL 206	8	113	44.3	5.0
RRISL 208	7	86	54.7	4.7
RRISL 211	7	99	46.9	4.6
RRISL 216	7	85	23.2	1.9
RRISL 217	8	82	30.9	2.5
RRISL 219	7	85	24.6	2.0
RRISL 2000	3	107	54.0	5.7
RRISL 2001	8	112	35.5	3.9
RRII 105	3	99	42.7	4.2

(P Seneviratne, K K Liyanage, K W Rupatunga, K B Karunasekera, I D M J Sarath Kumara, H P Peries, T M S K Gunasekera and L S Kariyawasam).

Smallholder/RRI collaborative clone trial 1- GPB/BST/SRT/2001/01-03

Eighth year girth measurements were taken from these trials. Table 22 shows girth measurements for the year under review and for past two consecutive years. All three clones planted in this trial show vigorous growth.

Table 22. *Mean girth (cm) of the trees of smallholder/RRI collaborative clone trial 1 (SRT trials 1-3) planted in 2001*

Clone	Site/Expt. No.	Year		
		6	7	8
RRISL 201	Kegalle (SRT/01/01)	59.96	63.4	67.0
	Homagama (SRT/01/03)	59.98	62.5	66.2
RRISL 203	Kegalle (SRT/01/01)	57.0	58.6	60.6
	Homagama (SRT/01/03)	52.8	54.6	57.8
RRISL 205	Kegalle (SRT/01/01)	50.08	52.8	55.5
	Homagama (SRT/01/02)	62.41	64.8	64.8

(P Seneviratne, K K Liyanage, K B Karunasekera, L S Kariyawasam and H P Peries)

Smallholder/RRI collaborative clone trial 2 – GPB/BST/SRT/02,2003/01-04

Seventh year mean girth of the four clones obtained from three sites planted in year 2002 and sixth year girth of clones planted in year 2003 are given in Table 23. Girth measurements of the current year and those for the previous two years are given.

Table 23. *Mean girth (cm) of the trees of Smallholder/RRI collaborative clone trial 2 (SRT trials 1-4) planted in 2002 and 2003*

Clone	Site/Expt. No.	Year		
		5	6	7
RRIC 201	Kalutara (SRT/02/02)	49.50	55.4	60.7
	Kalutara (SRT/02/03)	41.13	49.8	56.0
	Kaburupitiya (SRT/03/01)	57.6	63.1	
	Radawela (SRT/03/02)	52.6	56.3	
RRIC 205	Kalutara (SRT/02/02)	51.75	56.4	60.4
	Kalutara (SRT/02/03)	40.64	46.9	51.8
	Kaburupitiya (SRT/03/01)	52.0	58.1	
	Radawela (SRT/03/02)	53.9	59.3	
RRIC 206	Kalutara (SRT/02/02)	51.76	56.5	59.9
	Kalutara (SRT/02/03)	44.81	50.6	55.4
	Kaburupitiya (SRT/03/01)	48.0	52.4	
	Radawela (SRT/03/02)	53.0	57.0	
RRIC 121	Kalutara (SRT/02/02)	38.23	43.2	49.9
	Kalutara (SRT/02/03)	36.60	43.6	48.7
	Kaburupitiya (SRT/03/01)	50.28	56.4	
	Radawela (SRT/03/02)	51.8	57.3	

(P Seneviratne, K K Liyanage, K B Karunasekera and L S Kariyawasam)

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

Numbering of trees started previous year was completed during the year under review. Other Maintenance was kept to minimum possible due to lack of funds (P Seneviratne, K K Liyanage and I D M J Sarathkumara).

New plantings

Small Scale Clone Trials

Two small scale clone trials were established at Eladuwa and Neuchatel estates to test 2002 and 2004 hand pollination progenies.

Trial 1- In this trial 13 genotypes from 2002 hand pollination progeny were planted to test with two control clones. Randomized block design was used with four replicates per genotype. Replicate size was six.

Trial 2- In this trial 22 genotypes from 2004 hand pollination progeny were planted to test with two control clones. The same design as for the Trial 1 was used for this also.

Estate/RRI Collaborative clone trials

Estate/RRI collaborative clone trials were established as per the details given in Table 24 to monitor the performances of newly recommended clones further at commercial scale.

Table 24. *Details of the Estate/RRI collaborative clone trials established in the year*

Estate/Sub station	Clones planted
Eladuwa Estate, Matugama	RRISL 201,
	RRISL 203,
	RRISL 208
	RRISL Centennial 2 (87-139)
	RRISL Centennial 3 (87-370)
	RRISL Centennial 4 (92-124)
	RRISL Centennial 5 (92-132)
	RRISL 206
Hunuwella Estate, Opnayaka	RRISL 206, RRISL 211, RRISL 226
RRI Substation, Polgahawela	RRISL 2004, RRISL Centennial 2 (87-139)
	RRISL Centennial 3 (87-370)
RRI Substation, Kuruwita	RRISL 203,
	86-10,
	86-87,
	RRISL Centennial 3 (87-370)
Kumarawatta Estate, Moneragala	RRISL Centennial 3 (87-370)
	RRISL Centennial 4 (92-124)
	RRISL 203,
	RRISL 206
	92-358

(P Seneviratne, K B Karunasekera and H P Peries)

PLANT SCIENCE

P Seneviratne

SUMMARY

Studies on wintering, flowering and seed production continued as scheduled and with more clones. The data gathered reconfirmed high and reliable seed production of the clone RRIC 100 in dry areas of the country. Out of the RRISL 200 series clones studied, four clones, *i.e.* RRISL 217, RRISL 201, RRISL 202 and RRISL 222 produced over 10,000 seeds per hectare; in particular, the clone RRISL 201 was the highest seed producer recording 58,587 seeds per hectare at Kuruwita sub station. However, it is also emphasized that the pattern of the seed fall is unpredictable and nurserymen should be alert to collect their seed requirement in the early seed fall.

Plants rejuvenated through successive grafting exhibited juvenile characteristics determined by rooting capacity and other parameters such as growth rate and shoot angle. More passages were produced and cuttings were tested for juvenility. Young budding plants raised in plastic root trainers continued to perform poorly compared to young buddings of normal polybags. Central hole at the base of the normal bag was as effective as normal perforation for the growth of young buddings.

Some out yielding crown and trunk combinations have been identified from crown budding trials. Both *Hevea* species, *H. spruciana and H. pauciflora*, used for crowns reduced the yield of the trunk indicating more influence from the crown on the yield. Budwood plants when pollarded at higher levels produced more number of shoots for young budding. But, the number of shoots seems to be a clonal characteristic too. Young buddings of RRIC 121 have performed better than bare roots of the same clone.

Survey conducted on usage of rubber clones revealed that the clone RRIC 121 has been planted to cover more than 40% of the total extent under rubber in Sri Lanka. Yet, the two popular clones RRIC 100 and PB 86 still cover about 25% and 20% of the total extent respectively.

Tree girth, bark thickness and the individual tree yield (g/t/t) have decreased significantly with the increase in planting density from 500 to 800. However, higher YPH was recorded in higher densities. Further, in the low density trial, it was shown that for all clones tested, girth, g/t/t and y/t/a have decreased with increasing plant density from 350 to 550. However, YPH has increased with increasing plant density irrespective of the clones.

Higher yields could be achieved with quarter cuts and one third cuts tapped daily with stimulants. Daily tapping of half cuts have increased the brown bast percentage. According to the data gathered so far, ¼S upward cut tapped every other

day on the opposite higher panel seems to be the best tapping system for trees affected with brown bast.

Growth and the establishment rates of rambutan and jak plants were satisfactory and better than those of bud grafted (bg) and seedling (s) durian. Rambutan did not flower during the usual Feb-March 2008 due to the wet and cloudy weather prevailed. However, a reasonable fruit set occurred at the end of year 2008 and also during the Feb-March 2009 hence two crops were harvested during 2009.

All rubber nurseries of government, RPC owned and private were inspected according to the schedule and reports were sent. More than two million plants have been certified during the year. Training programmes on exploitation, bud grafting and nursery management were carried out. All experimental work, nursery activities and advisory visits expected by the stakeholders were attended satisfactorily. A large number of publications including eight advisory leaflets were done during the year under review.

DETAILED REVIEW

Staff

Dr (Mrs) Priyani Seneviratne, Head of the Department, Dr A M W K Seneviratne, Botanist, Mrs S A Nakandala, Assistant Botanist, Mr R P Karunasena, Mrs G A S Wijesekera, Mrs R K Samarasekera, Mr M N de Alwis, Mr M K P Perera, Mr D L N de Zoysa, Mr P D Pathirana and Mr P K W Karunatilaka Experimental Officers, Mrs D E Jayawardena and Mrs P D A H M A de Almeida, Clerk Typists were on duty throughout the year.

Having successfully completed research work and obtaining his PhD degree Dr A Wickramaratne, Assistant Botanist returned and resumed duties on 12.10.2009. Mr K A G B Amaratunga and Mr T U K Silva were promoted to Assistant Botanists with effect from 01.02.2009. Mr N M C Nayanakantha left for his post graduate studies at University of Delhi, India on 14.12.2009. Mr R Handapangoda, Technical Officer was transferred to the Plant Science Dept. with effect from 03.11.2009.

Research students

- M P S D Damayanthi, a final year student of Faculty of Agricultural Sciences, University of Sabaragamuwa completed her final year project on "Effect of different treatments for rooting of cuttings from seedling and clonal trees of *Hevea brasiliensis* (A.Juss.) Muell. Arg. under the supervision of Dr (Mrs) P Seneviratne.

- H G Dushantha Chamara, a trainee of Agunakolapallasse Agriculture Training School worked on nursery practices and got a thorough knowledge on nursery

monitoring for quality improvement under the supervision of Dr (Mrs) P Seneviratne.

- K G D Ishani Kaushika, a trainee of Angunakolapallessa, Agriculture Training School assisted the department staff to gather data on growth and yield experiment under the supervision of Dr (Mrs) P Seneviratne.

- H H R Thilakarathna, a trainee of Naiwala trained on all activities of the department for a period of four months.

- L O Y Jayasekara, Technical Assistant for Vitex Project continued to work for the project.

Seminars/Training Programmes/Workshops/Exhibitions conducted

Subject/Theme	Number of programmes	Beneficiary/Client	Officers involved
Tapper training programmes	05	RPCs, NIPM	K A G B Amaratunga W Karunathilaka
Bud grafting	09	RPC's, RDD and Private Sector	W Seneviratne N de Alwis L N de Zoysa R Handapangoda
Rain guards	03	RPCs	R P Karunasena
Immature upkeep and Field establishment	01	RPCs	M N de Alwis L N de Zoysa
Nursery management, Immature upkeep	01	NIPM	P Seneviratne M N de Alwis L N de Zoysa
Latex harvesting	01	RPCs	K A G B Amaratunga
Young budding	01	RPCs	M N de Alwis
Planting techniques	20	Smallholder Plantations Entrepreneurship Development Programme (SPEnDP)	M N de Alwis, L N de Zoysa R Handapangoda
CUT, Latex harvesting and Rain guards	01	RPCs	T U K Silva K A G B Amaratunga R P Karunasena
Knowledge update programmes	02	RDOs	P Seneviratne K A G B Amaratunga R P Karunasena M N de Alwis L N de Zoysa

Seminars/Training/Workshop/Conferences attended

Officer	Subject	Organization
P Seneviratne, W Senevirathna, N M C Nayanakantha, S A Nakandala, K A G B Amaratunga, T U K Silva, Experimental and Technical Staff	Centennial Rubber Conference Sri Lanka 2009 on 12th and 13th of May	Rubber Research Institute of Sri Lanka
P Seneviratne	National Committees on Biotechnology and Plant Breeding	Sri Lanka Council for Agricultural Research Policy
S A Nakandala	Number in Science	NASTEC and SLAAS E II
T U K Silva	Timber production in high density planting of *Hevea brasiliensis*	University of Sri Jayawardenapura
P Seneviratne W Senevirathna	Scientific Committee Meetings	Rubber Research Institute of Sri Lanka
P Seneviratne	Bio-safety: Status verification and Risk assessment at national level	Sri Lanka Council for Agricultural Research Policy
P Seneviratne W Senevirathna	Seed act and plant certification	Department of Agriculture
P Seneviratne	Knowledge development of the staff of RDD	RDD & RRISL

Visits

Advisory	- 20
Experimental	- 542
Nursery inspection	- 92
Miscellaneous	- 79
Total	- 733

LABORATORY INVESTIGATIONS

Tissue culture

***Propagation of clonal* Hevea**

Embryos and nodal cuttings were cultured just to maintain the tissue culture

activities. New experiments were not started during the year (N M C Nayanakantha, P Seneviratne and G A S Wijesekera).

FIELD EXPERIMENTS

Rubber seed production

Seed production of the clone RRIC 100 continued to be higher with compared to other three clones tested in the series, RRIC 121, RRIC 102 and RRIC 133 (Fig. 1) in spite of the *Phytophthora* attacks observed during the flowering season. From RRISL series, four clones, *i.e.* RRISL 217, RRISL 201, RRISL 202 and RRISL 222 produced over 10,000 seeds per hectare (Fig. 2). In particular, the clone RRISL 201 was the highest seed producer recording 58,587 seeds per hectare. Among the four foreign clones used, *i.e.* PB 260, BPM 24, RRII 105 and PB 28/59, both PB 260 and BPM 24 recorded a production of seeds in the range of 4,000 - 14,000 seeds per hectare (Fig. 3) (N M C Nayanakantha, P Seneviratne ,T U K Silva and P D Pathirana).

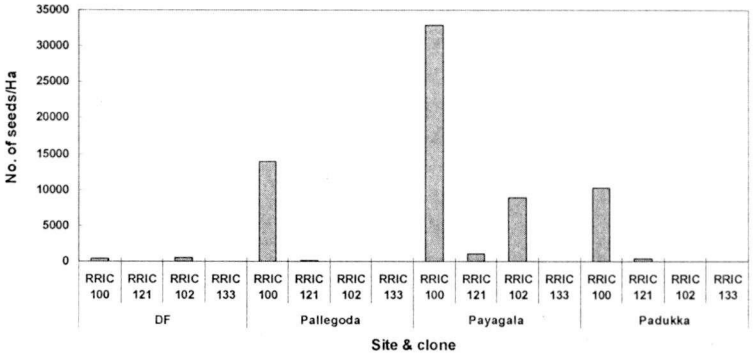


Fig. 1. *Annual seed production (number of seeds per hectare) of RRIC 100, RRIC 121, RRIC 102 and RRIC 133 in four different sites*

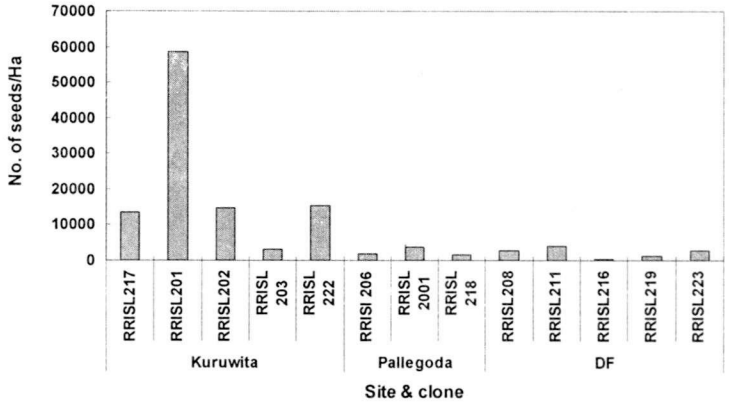


Fig. 2. *Annual seed production of RRISL clones in three different sites*

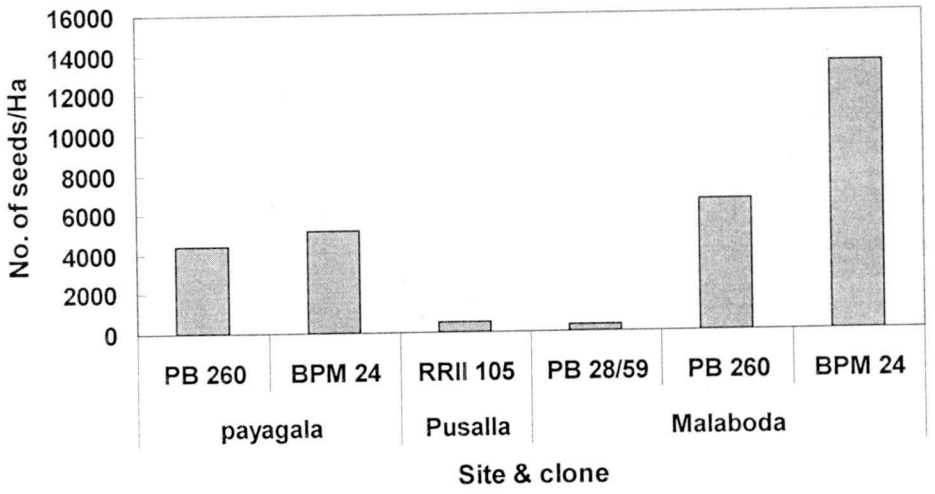


Fig. 3. *Annual seed production of PB 260, BPM 24, RRII 105 and PB 28/59 in three different sites*

Seed germination

Seed germination was not tested this year as collection of seeds was not done regularly. However, the external appearance and the quality when opened assured high quality of the seeds collected (N M C Nayanakantha, P Seneviratne and P D Pathirana).

Unusual seed fall

Late seed production was observed in PB 260 and RRIC 133 clearings. Seeds could be collected from clone RRIC 130 throughout the year showing no pattern (N M C Nayanakantha, P Seneviratne and P D Pathirana).

Wintering and flowering of rubber

The results of wintering and flowering revealed that there is a significant variation in wintering and flowering patterns among clones and sites. No clear wintering and refoliation was observed in clearings of RRIC 130 and RRIC 121 throughout the wintering season (N M C Nayanakantha, P Seneviratne and P D Pathirana).

Natural pollinators of rubber

About 11 insect species were sent to the Department of Zoology, University of Peradeniya, in 2008 for identification. They were to confirm the biology and other details of the insects (N M C Nayanakantha, P Seneviratne and P D Pathirana).

Clonal propagation

Rooting of cuttings (mist propagation) - CP/2001/1 - Dartonfield

Field planted rooted cutting of clones RRIC 100, RRIC 121 and RRIC 130 have reached an average girth of 49.1 cm after 7 years at planting distances of 8'× 7'. Trees of RRIC 121 and RRIC 130 have reached average girth of 53.1 cm and 52.8 cm respectively while RRIC 100 has given only 39.5 cm average girth.

Cutting of clones of RRISL 200 and 202 also were tested to induce roots using the mist propagator with little progress (P Seneviratne and G A S Wijesekera).

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

Successive grafting trials conducted to induce juvenile characteristics in elite materials of clone PB 28/59 are in progress. Attempts were made to produce plants from the above tree and from clone RRIC 130 through rooted cuttings (P Seneviratne and G A S Wijesekera).

Phase change of Hevea *(CP/1991-1/DF)*

Seedlings planted in consecutive years from 1991 to 2005 were cut back at 3' and the shoots appeared after cut back were checked for the rooting ability as an indicator of juvenility, using mist propagator. Rooting percentage is given in Table 1. As it can be seen from Table 1, the percentage rooting increases with the decrease of the age of the seedling.

Table 1. *Rooting percentage of shoots from seedlings planted from 1991 to 2005*

Year planted	Rooting %
1991	6.66
1992	6.66
1993	13.3
1994	13.3
1995	20.0
1996	6.66
1997	13.3
1998	13.3
1999	6.66
2000	-
2001	20.0
2002	-
2003	6.66
2004	13.3
2005	26.7

Once the shoots were harvested the trees were pollarded again at the height of 1' from the ground level and number of shoots appeared, length and diameter of the shoots and angle between the trunk and the shoot were measured. Results are

given in Table 2. In order to assess the juvenility, these shoots were also checked for their rooting ability in the mist propagator and the results are given in Table 3.

Table 2. *Number of shoots appeared, length, diameter and the angle between the trunk and the shoot of pollarded trees*

Year planted	Mean number of shoots appeared	Mean shoot length (cm)	Mean shoot diameter (mm)	Angle between the trunk and the scion
1991	1.8	-	7.3	-
1992	2	-	11.5	-
1993	0.5	-	10.5	-
1994	3	45.6	12.3	22.2°
1995	2.8	22.4	13.5	16.9°
1996	3.8	16.6	12.9	13.4°
1997	1.7	19.2	12.7	16°
1998	3	27.5	16.1	17.5°
1999	3.5	25	12.8	17.4°
2000	5	24.6	13.2	18.4°
2001	2.3	11.1	11.4	15°
2002	3.8	30	12.1	18.7°
2003	3	6.3	10.5	11.7°
2004	5	31.7	11.6	11.8°
2005	3.7	23.3	13.7	18.6

The number of shoots, their length and diameter show an increasing trend, while the angle between the main trunk and the shoot show an decreasing trend confirming the higher juvenility in younger trees. However, when the trees are pollarded close to the root system the resulting shoots are generally juvenile irrespective to their age. This is observed in the rooting percentage as there is no clear pattern. As expected a higher number of shoots has been produced by the oldest and hence the largest trees (Table 3).

Root system of* Hevea *(CP/1999/1 -NK)

Girth and yield measurements of trees with different root systems *i.e.* tap root and fibrous roots, but with same genetic make up, and which are being tapped, are given in Table 4. As far as all the pairs were concerned, seedlings with tap roots have given mean girth of 54.6 (± 4.96) cm, while their corresponding cuttings with fibrous roots have given 53.4 (± 6.25) cm mean girth. As far as the tree girth is concerned, except for the last pair, the cutting performs better in all pairs. Yield data show a relationship between the two types.

Table 3. *Rooting %, number of roots per shoot and mean root length of the shoots planted in mist propagator*

Year planted	Rooting (%)	No. of roots per shoot	Mean root length (cm)
1991	40	3.5	10
1993	0	0	-
1994	20	1	6
1995	37.5	1.33	13.75
1996	11.1	1	4
1997	33.3	3.33	4.85
1998	28.6	1	7
1999	29.4	1.4	7.36
2000	10	1.5	4
2001	33.3	1.2	9.5
2002	17.6	1.67	8.7
2003	40	1.67	12.2
2004	33.3	1.4	8
2005	26.7	2.25	4.3

(P Seneviratne and G A S Wijesekera)

Table 4. *Girth and the yield of the trees of the same genetic make up but different root systems (tap roots and fibrous roots)*

Pair No.	Girth of the tree (cm)	Mean g/t/t of the seedling	Girth of the correspondent cutting (cm)	Mean g/t/t of the correspondent cuttings
1	68	10.77 (±1.55)	87	17.1 (±1.52)
2	74.5	10.22 (±0.83)	90	5.08 (±0.98)
3	52	2.16 (±0.26)	70	3.92 (±0.52)
4	56	13.92 (±0.99)	53	10.94 (±0.95)
Average		9.27 (±2.5)		9.27 (±3.04)

(P Seneviratne and G A S Wijesekera)

Effect of the rootstock on growth and yield of rubber (YB/2005/DF)

Mean girth of the plants after two years of field planting are given in Table 5.

Table 5. *Mean girth of the plants after two years*

Number of days taken for germination	Man girth (cm) at 4'	
	RRIC 100	RRIC 102
12/13	15.25	13.7
14/15	13.4	14.7
17	13.9	-
18	13.4	12.8
19	13.2	12.4
20/21	13.15	12.5
22	14.4	13.4
23	14.2	12.2
24	12.25	-
25	-	14
26	13.4	-
27	-	11.5
32/49	-	13.6

(P Seneviratne and G A S Wijesekera)

Budgrafting

Successive grafting - BG/1999/1 - Dartonfield

Plants of 11th budgrfting passage were generated using budwood of the 10th passage. Nursery plants of first 6 generations were pollarded and number of shoots appeared, length of the shoots and angle to the main shoot were measured to assess the rejuvenation capacity.

Table 6. *Number of shoots appeared, their length and angle to the main shoot after pollarding*

Generation	No. of shoots	Mean shoot length (cm)	Angle
G_1	5.5	51	36.4°
G_2	4.5	46.6	40.8°
G_3	4	46.9	43.75°
G_4	5.6	43.1	36.5°
G_5	4.43	58.7	43.45°
G_6	2.89	29.3	37.6°

(P Seneviratne and G A S Wijesekera)

Rejuvenation of budwood plants - Egaloya Rubber Nursery

Another two generations were produced during the year. Altogether 11 successive bud grafting passages have been completed. Ten plants from each clone

belong to the 9th passage were planted in the nursery. Age and the mean girth of the trees of different passages are given in Table 7.

Table 7. *Age and the mean girth (cm) of the trees of different passages*

	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8
Age (years)	$5\,^{3}/_{12}$	$4\,^{6}/_{12}$	$3\,^{9}/_{12}$	$3\,^{3}/_{12}$	$2\,^{5}/_{12}$	2	$1\,^{6}/_{12}$	$1\,^{2}/_{12}$
RRIC 100	29.4	23.9	24.4	23.2	12.6	11.1	7.05	5.8
RRIC 102	23.4	19.9	16.7	15.1	13.8	11.4	7.2	5.6
RRIC 121	23.2	24.8	22.1	20.4	15.4	13	7.6	4.7

Nursery plants of the first eight generations were pollarded at 6" from the bud union and number of shoots appeared, shoot length, diameter and angle between the trunk and the shoot were measured as an assessment of rejuvenation. The number of shoots produced at three time periods are shown in Table 8. According to the data, it is evident that sprouting of shoots is faster in younger generations irrespective to the clone. Among the clones, a higher number of shoots has been produced in RRIC 121. At the end of the seven weeks, a higher number of shoots were recorded for older generations owing to the bigger sizes of the trunks as given in Table 7.

Table 8. *The number of shoots appeared measured at three different time intervals*

Time	Clone	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8
2 Weeks	**RRIC 100**	0	0	0	0	0.4	0.3	2	4
	RRIC 102	0	0	0.56	0	0	0.3	3.1	3.25
	RRIC 121	0	0	0	0	0	1.1	5.9	6.1
5 Weeks	**RRIC 100**	4	7.2	8	8.1	5	7.9	4.6	4
	RRIC 102	2	3.9	4.6	5.5	5	5.7	4.6	3.9
	RRIC 121	2.7	2.6	3.2	5	4.6	7.3	4.7	4.3
7 Weeks	**RRIC 100**	6.4	6.6	9	9.5	4.7	6.3	3.5	3.1
	RRIC 102	2.8	4.4	5.9	5.8	4.4	4.6	3.7	2.9
	RRIC 121	4	3.9	4.6	5.9	3.5	5.9	4.1	4.1

Diameter of the shoots produced by the different generations shows no clear trend (Table 9) but the shoots produced by trees from G3 to G6 are superior to the others perhaps as a result of getting ideal conditions with regard to the age as well as the growth of the mother tree. Clone RRIC 121 shows the best growth.

Table 9. *Diameter (mm) of the shoots produced by the different generations*

Clone	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8
RRIC 100	10	12.1	11	10	12.2	11.9	10.1	10.1
RRIC 102	8.9	10.4	10.5	11.1	11.1	10.7	11.1	8.9
RRIC 121	10.5	13.7	14.3	12.5	15	13.4	10.8	9.1

Mean length of the shoots produced and measured at different intervals show early sprouting in younger generations (Table 10). Results at the end of seven weeks evident higher juvenility in latter generations showing longer shoots in all three clones.

Table 10. *Mean length (cm) of the shoots produced and measured at different intervals*

Time	Clone	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8
5 Weeks	RRIC 100	1	2.8	2.8	3.3	10.9	14	19.4	20
	RRIC 102	2.7	6.9	15.3	6.3	8.4	5.8	22.6	10.6
	RRIC 121	8.3	5.5	8.5	10.1	13.3	15.9	20.3	13.3
7 Weeks	RRIC 100	6.2	13.3	12.6	11.2	24.4	26.4	25	20.4
	RRIC 102	7.9	12.3	15.6	14.4	22	23.3	26.1	21
	RRIC 121	11.1	14.1	15.2	23.4	29.9	31.1	26.9	15.2

When the heights of the first three whorls were measured, a clear increase in the height is observed as the mother tree gets younger irrespective to the large size of the trees of older generations (Table 11). The total length up to the third whorl shows an increasing trend up to 5-7 generations (Table 12).

Table 11. *Mean heights (cm) of the shoots of the first three whorls on trees of different generations*

Whorl	Clone	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8
1st	RRIC 100	20	28	28.2	28.5	29.7	29	24.9	21.5
	RRIC 102	21.7	27.5	33	37.1	40.1	33.7	27.5	24.6
	RRIC 121	32.9	29.1	40.6	35.8	37.9	39.1	24.8	19.7
2nd	RRIC 100	27.3	40.9	34.8	34.8	35.7	39.8	26.4	28
	RRIC 102	28.1	34.4	37.9	50.8	52.4	44	35.6	28.3
	RRIC 121	35.2	46.5	53.5	52.2	58.2	56.7	26.4	15.5
3rd	RRIC 100	34.5	25.7	23.2	23.9	28.8	29.2	26.9	41.9
	RRIC 102	31.4	22.2	29.8	27.1	14.8	15.2	45.2	20
	RRIC 121	26	30.2	30.1	42.7	47	49.6	35.7	31.9

Table 12. *The total length (cm) of the shoots up to the third whorl in different generations*

Clone	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8
RRIC 100	81.8	94.6	88.2	87.2	94.2	98	78.2	91.4
RRIC 102	81.2	84.1	100.7	115	107.3	92.9	108.3	72.9
RRIC 121	94.1	105.8	124.2	128.7	143.1	145.4	86.9	67.1

(P Senevi.atne and G A S Wijesekera)

Root trainers

Details of this experiment were given in the Annual Review for 2007. Mean girth measured at 4' after one year of field planting are given in Table 13.

Table 13. *Mean girth (cm) measured at 4' after one year of field planting*

Container Type	Para meter	Potting mixture							
		A	B	C	D	E	F	G	H
Black polythene cone shape (32 cm × 9 cm)	n	5	8	8	8	5	4	8	-
	mean	7.9	6.95	7.55	7.61	7.14	7	7.94	-
	SEM	0.58	0.66	0.79	0.35	0.42	0.41	0.59	-
Black polythene cone shape (40 cm × 15 cm)	n	9	6	6	10	3	6	8	4
	mean	8.05	8.6	7.92	8.75	6.5	7.83	8	9
	SEM	0.6	0.66	0.71	0.43	0.29	0.59	0.73	0.73
Plastic root trainer	n	2	-	2	4	-	2	-	3
	mean	6.85	-	6.75	7.75	-	7.25	-	7.67
	SEM	0.65	-	1.25	0.25	-	0.75	-	1.45
Normal Y/B bag	n	7	7	2	6	17	5	10	2
	mean	7.86	8.14	7.5	7.05	7.93	8	6.8	4.95
	SEM	0.67	0.58	1.5	0.91	0.36	0.57	0.35	0.45

According to the results plants raised in large size cone shape containers show the best growth. This may be due to the good initial growth in the plants grown in these containers. Poor field performance in the plants grown in the plastic root trainers is partly due to the poor initial growth and to the low number of replicates. Soil mixed with sand and coir pith or compost as potting mixture was the best (P Seneviratne and G A S Wijesekera).

Potting mixture and the container (PM/YB/2009)

The objective of this was to see whether the amount of soil in a bag could be reduced by adding coconut husks in to the bags along with soil for young buddings. The seeds of 2009 August were used. Bags were prepared as given in the Table 14. Amount of soil that can be saved and the height and the diameter of the plants after 10 weeks are given in Table 14.

Table14. *Amount of soil that can be saved and the mean height and the diameter of the plants after 10 weeks*

Treatment	% of soil saved (by weight)	Growth of the plants	
		Height (cm)	Diameter (mm)
T_1 Top soil + coconut husks cut into pieces	26	59.3 (±2.04)	7.09 (±0.17)
T_2 Top soil + two full coconut husks	22	56.9 (±1.52)	7.31 (±0.15)
T_3 Top soil + two coconut husks cut into halves	22	54.2 (±1.26)	6.8 (±0.12)
T_4 Top soil + hole at the base + perforation	-	56.1 (±1.3)	6.95 (±0.32)
T_5 Top soil + hole at the base	-	54.6 (±1.21)	7.0 (±0.1)
T_6 Top soil + perforation (control)	-	55.5 (±1.38)	6.9 (±0.12)

As it can be seen from the data, significant differences are not seen among treatments at the end of the 10 weeks. Effects of the central hole (1" × 1' size) will be expected to see in the root morphology than in the growth of the plant (P Seneviratne and G A S Wijesekera).

Irrigation systems for rubber nurseries

A technically specified sprinkler irrigation system designed for the Sub station at Moneragala was successfully completed and a young budding nursery was irrigated twice daily during dry spells. Another sprinkler irrigation system was designed for the young budding nursery at the Kuruwita sub station comprising non technical sprinklers (S A Nakandala, P Seneviratne and P D Pathirana).

Crown budding

RRIC 110 (1994 and 1996 replantings) - CB/1998/1 – Padukka estate

Details of the experiment were given in the Annual Review for 1996. Numbering was done and girth measurements were taken during the year in both Menerigama and Main Divisions. Mean girth and the brown bast percentage are given in Table 15.

In Menerigama Division, highest mean girth was obtained for the clone RRIC 121 whilst *Hevea spruciana* showed the lowest mean girth. The mean girth of clone RRIC 130 was lower than the last year figure as some of the higher girth trees were affected with brown bast. In the Main Division RRIC 110 trees showed the highest girth. High brown bast percentage was seen in *Hevea spruciana* in Menerigama Division. Yield records could not be taken due to unfavourable weather condition that prevailed (P Seneviratne and R K Samarasekera).

Table 15. *Mean girth (cm) and the brown bast percentage of RRIC 110 trees crown budded with different clones*

Clearing	Crown	No. of trees	Average girth (cm)	% of Brown bast trees
1995- RRIC 110 Menerigama Division	RRIC 100	138	66.91 ± 0.68	26.2
	RRIC 102	85	70.87 ± 1.05	28.5
	RRIC 117	92	69.37 ± 0.96	23.3
	RRIC 121	34	86.17 ± 1.35	19.0
	RRIC 130	38	67.64 ± 1.51	38.7
	H. spruciana	29	54.3 ± 1.29	73.1
1993- RRIC 110 Main Division	RRIC 100	95	59.37 ± 0.93	20.8
	RRIC 102	56	59.40 ± 1.2	15.1
	RRIC 117	63	60.85 ± 1.1	23.1
	RRIC 110 (control)	37	72.67 ± 2.3	22.9
	H. spruciana	10	59.31 ± 2.61	33.3

RRISL 224 trunk with different crowns (1992 replanting of Genetics and Plant Breeding Department) - CB/1999/1 - Gallewatta

Girth and yield measurements were taken during the year. Mean girth and yield of trees with different crowns are given in Table 16.

Table 16. *Mean girth and yield of trees with different crown clones*

Crown	Number of trees	Mean girth (cm) (SEM)	Average yield (g/t/t)
RRIC 100	37	75.59 (± 1.96)	76.3
RRIC 121	41	82.56 (± 1.98)	58.8
H. pauciflora	6	53.98 (± 3.38)	28.4
RRIC 100 + RRIC 121	6	86.68 (± 4.08)	78.0
RRIC 100 + 121 + 102	2	88.3 (± 3.2)	44.0

Trees crown budded with RRIC 100 + RRIC 121 + RRIC 102 show the best growth, where as those bud grafted with *Hevea pauciflora* show the lowest. Highest yield has been given from trees crown budded with RRIC 100 + RRIC 121. The lowest yield has been recorded from trees crown budded with *Hevea pauciflora*. This could be attributed to the lowest girth of those trees as well as to *Hevea pauciflora* being a different species which has a low yielding capacity (P Seneviratne and R K Samarasekera).

RRIC 130, RRIC 121, RRISL 217, PB 260, BPM 24, RRIM 717 and PR 305 - CB/1998/2 - Nivithigalakale

Details of the experiment were given in the Annual Review for 2001. Numbering the trees and measurements on girth and yield were taken during the year and are given in Table 17.

Table 17. *Mean girth and average yield of trees with different crown/trunk combinations*

Treatment	Trunk	Crown	Mean girth (cm)	SEM	No. of trees	Average yield (g/t/t)
1	PR 305	Control	53.09	± 1.2	21	28.17
	PR 305	RRIM 717	44.47	± 2.46	6	21.9
	PR 305	Pollarded	50.76	± 1.28	11	38.75
2	RRIM 717	Control	53.52	± 1.2	23	25.19
	RRIM 717	PR 305	42.74	± 1.92	5	30.37
	RRIM717	Pollarded	51.45	± 2.38	5	16.17
3	BPM 24	Control	49.6	± 1.89	9	24.33
	BPM 24	PB 260	50.4	-	-	-
	BPM 24	Pollarded	46.46	± 1.65	6	25.38
4	PB 260	Control	57.76	± 1.67	5	48.82
	PB 260	BPM 24	48.33	± 2.55	5	16.42
	PB 260	Pollarded	54.0	-	1	42.26
5	RRIC 121	Control	64.85	± 2.56	7	66.52
	RRIC 121	RRISL217	50.8	± 1.4	5	28.42
	RRIC 121	Pollarded	63.15	± 1.53	4	44.77
6	RRISL217	Control	58.36	± 2.27	6	33.68
	RRISL217	RRIC 121	51.18	± 2.66	5	29.94
	RRISL217	Pollarded	53.03	± 1.25	9	31.05
7	RRIC 121	Control	60.38	± 1.3	14	49.66
	RRIC 121	RRIC 130	52.85	± 0.35	2	36.55
	RRIC 121	Pollarded	65.56	± 2.76	10	68.89
8	RRIC 130	Control	57.43	± 1.49	15	45.33
	RRIC 130	RRIC 121	45.8	± 9.77	2	25.46
	RRIC 130	Pollarded	55.75	± 1.39	15	36.53

The clone RRIC 121 showed the highest girth whilst it was lowest in clone PR 305. As far as trunk and crown combinations are concerned, RRIC 130 crown on RRIC 121 trunk showed the highest girth.

Generally all trunk and crown combinations gave lower girth values than unbudded and pollarded RRIC 121 (P Seneviratne, L Zoysa and R K Samarasekera).

RRIC 130 crown budded with RRIC 133, BPM 24 and RRII 105 - 1999 - N'kele

Girth measurements and yield records of RRIC 130 trees crown budded with RRIC 133, BPM 24, RRII 105 and RRIC 102 control trees at N'kele are given in Table 18.

Table 18. *Average yield (g/t/t) and Mean girth (cm) of RRIC 130 trees crown budded with different clones*

Trunk clone	Crown clone	Average Yield (g/t/t)	Mean Girth (cm)
RRIC 130	RRIC 133	24.46	61.0 ± 2.72
	BPM 24	20.35	51.93 ± 1.82
	RRII 105	20.25	55.15 ± 1.91
	RRIC 102 (Control)	25.81	66.65 ± 4.25

The highest mean girth was recorded for control clone RRIC 102 whilst RRIC 130 crown budded with RRII 105 gave the lowest. The highest yield also was recorded for RRIC 102. This may be due to continuous growth in those trees (P Seneviratne and R K Samrasekera).

Budwood nurseries

The effect of height of pollarding on the number of shoots in budwood plants

The above experiment was started at Olikanda budwood nursery in July 2009 to see the effect of pollarding height. Clones RRISL 217 and PB 260 were used.

The following treatments were introduced.

T1 pollarding at the height of 6" from the apical bud
T2 pollarding at the height of 1' from the apical bud
T3 pollarding at the height of 1½' from the apical bud
T4 pollarding at the height of 2' from the apical bud
T5 pollarding at the height of 3' from the apical bud
T6 pollarding at the height of 4' from the apical bud

Eight plants were allocated for each treatment. Number of shoots appeared after pollarding was counted weekly and angle of the shoot to the main shoot were measured. Observations made on the number of shoots revealed that a higher number of shoots were produced when the trees were cut at 4'in both clones. The clone PB 260 produced only half of the number of shoots produced by clone RRISL 217 but the shoots were very vigorous. Also the number of shoots produced by trees cut at different heights were comparable in PB 260 (P Seneviratne and M K P Perera).

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

Regular visits were made to the budwood nurseries at Dartonfield, Dolahena and Olikanda. Weeding, manuaring, pollarding and application of fungicides were done according to the schedule.

Plants at Olikanda and Dartonfield nurseries were pollarded and budwood were supplied to stake holders as given in the Table 19.

Table 19. *Budwood harvested from Dartonfield, Olikanda and Dolahena nurseries*

Clone	Quantity (m)	Stake holder
RRISL 2000	10	
RRISL 2001	10	Madampe estate
RRISL 2002	10	
RRISL 2005	10	
RRISL 2006	10	Frocester estate
RRISL 202	10	
RRISL 218	10	
RRISL 2001	197	Galewatta division, Dartonfild group
RRISL 2000	20	
RRISL 2001	20	
RRISL 2004	20	Parambe estate
RRISL 2005	20	
RRISL 2002	05	
RRISL 2004	05	Elpitiya estate
RRISL 2005	05	
RRISL 2006	05	
RRISL 210	10	
RRISL 215	10	
RRISL 217	10	Halwathura estate
RRISL 218	10	
RRISL 219	10	
RRISL 203	08	Private nurseries
RRISL 2001	08	
RRISL 2001	50	Egaloya Government Nursery

(P Seneviratne and M K P Perera)

Moneragala Substation – Budwood and young budding nursery

There were about 8000 stock plants in the young budding nursery. Plants were irrigated with the sprinkler irrigation system installed. Manuring and weeding were done regularly (P Seneviratne, S A Nakandala and P D Pathirana).

Monitoring and certification of rubber plants

Nursery inspection and plant certification were done through out the year. Details of the nurseries belong to Regional Plantation Companies (RPC's), government, private sector and those in Moneragala region are stated in Tables 20,21,22 and 23 respectively.

Table 20. *Details of RPC nurseries established in 2008 August and 2009 January*

Regional Plantation Company	Number of estates	Number of nurseries	No. of plants established	Plants certification YB		
				2008 Aug.	2009 Jan.	Total
Agalawatta	05	08	73,000	22,100	2,000	24,100
Balangoda	07	11	238,770	40,200	5,000	45,200
Hapugastenna	02	03	66,000	8,000	58,000	66,000
Horana	03	06	23,931	12,850	12,900	25,750
Kahawatta	02	04	89,000	38,155	-	38,155
Kegalla	11	15	120,500	47,150	5,000	52,150
Kelani Valley	09	15	325,700	23,400	79,500	102,900
Kotagala	12	20	249,829	142,150	9,000	151,150
Lalan	01	01	55,000	33,000	-	33,000
Malwatta Valley	03	03	65,550	20,000	-	20,000
Maturata	01	01	500	2,500	-	2,500
Namunukula	06	06	73,000	31,400	-	31,400
Pussellawa	05	06	106,400	49,880	-	49,880
Total	**67**	**99**	**1,487,180**	**470,785**	**171,400**	**642,185**

Table 21. *Details of Government nurseries established in 2008 August and 2009 January*

Name of the nursery	Season	No. of plants established	Number of plants certified	Certified % as plants established
Egaloya	2008 Aug- YB	225,000	135,000	60
	2009 Jan - YB	250,000	155,000	62
Gurugoda	2008 Aug - YB	201,807	81,000	40.14
	2009 Jan - YB	250,000	150,000	60
Karapincha	2008 Aug - YB	191,000	-	-
	2009 Jan - YB	200,000	-	-
Walikadamulla	2008 Aug - YB	350,000	-	-
	2009 Jan - YB	380,000	180,000	47.40
Meerigama	2008 Aug - YB	300,000	-	-
	2009 Jan - YB	250,000	110,000	44
Middeniya	2008 Aug - YB	39,398	-	-
	2009 Jan - YB	51,000	-	-
Grand total		**2,688,205**	**811,000**	-

Table 22. *Details of private nurseries established in 2008 August and 2009 January*

Region	Season & Number of nurseries	No. of plants established	Number of plants certified
Kegalle	2008 Aug. YB (33)	457,950	117,500
	2009 Jan. YB (14)	299,800	186,700
Ratnapura	2008 Aug. YB (10)	197,500	89,600
	2009 Jan. YB (04)	133,000	-
Kalutara	2008 Aug. YB (10)	95,900	39,700
	2009 Jan. YB (06)	157,520	49,800
Total	77	**1,341,670**	**483,300**

Table 23. *Details of Nurseries in Moneragala established in 2008 August & 2009 January*

Nursery	Nursery inspected	No. of plants established	Number of plants certified
Government Nursery	2008 Aug. YB	95,000	-
Moneragala	2009 Jan. YB	430,000	335,000
Private	2008 Aug. YB	34,000	25,250
	2009Jan. YB	537,100	-
Wellassa	2008 Aug. YB	25,000	-
	2009Jan. YB	350,000	-
Hapugastenna Pl.	2008 Aug. YB	-	-
	2009 Jan. YB	-	-
Balangoda Pl.	2008 Aug. YB	2,000	1,700
	2009 Jan. YB	58,600	-
Malwattavalley Pl.	2008Aug. YB	8,000	1,900
	2009 Jan. YB	4,000	-
Total		**1,543,700**	**363,850**

(P Seneviratne, A M W K Senevirathna, M N de Alwis, L Zoysa and R Handapangoda)

Planting techniques

Field planting with polybags - PT/1998/1 - Nivithigalakele

Trees of this experiment are now 11 years old and are in tapping. Annual girth increment measured previous year showed no significant difference among treatments. Girth measurements were not taken during the year under review (P Seneviratne and M N Alwis).

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

Details of the experiment were given in the Annual Review for 2001. Girth and annual girth increment for the trees tapped and untapped are given in Table 24.

Table 24. *Mean girth of trees grown under three different soil conditions (SEM values are given in brackets)*

Soil condition of the planting hole	Tapped		Not tapped	
	Girth (cm)	Girth increment (cm)	Girth (cm)	Girth increment (cm)
Bad	55.58 (± 0.797)	1.16 (± 0.119)	55.89 (± 0.759)	2.42 (± 0.166)
Moderate	57.44 (± 1.222)	1.47 (± 0.153)	57.12 (± 1.297)	2.54 (± 0.192)
Good	56.69 (± 0.565)	1.16 (± 0.085)	56.12 (± 0.647)	3.28 (± 1.002)

Mean girth of the trees that are being tapped and not tapped are comparable though higher girth increment is observed in untapped trees. Correlation among the initial girth of the trees and the present girth are given in Table 25. Correlations exist though the values are low.

Table 25. *Correlation among the current girth and the initial girth*

	Tapped			Not tapped		
	Bad	**Moderate**	**Good**	**Bad**	**Moderate**	**Good**
Correlation coefficient (r)	0.359	0.509	0.335	0.345	0.303	0.279
P value	0.0141	0.0047	0.0001	0.0028	0.0684	0.0052
Sample size (n)	46	29	128	73	37	99
STDEV	5.404	6.581	6.392	6.487	7.89	6.440

(P Seneviratne and L Zoysa)

Comparison of planting material-PT/Galewatta/2007

The experimental details are given in the Annual Review for 2007. Fertilizer application was done four times during the year. Mulching was done monthly with one Kg of paddy straw per application. Some trees were lost due to repeated lightning strikes and plants affected with *Fomes* were treated. Mean girth of the different types of plants are given in Table 26.

As far as the growth is concerned, young buddings of clone RRIC 121 show the highest girth while bare roots of RRIC 121 show the lowest (P Seneviratne and M K P Perera).

Table 26. *Mean girth of the different types of planting materials. SEM values are given within brackets*

Clone and type of the plant	Mean girth (cm)
RRIC 121 young budding	19.2 (±0.154)
RRISL 201 young budding	16.8 (±0.235)
RRIC 121 bare roots	16.2 (±0.117)
PB 260 bare roots	17.2 (±0.113)

(P Seneviratne and M K P Perera)

Cultural practices during immature phase

Branch induction - CP/2001/1 - Pallegoda

Details of the experiment were given in the Annual Review for the year 1999. Girth data and yield data collected during the year for clone RRIC 121 and for the mixed clonal area are given in Table 27.

Table 27. *Mean girth (cm) and mean yield (g/t/t) for clone RRIC 121 and mean girth for the mixed clonal area*

Treatments	Clone				
	RRIC 121			Mixed	
	No. of trees	Girth (cm)	g/t/t	No. of trees	Girth (cm)
T_1 – Leaf cap	27	81.4 (±2.05)	88.6 (±5.12)	14	68.5 (±1.56)
T_2 - Leaves cut	26	76.7 (±3.26)	82.2 (±4.22)	16	60.7 (±2.43)
T_3 - 3" long apex removed	23	81.6 (±1.43)	92.35 (±6.52)	18	63.6 (±2.46)
T_4 – Control	28	78.9 (±1.31)	86.7 (±4.77)	14	58 (±2.58)

Both leaf cap method and by removing 3" long apex have given comparable and high girth. But the canopy architecture of the trees in which the apices were removed show no main trunk. Girth of the control trees are the lowest for both clearings (P Seneviratne, G A S Wijsesekera and L Zoysa).

Clonal composition in rubber plantations

Data gathered on the composition of rubber clones under the management of Regional Plantation Companies revealed that the usage of clone RRIC 121 has already exceeded the limits. The exact extent planted with RRIC 121 is not known as the statistics are not available for small holder sector. Based on the data available for the RPCs and the plants produced by the nurseries over the years, the calculated clonal composition is shown in Fig. 4.

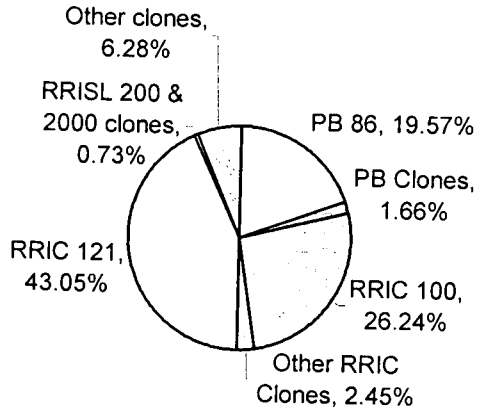


Fig. 4. Clonal composition of rubber plantations in Sri Lanka

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

Details of the experimental layout were given in the Annual Review for 1992. Growth and yield parameters of the clones tested under four different densities are given in Table 28. Tree girth and bark thickness have decreased significantly with the increase in planting density. A similar decreasing trend was observed in the individual tree yield (g/t/t). However, higher YPH was recorded in higher densities. The clone RRIC 110, affected by *Corynespora* leaf disease showed the poorest performance irrespective to the planting density. In particular, wind damage and the infection resulted in low yields per hectare in RRIC 110. All RRIC 110 trees were uprooted in July 2009.

Table 28. *Effect of planting density on growth and yield parameters of rubber. (a) tree girth (cm) and bark thickness (mm) at 150cm height and % of trees in tapping, (b) tree yield (g/t/t) and estimated YPH (kg/ha/year)*

(a)

Density	RRIC 100				RRIC 110*		RRIC 121			
	Girth (cm)	BT (mm)	% trees in tapping	Tappable trees/ha	% Trees in tapping	Tappable trees/ha	Girth (cm)	BT (mm)	% Trees in tapping	Tappable trees/ha
500	68.08	7.72	72.81	364	54.77	274	77.15	7.39	72.19	361
600	66.30	7.68	68.91	413	42.09	253	73.07	7.06	71.58	429
700	61.24	7.56	71.39	500	33.88	237	70.34	6.79	67.27	471
800	61.75	7.19	77.40	619	32.58	261	68.24	6.79	78.42	627

* **Trees were uprooted in July 2009 hence growth data, *i.e.* girth and BT are not available for RRIC 110**

(b)

Density (tree/ha)	RRIC 100		RRIC 110*		RRIC 121	
	Yield (g/t/t)	Yield (kg/ha/yr)	Yield (g/t/t)	Yield (kg/ha/yr)	Yield (g/t/t)	Yield (kg/ha/yr)
500	15.83	763	12.21	461	35.20	1660
600	15.64	869	17.25	620	30.00	1681
700	12.68	860	13.48	429	29.79	1894
800	12.28	1021	11.91	419	22.93	1928

*** Yield data for the clone RRIC 110 was recorded only up to June 2009**

(T U K. Silva, V H L Rodrigo and A Nugawela)

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

Details of the experiment were reported in the Annual Review for 1996. Girth measurements at 5' height, daily volume measurements and metrolac readings were recorded. Estimated yields (YPH) were calculated for the total tapping days of the year 2009. The mean girth, g/t/t and the yield per hectare (YPH) are given in Table 29.

According to the data for all clones tested, girth, g/t/t and y/t/a have decreased with increasing plant density. However, Y/P/H has increased with increasing plant density irrespective of the clones.

Exploitation

Longer tapping cycles through shorter tapping cuts

This experiment was started in June 2009 to see the effectiveness of shorter tapping cuts to save on the bark without affecting the productivity.

One tapping block from 2003 clearing at Pitiyakanda Estate with clone RRIC 117 was selected for the experiment. Four treatments were introduced and fifty (50) trees were allocated for each treatment.

Treatments are as follows:

T_1 - ¼ S d_3 + 12/y Ethrel (5%) + Rain guards
T_2 - ⅓ S d_3 + 12/y Ethrel (2.5%) + Rain guards
T_3 - ¼ S d_3 + 12/y BUT + Ethrel (5%) + Rain guards
T_4 - ½ S d_3 + Ethrel (2.5%) Control + Rain guards

Daily latex yields were collected and measured while DRC was calculated by using the metrolac readings. Daily amount of scrap was also measured. Pre treatment data were collected for a period of one month.

Table 29. *Effect of planting density on growth and yield parameters of rubber*

	RRIC 100				RRIC 121				RRIC 133				PB 260			
Density	**Girth (cm)**	**g/t/t**	**y/t/a estimated (kg)**	**YPH estimated (Kg)**	**Girth (cm)**	**g/t/t**	**y/t/a estimated (kg)**	**YPH estimated (Kg)**	**Girth (cm)**	**g/t/t**	**y/t/a estimated (kg)**	**YPH estimated (Kg)**	**Girth (cm)**	**g/t/t**	**y/t/a estimated (kg)**	**YPH estimated (Kg)**
350	91.8	49.5	7.92	2772	90.1	54.8	8.76	3066	94	50.8	8.12	2842	85.7	43.5	6.96	2436
425	84.8	47.7	7.63	3242	84.7	48.9	7.82	3323	85.1	47.6	7.61	3234	80.0	40.7	6.51	2766
500	80.9	42.3	6.8	3386	80.4	43.8	7.00	3500	83.7	40.4	6.46	3230	73.3	37.1	5.94	2970
575	74.3	37.2	5.92	3421	78.3	38.9	6.2	3565	81.5	35.9	5.74	3300	72.8	33.2	5.31	3053

Estimated tapping days per year – 320

Tapping system - ½ S d/2

(A Nugawela, P Seneviratne and K A G B Amaratunga)

Mean girth, Bark consumption and Yield for the period from June to December 2009 are given in Table 30.

Table 30. *Mean girth, bark consumption and yield for the period from June to December 2009*

Treatment	No. of trees	Mean girth (m)	Bark consumption (cm)	No. of tapping days (Av)	Average g/t/t
T1- ¼ S d_3 + 5%E 12/y	56	55.69	14.12	69 (9.85)	24.0
T2- ⅓ S d_3 + 2.5%E 12/y	57	54.64	13.98	69 (9.85)	22.01
T3- ¼ S d_3 + 5% E 12/y BUT	60	54.2	20.15	69 (9.85)	25.7
T4- ½ S d_3 + 2.5% E (55 days)	56	55.02	13.5	69 (9.85)	24.1

Highest g/t/t in T_3, *i.e.* ¼S d_3 + 5% E 12/y which was tapped from bottom and upward (BUT) is partly due to deep tapping (P Seneviratne and R P Karunasena).

Girth at opening (TG/99/1) - Galewatta

Mean girth increment for two clones under same tapping system and that for the untapped trees are given in Table 31a. The girth increment of the untapped trees are comparable for both clones.

Table 31a. *Mean girth increment for two clones under same tapping system and that for the untapped trees*

Clone	Tapping system	Mean girth increment (cm)				
		G 40	G 45	G 50	Mean for clone	Un tapped
RRIC 102	½ S d/2 + 2.5 Eth.4/y	0.75	0.78	0.90	0.81	2.23
RRIC 121	½ S d/2 + 2.5 Eth.4/y	0.92	0.99	1.01	0.97	2.61

The girth of the trees tapped and untapped for the two clones are given in Table 30b. However, the girth difference between the tapped and untapped trees of clone RRIC 121 is continued to be low.

Table 31b. *Mean girth (cm) of the tapped and untapped trees for the two clones*

	Tapped trees				
Clone	G 40	G 45	G 50	Mean for the clone	Untapped trees
RRIC 102	62.35	61.69	65.91	63.32	87.25
RRIC 121	68.88	70.57	70.55	70.0	84.45

(P Seneviratne and R P Karunasena)

Shorter replanting cycles - SRP/2007

Details of the experiment were given in the Annual Review for 2007. Numbering, colour banding and rain guarding were done during the year. Ethrel application was done in every 3 months through out the year.

T3 and T4 treatments were changed from the beginning of the year 2009 as shown in the Table 32. Number of tapping days, Average yield (g/t/t), crop per year and YPH for different treatments for the year 2009 are given in Table 32.

Table 32. *Number of tapping days, Average yield (g/t/t), crop per year and YPH for different treatments*

Treatments	No. of tapping days	No. of trees	Average g/t/t	Crop/year (kg)	YPH (kg)
T_1 - ¼ S d/1+2.5% ET (4/y)+RG	27	20	12.32	4.0	1996
T_2 - ½ S d/3+2.5% ET(4/y) +RG	9	20	23.56	2.5	1272
T_3 - ¼ S d/2 – ET+ RG	13	20	13.40	2.0	1045
T_4 - ¼ S d/1 + ET- (4/y) RG	15	19	11.29	2.0	1016

The highest YPH was recorded in T_1 whilst it was the lowest in T_4. Regular and higher number of tapping in T_1 with rainguards may have contributed for higher YPH (P Seneviratne and R K Samarasekera)

Selecting clones for the Smallholder Sector

This experiment was started in March 2009 to see the effectiveness of daily tapping aganst conventional ½ S d_2 system of tapping.

One tapping block from 2001 clearing at Sapumalkanda Estate, Clunes lower division having clone RRISL 201 which is tapped on "A" panel was selected for the experiment. Two treatments were introduced and for each treatment 25 trees were allocated from the selected tapping block.

Treatments are as follows.

T_1 - ½ S d_1 + Rain guard

T_2 - ½ S d_2 + Rain guard

Daily latex yields were recorded and metrolac reading was used to calculate the DRC %. Daily amount of scrap was also measured.

Experiment was started in March 2009 and pre-treatment data were recorded for a period of one month. Before commencing the experiment, the quality of tapping in both the treatments was recorded.

Yields were recorded from an area under normal estate practice *i.e.* ½ S d_3 + Rain guard + 2.5% Ethrel (5/y) from October, 2009 (T_3). Average girth, number of tapping days, average g/t/t and brown bast percentage are given in Table 33.

Table 33. *Average girth, number of tapping days, average g/t/t and brown bast percentage*

Treatments	Pre treatment g/t/t	No. of trees	Mean girth (cm)	No. of tapping days Total (Av)	Average g/t/t	Brown bast %
T_1 - ½ S d_1+ RG	23.5	20	69.9	251 (28)	23.56	20%
T_2 - ½ S d_2 + RG	18.4	23	66.2	122 (14)	21.65	8%
T_3 - ½ S d_3 + RG + 2.5% ET(5/y)	-	13	65.18	29 (10)	47.26	-

Comparable g/t/t have been recorded for d1 and d2 tapping while twice that has been obtained through d3 tapping *i.e.* Low frequency tapping with 2.5 % E (5/y). Very high brown bast percentage is recorded for trees under daily tapping (P Seneviratne, R P Karunasena and R K Samarasekara)

Tapping Panel Dryness

Continuous monitoring of TPD (TPD/2002/03)

Percentage fully, partial and total dry trees for different clones and for different sites are summarized in Table 34. Site AM 1995 showed highest level of TPD while site AM 1992 showed lowest % TPD.

Table 34. *Percentage fully, partial and total dry trees for different clones and for different sites*

Clone	Site	% fully dry	% partial dry	%Total TPD
RRIC 100	CL-1998	18.2	0.3	18.5
	CL-1997	21.9	1.6	23.5
	AM-1995	30.1	1.3	31.4
RRIC 102	AM-1992	15.4	1.0	16.4
RRIC 121	US-1997	17.4	1.9	19.0
	AM-1996	25.7	1.4	27.1
	CL-1997	17.4	0.0	17.8
RRIC 130	CL-1997	18.5	2.5	21.0
	CY-1997	20.8	1.5	22.4
	AR-1996	26	2.3	28.3

AM - Ambetenna, AR - Arappolakanda, CL – Culloden, CY – Clyde, US - Uskvalley
(A M W K Senevirathna and K A G B Amaratunga)

Exploitation of TPD trees (TPD/2008/02)

Details of the experiment were given in the Annual Review for 2008. Pre treatment (Pre. Tr.) and monthly average yield (g/t/t) and treatment average yield (Ave) of treatments, T_1 to T_6 are given in Table 35.

Table 35. *Pre treatment (Pre. Tr.) and monthly average yield (g/t/t) and treatment average yield (Ave) of treatments, T_1 to T_6*

	Pre. Tr.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Ave
T_1	38.6	29.0	25.0	25.4	27.2	22.1	20.0	13.8	7.5	7.0	7.2	8.3	8.3	14.1	15.2	10.8	12.8	***15.9***
T_2	38.8	30.6	27.0	27.5	33.8	25.3	23.4	17.5	11.5	15.5	10.6	10.2	11.8	9.7	13.9	19.0	14.1	***18.8***
T_3	16.1	14.2	12.4	13.1	19.3	13.5	10.8	8.3	5.3	4.6	8.4	7.3	6.7	4.7	5.5	6.3	5.0	***9.1***
T_4	29.4	24.8	16.5	14.3	14.5	9.6	8.3	6.2	3.4	2.9	2.7	2.6	2.8	2.7	2.8	4.4	5.4	***7.7***
T_5	13.2	10.2	8.9	9.0	8.4	5.6	3.8	2.1	0.6	0.4	1.2	0.9	0.7	1.1	0.8	1.0	2.2	***3.6***
T_6	61.9	52.3	42.5	47.7	56.5	49.9	45.6	34.8	22.5	20.5	22.2	25.3	25.9	25.3	30.1	33.5	37.4	***35.8***

T_1 ½ S D/2 ↓ (continuous tapping on the same panel)

T_2 ¼ S D/2 ↑ on the opposite higher panel

T_3 1/8 S D/2 ↑ + 1.25 ET (3/12 mon), on the opposite higher panel

T_4 ¼ S D/2 ↓ on the opposite panel

T_5 ¼ S D/2 ↓ on the same panel

T_6 ½ S D/2 ↓ on healthy trees

According to the data gathered so far, ¼S upward cut every other day on the opposite higher panel (T_2) is the best tapping system for trees affected with TPD. Continuous tapping on the same panel at ½S D/2 (T_1) followed by a rest too gave good yields compared to the other treatments (A M W K Senevirathna and K A G B Amaratunga).

Treatments for TPD trees

Application of VITEX for TPD and healthy trees (TPD/2009/01)

A new experiment was started in order to test the effectiveness of 'Vitex' as a latex stimulant and as a treatment for tapping panel dryness. Chemical was imported and supplied by S&S Trading Pvt. Ltd., 287, Grandpass Road, Colombo 14. Rubber fields that were tapped on B panel (Clone RRIC 121) planted in 1993/1994 were selected from the Dartonfield Estate of the Rubber Research Institute of Sri Lanka.

15 trees for each of the following treatments from both healthy and TPD trees were selected (T_0-T_3). Vitex and Ethephon were applied at 1g per tree at 10 and 6 day intervals for healthy and TPD trees, respectively whereas, Mortex at 1g per tree at monthly and 6 day intervals respectively. Details of the experiment are given in the Table 36. A summary on average DRC and yield per tree per tapping (g/t/t) of healthy and TPD affected trees after 30 and 48 rounds of chemical applications, respectively for the experimental period in 2009 are given in Table 37.

Table 36. *Treatment layout, number of trees and tapping system of the Vitex experiment*

Treatments	Healthy trees		TPD trees	
		No. of trees		No. of trees
Control (T_0)	½ S d/2	15	½ S d/2	15
Vitex (T_1)	½ S d/2 + 1g/10 d	15	½ S d/2 +1g/6 d	15
Ethephon (T_2)	½ S d/2 + 1g/10 d	15	½ S d/2 +1g/6 d	15
Mortex (T_3)	½ S d/2 + 1g/ 30 d	15	½ S d/2 +1g/10 d	15

Table 37. *Average DRC and yield per tree per tapping (g/t/t) in healthy and TPD affected trees after 30 and 48 rounds of chemical applications respectively for the experimental period in 2009*

	Healthy trees		TPD trees	
Treatment	DRC	g/t/t	DRC	g/t/t
T_0	36.0	32.9	39.4	1.6
T_1	36.2	37.3	45.9	4.7
T_2	38.3	42.7	46.2	6.4
T_3	37.7	37.9	44.8	3.9

(A M W K Senevirathna, K A G B Amaratunga, L.O.Y. Jayasekara and A Nugawela, funded by S & S Trading Pvt. Ltd., 287, Grandpass Road, Colombo 14)

Rubber and Oil palm (2006) – NSF/RG/2005/AG/13

Final report of this Research Project was submitted to the National Science Foundation, Sri Lanka at the end of 2009. All details and data are found in Senevirathna (2009).

Girth of rubber revealed a linear increase in growth with time (r^2=0.98). Although the inter plant distance of oil palm is 3.3m higher to that of rubber, canopy overlapping of both crops reached after three years of growth because of the faster canopy development in oil palm. LRC of both crops revealed more or less similar non-rectangular hyperbolas with A_{max} around 20 µmol m^{-2} s^{-1}; however, CRC showed 73.6 µmol m^{-2} s^{-1} A_{max} in rubber compared to 50.5 µmol m^{-2} s^{-1} for oil palm. Regular monitoring of soil moisture indicated that moisture levels in sites planted with oil palm in 2001 were lower throughout compared to other sites indicating a trend in decreasing soil moisture levels with age of oil palm (A M W K Senevirathna, W Karunathilake and P Karunadasa).

Early selection of clones by physiology (PH/2007)

Experimental details were given in the Annual Review for 2007. Girth and bark thickness measurements taken at the end of the reporting year are given in the Table 38.

Table 38. *Mean girth and bark thickness of different clones measured at 120 cm height*

Clone	No. of trees	Girth at 120 cm (cm)	Bark thickness at 120 cm (cm)
RRISL 2000	17	20.6	0.31
RRISL 2001	18	19.0	0.30
RRISL 2002	16	15.9	0.28
RRISL 2003	17	17.6	0.26
RRISL 2004	16	17.8	0.30
RRISL 2005	18	21.5	0.30

(A M W K Senevirathna and W Karunathilake)

Development of a modified tapping knife

Further developments are in progress in models developed with the National Engineering Research and Development (NERD) Centre and with the Mechanical Engineering Department of the University of Moratuwa (A M W K Senevirathna and K A G B Amaratunga in collaboration with the University of Moratuwa and NERD Centre).

New ethrel trial

Two tapping blocks were selected from RRIC 100 of 1997 clearing at Galewatta Division of Dartonfield Group. Each tapping block was divided in to two

and following stimulation treatments were introduced for each half of the tapping block. Ethrel was applied with a ¾" x ½" coconut husk brush.

Block 1

T1 5% Eth. + Coconut oil (1:1)
T2 5% Eth + hot water (1:1)

Block 2

T3 5% Eth. + hot water (1:1)
T4 5% Eth + Coconut oil (1:1)

Yield data recorded are given in the Table 39. This field was not rain guarded by the estate during the year under review and hence only four out of six stimulations could be done. However, the brown bast percentage shows a clear increase when ethrel was diluted with coconut oil.

Table 39. *Yield and brown bast percentage for different treatments*

Treatment	After stimulation g/t/t	Brown bast %
T_1	40.13	8.9
T_2	34.74	4.2
T_3	36.51	5.9
T_4	32.73	10.7

(P Seneviratne and R P Karunasena)

Intercropping

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

The objective of the experiment together with treatment layout was given in the annual report for 2002. Growth of rubber measured at 150 cm height was monitored (Table 40) Girth was higher in wider within row systems, *i.e.* T_3 and T_4. Thickness of virgin bark of rubber was comparable among treatments (Table 41). Trees were rainguarded and tapped with a half spiral cut on every three days with five stimulation rounds of Ethephon per year (S/2 d_3 ET2.5%). Daily latex yields were monitored by measuring latex volume and % dry rubber content (% DRC). Wider within row systems, *i.e.*, T_3 and T_4 recorded higher g/t/t values than the other two systems, *i.e.*, T_1 and T_2 (Table 43). In general, T_3 recorded higher YPH values due to the higher g/t/t and higher number of trees in tapping (Table 42 & 43). Basal girth of tea plants was comparable among treatments (Table 44). Growth and the

establishment rates of rambutan and jak were satisfactory and better than those of bud grafted (bg) and seedling (s) durian (Table 45). Rambutan did not flower during the usual Feb-March 2008 due to the wet and cloudy weather prevailed. However, a reasonable fruit set occurred at the end of year 2008 and also during the Feb-March 2009 hence two crops were harvested during 2009 (Table 46). Rambutan yield was increased with the age from 2007 and the highest yield per tree per year was recorded in the trees in wider spatial arrangement of rubber, *i.e.* T_4.

Table 40. *Mean girth (cm) 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	57.60	57.50	57.45	56.26	60.15
T2 (3m×3m)-18m	60.70	58.20	55.35	54.98	56.46
T3 (3.5m×3.5m)-15m	62.85	60.71	59.93	58.23	58.23
T4 (3.5m×3.5m)-18m	63.73	60.92	59.16	60.13	61.53

Table 41. *Summary of the mean bark thickness of rubber (mm). Measurements were made at 150 cm height*

Main trts.	Sub treatments				
	Tea	Cinnamon	Durian	Rambutan	Sole rubber
T_1	5.98	5.87	5.45	5.64	6.08
T_2	5.95	5.88	5.77	5.91	6.00
T_3	5.90	6.15	5.92	6.02	5.82
T_4	5.89	5.95	5.86	5.79	5.90

Table 42. *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		Mean	
	%TIT	TIT_{ha}	%TIT	TIT_{ha}	%TIT	TIT_{ha}	%TIT	TIT_{ha}	%TIT	TIT_{ha}	%TIT	TIT_{ha}
T1	85.12	315	90.74	336	85.57	317	79.38	294	86.67	321	85.50	316
T2	89.40	283	80.72	256	83.76	266	84.64	268	72.49	230	82.20	261
T3	94.39	292	95.24	294	98.04	303	93.02	287	95.24	294	95.19	294
T4	86.26	229	96.25	256	97.22	259	78.89	210	71.21	189	85.97	229

Table 43. *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		Mean	
	g/t/t	YPH	g/t/t	YPH	g/t/t	YPH	g/t/t	YPH	g/t/t	YPH	g/t/t	YPH
T1	37.06	1259	35.51	1292	31.64	1071	34.99	1095	53.03	1843	38.44	1312
T2	41.01	1237	42.39	1146	40.82	1173	43.29	1221	34.79	828	40.46	1121
T3	41.80	1326	53.74	1688	50.15	1669	54.57	1661	55.48	1765	51.15	1622
T4	48.80	1183	39.72	1093	56.36	1557	45.88	1032	62.29	1287	50.61	1230

Table 44. *Summary of the growth performance of rehabilitated (RH) and un-rehabilitated (URH) Tea under different planting arrangements of rubber*

Main treatment	Basal girth (cm)	
	Tea (URH)	Tea (RH)
T1 (3m×3m)-15m	16.89	15.16
T2 (3m×3m)-18m	16.35	15.64
T3 (3.5m×3.5m)-15m	16.42	15.02
T4 (3.5m×3.5m)-18m	18.15	15.83

Table 45. *Summary of the growth performance of Rambutan, Jak, bud grafted Durian (bg) and Durian seedlings (s) in different planting arrangements of rubber*

Main treatments	Basal girth (cm) at 10 cm height			
	Rambutan	Jak	Durian (bg)	Durian (s)
T1	49.08	33.33	8.62	4.15*
T2	48.89	42.88	27.20	12.31
T3	46.03	29.35	21.92	7.92
T4	48.50	32.00	4.33*	16.57

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

Table 46. *Census of the harvestable Rambutan fruits in different planting systems of rubber during 2009*

Main treatments	Rambutan crop 2009					
	Crop I (Feb – March)		Crop II (June – July)		2009	
	Total fruits	Fruits/ tree	Total fruits	Fruits/ Tree	Total fruits	Fruits/ tree
T1	6907	201	10895	199	17802	400
T2	1858	131	7474	275	9332	406
T3	2077	156	5176	240	7253	396
T4	4106	215	6026	308	10132	523

(V H L Rodrigo and T U K Silva)

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

The experimental details were given in Annual Review for 1996. The growth of rattan was rapid and pruning was done to allow the tappers walk in the field. Manuring was completed during the year. Measurements could not be taken due to inaccessibility. Harvesting is expected during the coming year (P Seneviratne and M K P Perera).

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

The experimental details were given in the Annual Review for 1998. The growth of rubber trees was highest in the treatment with the widest inter row spacing with single trees.

Yield measured as g/t/t also shows the same trend.

Table 47. *Cinnamon bark yield (kg/ha) under different inter row spacing*

Treat-ment	7.2S	8.4S	9.6S	10.8S	12.0S	13.2S	13.2P	14.4P	15.6P	16.8P	18.0P
Bark yield	537.7	765.0	585.6	739.0	676.5	738.5	565.3	534.4	475.3	561.5	630.9

S- Single rubber row treatments, P-paired rubber row treatments

Table 48. *The growth of rubber measured as girth (11th year of planting)*

Treat -ment	7.2S	8.4S	9.6S	10.8S	12.0S	13.2S	13.2P	14.4P	15.6P	16.8P	18.0P
Girth (cm)	63.0	64.7	66.2	67.7	71.1	75.1	67.1	65.3	64.9	64.8	65.8

Table 49. *Rubber yield in grams/tree/tapping under different inter row spacing*

Treat-ment	7.2S	8.4S	9.6S	10.8S	12.0S	13.2S	13.2P	14.4P	15.6P	16.8P	18.0P
Rubber yield g/t/t	25.2	24.1	27.0	29.8	31.2	36.2	21.8	23.1	24.8	28.2	26.8

(P Seneviratne and M K P Perera)

PLANT PATHOLOGY AND MICROBIOLOGY

C K Jayasinghe

SUMMARY

The incidence of common canopy and bark diseases was mild in all rubber growing districts. White root disease continued to be a threat to new clearings and mature plantations. It was observed that the cover crop, *Mucuna bractiata* can harbour white root disease. Sporadic attacks of cockchafer grubs were reported from Avissawella and Rathnapura districts. The fungicide mancozeb was shown to be highly effective in the management of bark cracking dis-order. Large scale production of the TMTD based repellant against mammalian pests was commenced using a "Colloid Mill". The invasive mealy bug *Paracocus marginatus* invaded the rubber plantations and nurseries and immediate steps were taken to manage the infestations. More than 10 Public Meetings and Seminars were conducted to educate the stake holders on prevention and control of this deadly insect. A fruit fly attack was reported from a rubber seedling nursery. Improvement of sanitation in and around the nursery effectively controlled this infestation. *Ricinus* sp. was shown to be an alternative host for the pathogen *Corynespora cassiicola*. Observations of the annual screening programmes against Corynespora leaf fall indicated that more than 85% of the recommended clones are highly resistant to the disease. The Corynespora management project entitled "Improvement of Management Strategy in Combating Corynespora Rubber Leaf Fall Disease" funded by Common Funds for Commodities, The Netherlands was successfully completed.

DETAILED REVIEW

Staff

Dr C K Jayasinghe, Acting Head of the Department, Ms T H P S Fernando, Assistant Plant Pathologist and Audio Visual Production Officer, Mr W Amaratunge were on duty throughout the year. Dr W P K Silva, Head of the Department was on no pay leave in Australia. Experimental Officers Mr E B Fernando, Mrs B I Thennakoon, Mrs D Siriwardena, Mr C Wijayarathna, Mr P Pieris, Mrs N Jayawardana and Mr N Nishantha continued to work in the department.

Temporary staff

Miss I Vithanage was on training for clerical work till the end of February 2009 and Miss W M M D Weerasuriya worked as a Technical Assistant in the Corynespora Management Project funded by CFC, The Netherlands till the end of March 2009.

Extension activities

Dr C K Jayasinghe and Mrs T H P S Fernando served as resource personnel in training Estate Managers, Assistant Superintendents and Field Officers. Mr E B Fernando, Mrs B I Tennakoon, Mrs D Siriwardena, Mr C Wijayarathna, Mrs N Jayawardana and Mr 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.

Seminars/Trainings/Workshops/Conferences/Meetings attended

Officer/s	Subject/Theme	Organization
CK Jayasinghe	Workshop on Agronomy and Transfer of Technology	International Rubber Research & Development Board, Malaysia
CK Jayasinghe	IRRDB – IRRI International Rubber Conference and Annual General Meeting	International Rubber Research & Development Board, Malaysia
CK Jayasinghe	Improvement of Management Strategy in Combating Corynespora Leaf Fall	Indonesian Rubber Research Institute, Indonesia.
CK Jayasinghe	National Plant Protection Committee	Sri Lanka Council for Agricultural Policy
CK Jayasinghe	Research Forum, Crop Protection	Coconut Research Institute
CK Jayasinghe	Pesticides Technical and Advisory Committee	Department of Agriculture
CK Jayasinghe	Centennial Rubber Conference Sri Lanka – 2009	Rubber Research Institute of Sri Lanka
THPS Fernando	Centennial Rubber Conference Sri Lanka – 2009	Rubber Research Institute of Sri Lanka
THPS Fernando	Global Climate Change and its Impacts on Agriculture, Forestry and Water in the Tropics	CDM Study Centre, Faculty of Agriculture, Peradeniya

Seminars/Training Programmes/Workshops/Exhibitions conducted

Officers	Subject/Theme	Beneficiary/Client
C K Jayasinghe	Efficient management of economically important diseases	Participants of the Centennial Rubber Conference
THPS Fernando	Ways to eradicate menace of mammalian pests and white root disease	Participants of the Centennial Rubber Conference

Officers	Subject/Theme	Beneficiary/Client
PP & MB Dept. Staff	Maladies of the rubber tree: theory and practical	NIBM
PP & MB Dept. Staff	Diagnosis and management of *Hevea* diseases	RPCC Undergraduate students from Agriculture schools, School children
CK Jayasinghe	Identification and control of Papaya mealy bug	RPCC Rubber Development Officers, small holders, general public

Visits

The department staff made 45 advisory, 225 experimental and 148 other visits.

GENERAL

The weather conditions during the refoliation period were not conducive for the development of Oidium leaf fall and Colletotrichum leaf disease. Though the frequent rains were experienced in May/June, Phytophthora leaf fall was not evident during the South West monsoon period except on susceptible clones at vulnerable sites.

However, White root disease continued to be a threat to new clearings and mature rubber plantations. It was observed that the cover crop, *Mucuna bractiata* can harbour *Rigidoporus microporus* and disease can be spread to rubber plants from infected *Mucuna* cover. Papaya mealy bug infestations spread during the 1st quarter reduced to negligible levels towards the latter part of the year. Sporadic attacks of cockchafer grubs were reported from Avissawella and Rathnapura regions. Several reports on bark cracking disorder were received and necessary advice was given to control the disease. Large scale production of the repellent was commenced as mammalian pest attacks increased tremendously. The Corynespora Management Project entitled "Improvement of Management Strategy in Combating Corynespora Rubber Leaf Fall Disease" funded by Common Funds for Commodities (CFC), The Netherlands was successfully completed in August 2009.

LABORATORY AND FIELD INVESTIGATIONS

Chemical control of *Hevea* diseases (CC/89/1)

***Screening of fungicides against* Rigidoporus microporus**

Experiments are in progress to evaluate the efficiency of the new fungicide, "frutonil" at three experimental sites against *Rigidoporus microporus* (C K Jayasinghe, E B Fernando and B I Tennakoon).

Management of Corynespora leaf fall disease under nursery conditions

Preliminary experiments were completed to find out the possibilities to manage CLFD by inducing resistance of the plants. The chemicals are to be tested under

nursery conditions (T H P S Fernando, C K Jayasinghe, R L C Wijesundera, C Wijayarathna and D Siriwardena).

Management of secondary leaf fall of the clone RRIC 121

During the year 2009, the secondary leaf fall caused by *Oidium heveae* remained in a mild condition. Hence, chemical controlling programme was not carried out (C K Jayasinghe, T H P S Fernando and C Wijayarathna).

Management of the bark cracking disorder

Regular observations made for three years confirmed that the fungicide, mancozeb (6g in 1 litre of water) is highly effective in management of bark cracking disorder. All the plants treated with this chemical showed a rapid recovery with the regeneration of new roots (W P K Silva, C K Jayasinghe and N Nishantha).

Biology of pests (BP/90/1)

Susceptibility of different leaf stages to Corynespora Leaf Fall Disease

Twenty tagged twigs of the clone RRISL 202, the CLFD susceptible clone was sprayed with the fungicide carbendazim (1g/litre) and mancozeb (3g/litre) alternatively at 5-d intervals. Ten tagged twigs were kept under normal conditions without fungicide applications. The fungicide application was continued till the maturity of the leaves. The observations for the appearance of Corynespora lesions on tagged twigs were recorded. The percentage disease incidence of chemically protected twigs (4.6%) was significantly less compared to the control-twigs (65.2%) (T H P S Fernando, C K Jayasinghe, R L C Wijesundera and D Siriwardena).

Studies on the epidemiology of *Corynespora cassiicola*

The experiment to study the epidemiology of CLFD in the clone, RRISL 202 (CLFD susceptible) at Kuruwita substation was continued. The observations on spore releasing pattern, leaf fall pattern, average disease severity index (ADSI) and weather data were monitored (T H P S Fernando, C K Jayasinghe, W P K Silva and D Siriwardena).

Screening of clones for leaf and panel diseases (SC/89/1)

Maintenance of nurseries established for screening purposes

Nurseries were generally maintained. Screening of clones against Corynespora leaf fall disease was completed (W P K Silva, T H P S Fernando, C Wijayarathna and N Nishantha).

Screening *Hevea* clones for Corynespora leaf fall disease

The survey carried out on mature clearings revealed that no new clones were showing CLFD incidence. The Average Disease Severity Index (ADSI) for the evaluated clones are given in Table 1.

Table 1. *Disease survey for Corynespora leaf fall disease under field conditions, year 2009*

Clone	Average Disease Severity Index (ADSI)
RRIC 121	0
RRIC 102	0
RRIC 130	0
RRISL 203	0
PB 260	0
RRIC 133	0.67
RRISL 201	1.65
RRISL 205	0
RRISL206	0
RRISL210	NA
RRISL211	0
RRISL215	0
RRISL216	0
RRISL217	0
RRISL219	0
RRISL2001	0
RRISL2003	0
PB 235	0
BPM 24	0
PB 217	0
RRISL 208	1.0
RRISL 220	0
RRISL 221	0
RRISL222	0
RRISL223	1.5
RRISL226	0
RRISL2000	NA
RRISL2002	NA
RRISL2004	NA
RRISL2005	NA
RRISL2006	NA
GPS 1	0
PB 255	0
PR 255	0
PR 305	0
RRII 105	0
RRIM 712	NA
RRISL 200	3.5
RRISL 202	2.5

N.A.- Not Available (mature clearings): ADSI, 0, free from the disease;0.01-1.0, slight infections; 1.01-2.00, moderate infections; 2.01-3.00, severe infections
(W P K Silva, C K Jayasinghe, T H P S Fernando and N Nishantha)

Comparison of clonal screening methods against Corynespora leaf fall disease

Ten clones were evaluated against their susceptibility/resistance towards CLFD using detached leaf method. There were significant variations in the mean lesion scores of different clones when evaluated by the *in vitro* assays using conidia or the toxic culture filtrate. The clones were screened in a bud wood nursery and the lesion types produced by these clones agreed with the symptoms observed in field plants. The same clones screened under natural conditions showed that 85% of the clones in the RRISL recommendation list are free from CLFD and ranked as resistant. Six percent of the clones showed mild infections, 6% moderate infections while 3% of the clones showed severe infections (Fig.1). The laboratory based *in vitro* screening methods should be used only for preliminary data. Since field experiments take a considerably longer period, the bud wood nursery experiments which takes a shorter time can be recommended to screen clones for resistance or susceptibility to CLFD (T H P S Fernando, C K Jayasinghe, R L C Wijesundera, W P K Silva and N Nishantha).

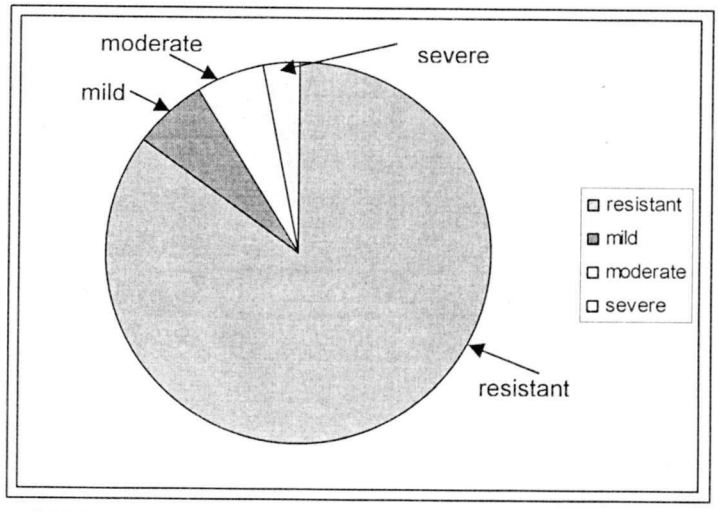


Fig. 1. Ranking of RRISL recommended clones against Corynespora leaf fall disease based on field screening method

Determination of the reasons for the disparity between the *in vitro* and *in vivo* screening tests against Corynespora leaf fall disease

The comparative evaluation of the different screening methods revealed that the *in vivo* methods: screening at nursery level or under natural field conditions was reliable. The *in vitro* screening methods are not dependable and a series of experiments were carried out to determine the reasons for the disparity between *in vitro* and *in vivo* testing.

Incidence of CLFD on different stages of the plants under natural conditions

Two CLFD resistant clones (RRIC 121 & RRIC 100) and two CLFD susceptible clones (RRIC 201 and RRISL 202) were used to record the incidence of CLFD under natural conditions on different stages of the plant. All the clones are susceptible to the disease under nursery conditions (Table 2).

Table 2. *Incidence of CLFD under natural conditions*

	Leaf stage	
Clone	**Mature**	**Immature**
R 121 (Field)	X	X
R 121 (Nursery)	√	√
R 100 (Field)	X	X
R 100 (Nursery)	√	√
R 201 (Field)	√	√
R 201 (Nursery)	√	√
R 202 (Field)	√	√
R 202 (Nursery)	√	√

√ - Disease present X – Disease absent

***Possibilities of artificial inoculation of different clones* - In vitro**

According to the results of artificial inoculations in the laboratory conditions, resistance or susceptibility changed with the maturity of the leaves. Detached immature leaves (late copper brown) of all clones produced lesions upon inoculation using conidia while on mature leaves of all the clones no lesions were observed (Table 3).

Inoculation of field plants

The field plants (10 years of age) having copper brown leaves were artificially inoculated using a highly virulent isolate. Conidial suspensions were sprayed daily (morning and evening) for seven days. Plants were inoculated under different whether conditions and under favourable conditions RRIC 121, plants regarded as resistant to CLFD succumbed to the disease. According to the results, the clones presently free from CLFD (*e.g.* RRIC 121) are susceptible to the disease under favourable conditions. Experiments are in progress to find out the factors affecting the establishment of CLFD infection (T H P S Fernando, C K Jayasinghe, R L C Wijesundera and D Siriwardena).

Table 3. *Possibilities for artificial inoculation of different stages of the clones by Corynespora cassiicola*

Clone	Leaf stage	
	Mature	Immature
R 121 (Field)	x	√
R 121 (Nursery)	x	√
R 100 (Field)	x	√
R 100 (Nursery)	x	√
R 201 (Field)	x	√
R 201 (Nursery)	x	√
R 202 (Field)	x	√
R 202 (Nursery)	x	√

√ - Disease, X – No disease

Genetic variability of the new population of *Corynespora cassiicola* in Sri Lanka

Cultural, reproductive, physiological and pathological characteristics of the present population of *Corynespora cassiicola* showed three distinct groups. Studies were initiated to see the genetic variability among the isolates using Random Amplified Polymorphic DNA. (RAPD) (T H P S Fernando, C K Jayasinghe, R L C Wijesundera, K Liyanage and D Siriwardena).

Studies on beneficial soil microflora (PP/SM/89)

Decorative handicrafts from partially decomposed rubber leaves

Priority was given to the preparation of key tags and book marks as there was a good demand for those items in crop clinics held in rubber growing regions (C K Jayasinghe and N Jayawardena).

Surveillance of potential pests and disease outbreaks (PP/SP/89)

Studies on unusual yellowing and buckling of rubber leaves

Unusual buckling and yellowing of leaves of some rubber trees towards the latter part of the year were noticed in the year 2009. All possible causes were investigated for three consecutive years and it was concluded that this abnormality is a characteristic feature of the clone RRIC 102. Observations were made in 12 locations representing Ratnapura, Awissawella, Kegalle and Kalutara regions. Same symptoms were observed also on recently introduced clone RRISL 226, where one of the parents was RRIC 102. However, trials undertaken on fertilizer application as a remedial measure by the Soils and Plant Nutrition Department are in progress (W P K Silva, C K Jayasinghe and N Nishantha).

Management of cockchafer grub attacks

It has been shown that drenching of soil with Chlopyriphos effectively controls the grubs while erection of light traps reduces the adult beetle population. However, several limitations have been identified in both these techniques. With this background entomopathogenic fungus, *Metarrhazium anisopliae* was tested against grubs with the view of developing a biological control system. Initial experiments were conducted with the collaboration of Coconut Research Institute and no promising results were obtained. Hence, it was decided to screen another entomopathogenic agent, *Beauveria bassiana* with the assistance of Tea Research Institute (C K Jayasinghe, N Nishantha with the collaboration of CRI).

Spread of Papaya mealy bug in rubber nurseries and young clearings

New species of mealy bug has been detected in rubber nursery plants and young clearings in Meerigama and Gampaha regions during 1st quarter of the year 2009. It was identified as *Paracocus marginatus* with the assistance of Dr (Mrs) Shanika Jayasekara (CARP) and Mrs G Rajendramani (University of Jaffna). It is believed that this invasive species has spread to rubber from papaya as all infections on rubber have been detected in the vicinity of severely affected papaya trees. By April, severe infestations of papaya mealy bug were noticed in a four year old clearing at Hadakeliyagalawatta, Ambanpitiya. This was the first report of attacking mature rubber trees by this invasive pest. Immediate steps were taken to spray imidacloprid 20% (one ml in 1 litre of water) to the canopies and ground weed growth. Two rounds were sprayed at weekly intervals and brought the insect population under control. At this occasion also it was noticed that this invasive species has spread to the rubber clearing from papaya and all infections have been detected in the vicinity of severely affected papaya trees. Interim circulars have been sent to all estate managing companies stating the management strategies. Smallholders were educated about this situation through Advisory Services department of the RRISL and Rubber Development Department. More than 10 public meetings and seminars were conducted to explain the preventive and control measures. However, towards the 3rd quarter, infestations reduced to negligible levels not only on rubber but also on other hosts (C K Jayasinghe and N Nishantha).

A fruit fly attack on rubber seedlings

A fruit fly attack was reported from a rubber seedling nursery. This was the first report of a fruit fly attacking rubber plants. Steps were taken to improve the sanitation of the nursery. Application of the 'Neem' product as a repellent was also successful (T H P S Fernando, C K Jayasinghe and B I Tennakoon).

New alternative hosts for *Corynespora cassiicola*

Corynespora cassiicola was repeatedly isolated from plants of *Ricinus* Sp. which are closely situated to rubber plantations in the Kalutara district. Koch's postulates were proved and this is the first report of *Ricinus* Sp. as an alternative host

from Sri Lanka. Cross-inoculation studies are in progress using rubber and Ricinus plants to expand the host-range (T H P S Fernando, C K Jayasinghe, R L C Wijesundera and D Siriwardena).

Formulation of a repellant against rodents and mammalian pests in rubber lands

Large scale production of the TMTD based repellant was commenced during this year after receiving the "Colloid Mill" from the Rubber Technology Section. Several improvements to the formulation were made changing the thickening agent and binder. It was observed that repeated applications of chemicals at least once in three months are required for the protection of the rubber tree from porcupine and wild boar attacks. Further, it was observed that a spiral of barbed wire loosely kept around the collar region protects the tree from a porcupine attacks successfully. This is a long term solution when compared to the application of chemicals (C K Jayasinghe, E B Fernando and B I Tennakoon).

Defense mechanisms of rubber (DM/89/1)

Identification of a biological agent for the management of CLFD

Isolation of an endophytic bacteria from the highly susceptible clone RRIC 110 against Corynespora Leaf Fall Disease is in progress (T H P S Fernando, C K Jayasinghe, R L C Wijesundera and C Wijeratne).

MISCELLANEOUS

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

Two multiclonal clearings established with disease resistant and susceptible clones at Kuruwita Substation, Rathnapura were generally maintained. The girth and disease severity index of CLFD was recorded (T H P S Fernando, C K Jayasinghe, R L C Wijesundera and D Siriwardena).

Effect of fertilizer application on the severity of Corynespora leaf fall disease

The CLFD severity during the year 2009 remained mild. Therefore, there was no visual difference of the average disease severity index was observed among the different treatments (C K Jayasinghe and T H P S Fernando with the collaboration of Soils and Plant Nutrition Department).

SOILS AND PLANT NUTRITION

Lalani Samarappuli

SUMMARY

Planned, promoted, implemented and monitored more than 25 research and development activities in relation to improvement of soil fertility, increasing efficiency of nutrient uptake, soil, water and nutrient management and weed management.

Data so far collected up to budgrafting stage suggests that application of 50g of HERP as the P source is adequate for the growth of young budding plants raised on *Agalawatta* series soils. A new research project was initiated to determine the potential of land application of bio-char, biomass derived black C, in rubber plantations of Sri Lanka. Preliminary investigations revealed that the commercially available bio-char have high CEC, K and Mg levels and may be used as a soil amendment to improve fertility.

Two NPK fertilizer mixtures were formulated in view of cutting 50% of urea requirement during immature period of rubber with good growth of *Mucuna bracteata* cover crop. Bacterial and fungal species with the ability of forming "biofilm" were isolated and identified for *Agalawatta* series soils.

A new user friendly computer programme was developed using Visual Basic for site specific fertilizer recommendations for mature rubber. Site specific fertilizer recommendations for 4000 hectares were issued. Approximately 265 ha were surveyed for suitability of planting rubber under land selection programme. The Department analyzed approximately 4000 samples (15,000 parameters) for outside organizations including more than 500 fertilizer samples for rubber growers to assure application of good quality fertilizers to their rubber lands.

DETAILED REVIEW

Staff

The Head of the Department, Dr (Mrs) Lalani Samarappuli and Dr R S Dharmakeerthi, Soils Chemist were on duty throughout the year. Mrs R Hettiarachchi, Assistant Soils Chemist, continued her postgraduate studies while on duty throughout the year.

Experimental Officers, Messrs H D S P Perera, C Maheepala, S N Silva, P Karunadasa, U Mitrasena, A N Yakandawela, T B Dissanayake, V Edirimanne, A Thevarapperuma and T Gunatilleke and the English Stenographer Mrs L Rupasinghe were on duty throughout the year. Technical Officer, Mr J A S Chandrasiri reassumed duties in July after on no pay leave. Experimental Officer Mr P R Puhambugoda was on duty until July.

Research students

- Mr Gayantha Vithana from the Rajarata University of Sri Lanka carried out his final year project on "Some investigations on P fertilizer use in young budding nurseries " under the supervision of Dr R S Dharmakeerthi.

Seminars/Conferences/Meetings/Work-shops addressed

Officer	Subject	Organization
L Samarappuli	Fertilizer for rubber during poor trading conditions	Scientific Committee Meeting, RRISL
L Samarappuli	Soil management practices for Environmental and Economic Sustainability	Centennial Rubber Conference, RRISL
L Samarappuli	Nutrient recycling in rubber: An agroforestry system	Soil Science Society of Sri Lanka
L Samarappuli	Towards a biomass economy for Sri Lanka	Bio Energy Association of Sri Lanka
RS Dharmakeerthi	Advances in nutrient management in rubber and way forward	Centennial Rubber Conference, RRISL

Seminars/Conferences/Meetings/Work-shops attended

Officer	Subject	Organization
L Samarappuli	TEC meetings for fertilizer purchasing	RDD
L Samarappuli	Meetings on fertilizer quality	MPI
L Samarappuli	Climate change/CDM	Ministry of Environment
L Samarappuli	National Fertilizer Advisory Committee Meetings	National Fertilizer Secretariat
L Samarappuli	Annual General Meeting, Institute of Biology, 2009	Institute of Biology
L Samarappuli and RS Dharmakeerthi	Scientific Committee Meetings	RRISL
L Samarappuli and RS Dharmakeerthi	Annual General Meeting, Soil Science Society of Sri Lanka 2009	Soil Science Society of Sri Lanka
RS Dharmakeerthi	SRICANSOL II Steering Committee Meetings	Soil Science Society of Sri Lanka
RS Dharmakeerthi	Board of Study in Soil Science	Postgraduate Institute of Agriculture

Training programmes

Client	No. of programmes
Estate Managers	5
Field Officers	3
Rubber Development/Extension Officers	1
University Students	4
Diploma Students	3
School Teachers	1

Advisory visits

Client	No. of visits
Plantations	05
Smallholdings	10

LABORATORY AND FIELD INVESTIGATIONS

Soil fertility management

Ground cover management

Performance of Mucuna bracteata under mature rubber

The experiment started to study the performance of *Mucuna bracteata* in different shade conditions under mature rubber was continued. The biomass production and litter accumulation of *Mucuna* at different shade conditions were gathered and data are being analysed (Lalani Samarappuli and P Karunadasa).

Another experiment is in progress to study the establishment and growth of *Mucuna* under mature rubber (3 years before uprooting). Data on continuous growth of *Mucuna* after replanting with rubber is presented in (Table 1) (Lalani Samarappuli, U Mitrasena and T Gunathillake).

Table 1. *Growth of* Mucuna *under immature rubber*

Age of rubber plants	Growth of *Mucuna* as percentage coverage (%)	
	Mature rubber with *Mucuna*	Mature rubber without *Mucuna*
6 months	75	20
1 years	90	40
1 ½	100	80
2 years	100	100

Establishment of Mucuna bracteata

In order to further improve the propagation technique of *Mucuna*, a new experiment was started to study different rooting media on the success rate of polybagged *Mucuna* cuttings. This experiment was continued (L Samarappuli, U Mitrasena and T Gunathilake).

Another experiment was started to study the effectiveness of poly tunnel on the success rate of *Mucuna* cuttings as a planting technique. This experiment was unsuccessful (L Samarappuli and P Perera).

Mucuna bracteata *on soil fertility*

An experiment is in progress to study the biomass production and litter accumulation of *Mucuna* under rubber and its decomposition and its contribution under different soil series and climatic conditions. Biomass production of both green matter and litter are presented in Tables 2 and 3, respectively (Lalani Samarappuli and P Karunadasa).

Table 2. *Dry matter production of green vegetation*

Age (years)	Green matter dry weight (kg/ha)		
	Bibile estate	Nottinghill estate	Nalanda estate
4	-	-	2200
7	1130	797	-

Table 3. *Mean dry matter production of* Mucuna *litter*

Age (years)	Litter dry weight (kg/ha)		
	Bibile estate	Nottinghill estate	Nalanda estate
4	-	-	5600
7	715	780	-

Mucuna bracteata *in substituting N fertilizer, urea*

According to the data gathered it was observed that 50% of the costly N fertilizer; urea can be cut down during the immature phase of rubber with good growth of *Mucuna bracteata* cover crop. Two NPK fertilizer mixtures were formulated in view of cutting 50% of urea requirement during immature period (Table 4) (Lalani Samarappuli, P Karunadasa, U Mitrasena and T Gunathilake).

Table 4. *Composition of the two new fertilizer mixtures*

Mixture	Urea	IRP/ERP	MOP	Total
R/U 9:20:8 (*Parambe* series)	15	58	13	100
R/U 7:16:16 (other soil series)	20	66	14	100

Planting practices for tree legumes

Four field experiments are in progress, three in intermediate zone; at Nottinghill estate, Kahapathwela, Dammeria estate, Passara, Nalanda estate, Naula and

the other experiment in wet zone; at Dorset division, Clyde estate, Tebuwana to study the performance of *Gliricidia sepium* as a successful tree legume species that can be grown between the rows of rubber plants which could provide wood material as energy for dendro power and leaf material as green manure. Growth measurements in three experiments are presented in Table 5 (Lalani Samarappuli, P Karunadasa, U Mitrasena and T Gunathilake).

Table 5. *Effect of different treatments on growth of rubber plants*

Treatments	Nottinghill 4 1/2 years girth (cm)	Dammeria 4 years girth (cm)	Nalanda 4 years girth (cm)
Control	35.9[a]	29.0[a]	19.6[a]
Gliricidia 450 sticks/ha (single row)	38.8[a]	28.1[a]	20.2[a]
Gliricidia 900 sticks /ha (double row)	38.3[a]	28.4[a]	19.7[a]

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

Weeds and weed control

Circle weeding

Weeding cost was calculated for "power mat" and compared with the cost of manual weeding (Table 6) (Lalani Samarappuli, T Gunatilleke, A Thevarapperuma and U Mitrasena).

Table 6. *A cost comparison*

Activity	Manual weeding	"Power Mat"
Material cost (Rs/ha/yr)	-	13,500
Labour cost (Rs/ha/yr)	18,000	900
Total cost (Rs/ha/yr)	18,000	14,400

Experiment started to study the effectiveness of mulching of paddy straw treated with commercially available weedicides as a weed control method around the rubber plants is terminated. Data are being analysed. Same experiment with some modifications was started (Lalani Samarappuli, T Gunatilleke, A Thevarapperuma and U Mitrasena).

Circle weeding using grass cutter

An experiment was started to study the possibility of using a motorized grass cutter as a weed control method around both immature and mature rubber plants (Lalani Samarappuli, T Gunatilleke, A Thevarapperuma and U Mitrasena).

Management of different weed species

Control and regeneration of different weed species after application of different commercially available weedicides were done. Data are being analysed (Lalani Samarappuli, T Gunatilleke, U Mitrasena and A Thevarapperuma).

Soil moisture stress management (Feasibility of growing rubber in drier areas)

Mulching

Yield measurements in the two field experiments at Bibile estate, Bibile and Nottinghill estate, Kahapathwela to study the effect of mulching on yield of *Hevea* plants are given in Table 7 (Lalani Samarappuli, P Karunadasa, U Mitrasena and T Dissanayake).

Table 7. *Effect of mulching on yield of rubber plants*

Treatment	Bibile Yield (g/t/t)	Kahapathwela Yield (g/t/t)
No mulch	37.2[b]	42.8[b]
With mulch	46.0[a]	49.6[a]

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

The effectiveness of different mulching materials on yield of *Hevea* plants grown in comparatively drier areas are being studied in a field experiment (SMC-Ag/M/99/1) at Nottinghill estate, Kahapathwela. Effect of paddy straw, coir dust, paddy husk, and green manure on yield of rubber is given in Table 8 (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 8. *Effect of different mulching materials on yield of rubber*

Treatment	Yield (g/t/t)
No mulch	28.4[a]
Paddy husk	36.2[a]
Coir dust	40.1[a]
Green manure	30.5[a]
Paddy straw	37.2[a]

(Means with same letter are not significantly different)

Ground cover management

The performance of *Mucuna bracteata* in comparison with *Pueraria phaseoloides* under dry agro-climatic conditions was studied. Girth of rubber plants with *Mucuna* and *Pueraria* are presented in Table 9 (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 9. *Effect of different treatments on growth of rubber plants*

Treatments	Nottinghill 4½ years girth (cm)	Dammeria 4 years girth (cm)	Nalanda 4 years girth (cm)
Pueraria	35.9[a]	29.0[a]	19.6[a]
Mucuna	38.0[a]	32.9[a]	22.0[a]

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

Fertilizer practices for overcoming moisture stress

Effectiveness of potassium and mulching to overcome moisture stress and to improve yield of *Hevea* under comparatively dry climatic conditions was studied in a field experiment at Bibile estate, Bibile. Two K levels (recommended and double the recommended level) with and without a surface mulch were applied in this experiment. Yield data are presented in Table 10 (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 10. *Yield of rubber trees (g/t/t)*

	K_1 (recommended level)	K_2 (double the recommended level)
Without mulch	32.1[a]	38.6[a]
With mulch	37.6[a]	39.7[a]

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

Rubber as a system to mitigate climate change: Biomass accumulation (carbon sequestration) in rubber plantations

The objective of this study is to highlight the potential of rubber plantations to carbon trading through carbon sequestration under Sri Lankan conditions. An experiment was initiated to compare the biomass accumulation and carbon stocks among rubber, teak and mahogany (Table 11). This would be helpful to growers to get information in selecting a tree species in terms of biomass and carbon stocks in their plantations (Lalani Samarappuli and K A N A Appuhamy).

Table 11. *Growth parameters, biomass accumulation and carbon stocks among rubber, teak and mahogany*

Age (years)	Parameter	Species		
		Teak	Mahogany	Rubber
1	Height (m)	3.41	1.65	0.87
	DBH (cm)	1.97	1.75	2.19
	Biomass (kg)	0.74	0.48	0.89
	Carbon	0.37	0.24	0.45
4	Height (m)	9.30	1.81	9.54
	DBH (cm)	7.51	1.94	9.03
	Biomass (kg)	21.82	0.63	33.75
	Carbon	10.91	0.32	16.87

Fertilizer use and plant nutrition

Fertilizers to nursery plants

Investigations on the usefulness of bio-char in rubber plantations in Sri Lanka

Evidence is accumulating from the research conducted elsewhere during the recent past that bio-char, biomass derived black C, can act as a soil conditioner enhancing plant growth by supplying and more importantly, retaining nutrients and by providing other services such as improving soil physical and biological properties. In addition, bio-char application to soil has been proposed as an unique approach to C sequestration where bio-char offers both a large and long term C sink. We initiated trials to determine the potential of land application of bio-char in rubber plantations of Sri Lanka.

Initially, the agronomic effectiveness of commercially available charcoal in young budding nurseries are evaluated. Bi-ochar, ground to pass through 2-mm sieve, were applied at a rate of 2% by weight (30 tons per ha) with and without the young budding fertilizer mixture using Agalawatta series soils. Characteristics of the used biochar is given in Table 12. It appears that the used biochar is a very alkaline material and rich in soil plant nutrients such as K and Mg. The cation exchange capacity of the used biochar is also very high. Growth parameters and nutrient uptake by the seedling were measured during the nursery period (Table 13 and 14) indicate the performance of young budding plants at the budgrafting stage. Application of biochar at 30 tons per ha has a negative impact on the growth of young budding plants when the young fertilizer was used at half the recommended rate (Table 13). However, when biochar is applied along with the full recommended fertilizer level, growth is similar to the plants in the currently recommended fertilizer dosage without biochar (Table 14). The experiment is being continued to evaluate the scion growth after bud grafting as well as the changes in the soil fertility after amending with biochar (R S Dharmakeerthi, J A S Chandrasiri and V Edirimanne).

Table 12. *Some chemical properties of the soil and bio-char used in the experiment*

Property	Unit	Soil	Bio-char
pH	1:2.5 water	4.85	9.55
CEC	cmol(+)/kg	3.60	19.51
Exchangeable Ca	Mg/kg	47	5181
Exchangeable Mg	Mg/kg	11	407
Exchangeable K	Mg/kg	16	2662
Exchangeable Na	Mg/kg	11	306

Table 13. *Effect of biochar and fertilizer on some growth parameters at bud grafting stage in experiment 1*

Treatment	Height cm	Diameter mm	Leaf area cm^2/plant	No. of leaves
Soil only	61	6.7	523	20
Soil + current fertilizer recom.	70	7.9	1071	28
Soil + bio-char	58	6.8	630	21
Soil + bio-char + 50% current fertilizer recom.	61	7.5	1030	28
Soil+ 50% current fertilizer recom.	68	7.8	1150	28

Table 14. *Effect of biochar and fertilizer on some growth parameters at bud grafting stage in experiment 2*

Treatment	Height cm	Diameter mm	Leaf area cm^2/plant	No. of leaves
Soil only	59	6.8	1239	32
Soil + current fertilizer recom.	56	7.4	1445	35
Soil + bio-char + current fertilizer recom.	60	7.4	1484	34

Investigations on P fertilizer use in young budding nurseries

Application of P fertilizer either 50g of HERP as a basal dressing only or DAP in liquid formulation without a basal P application in young budding nurseries has been found to be adequate to supply the P requirement of the seedling plant in number of occasions. This experiment further tests the above observation using Agalawatta series soils. It also determines the P fixation capacity of different rubber growing soils and the fertilizer P requirement of young budding plants.

Different P fertilizer combinations from the current recommendation were tested in a nursery experiment conducted at the Dartonfield Estate. N, K and Mg fertilizers were applied as recommended. Growth parameters measured at the bud grafting stage (Table 15) indicate that application of P fertilizers only as a basal dressing is adequate for the seedling growth up to the bud grafting stage, reconfirming previous findings. This experiment is continued to evaluate the scion growth and P

fixation in different soils (R S Dharmakeerthi, C K Maheepala, J A S Chandrasiri and V Edirimanne).

Table 15. *Effect of different P fertilizer combinations on some growth parameters at bud grafting stage*

Treatment	Height (cm)	Diameter (mm)	Leaf area (cm^2/plant)	No. of leaves
No P fertilizer	59	6.8	1239	32
50g HERP as a basal dressing	63	7.7	1388	35
DAP in liquid mixture	60	7.2	1289	32
50g HERP + DAP (current fertilizer recom.)	56	7.4	1445	35

Fertilizers to immature rubber

Method of fertilizer application

Two field experiments started at Nottinghill estate and Dorset division, Clyde estate, to study the effect of cutting fertilizer pits on growth of *Hevea* under comparatively wet and dry agro-climatic conditions were in progress. Treatments consisted of two distances from the tree (1 ft. and 1½ ft), two application frequencies (4 and 2 per year) and a control. Growth measurements at 3½ years after planting are presented in Table 16 (Lalani Samarappuli, P Karunadasa, U Mitrasena and T Gunathilake).

Table 16. *Girth of rubber plants (cm)*

Treatments	Nottinghil	Dorset
Control	29.8^{b}	25.2^{b}
4 applications/yr & 2 ft. away	32.0^{ab}	26.7^{ab}
4 applications/yr & 2½ ft. away	34.2^{a}	29.4^{a}
2 applications/yr & 2 ft. away	31.0^{ab}	29.4^{a}
2 applications/yr & 2½ ft. away	31.8^{ab}	28.2^{ab}

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

Mature rubber

Micronutrient requirement of mature rubber plants

Under this experiment three major soil series (*i.e.* Boralu, Parambe and Homagama) were selected to measure the micronutrient status in both soil and plants at different age categories. This experiment was in progress to study the micronutrient level under different soil groups as sufficient or deficient (R P Hettiarachchi, L Samarappuli, U Mitrasena and T Gunathilake).

Nutrient requirement of new* Hevea *clones

Simple protocol for fertilizer recommendation to immature rubber with a simulation model based on ecophysiological parameters

This experiment started in order to develop a simulation model based site-specific fertilizer recommendation program for immature rubber. Several experiments were laid down in two contracting agro ecological conditions (Sapumalkanda and Bibile) using two clones (RRIC 121 and RRISL 203) and five fertilizer levels (0, 50, 100, 150 and 200% of the currently recommended levels). The data are being analysed (R S Dharmakeerthi, V H L Rodrigo, S N Silva, C K Maheepala, V U Edirimanne and J A S Chandrasiri).

Trials conducted in Monaragala

The experiment to evaluate the fertilizer requirement of two *Hevea* clones grown in Monaragala region was continued for the fifth year at the Kumarawatta Estate. Growth measurements made at the end of 5th year indicated significant differences among all factors tested, *i.e.* fertilizer mixture, fertilizer levels and clones (Table 17). Data suggests that application of a Mg fertilizer source as well as increasing the fertilizer level upto 200% of the currently practiced level have no additional benefit to the growth of the plant. Growth of the RRIC 121 is better than that of RRISL 203 under the conditions of this experiment (R S Dharmakeerthi, S N Silva and C K Maheepala).

Table 17. *Effect of fertilizer mixture, fertilizer level and clone on the growth of Hevea after 5 years of planting in Monaragala*

Fertilizer mixture	Girth (cm)	Fertilizer level	Girth (cm)	Clone	Girth (cm)
R/U/12:14:14+Mg	28.5	No fertilizer	24.0	RRISL 203	25.9
R/U/15:15:7+Mg	25.9	100%current recommendation	30.3	RRIC 121	29.5
R/U/12:14:14	29.5	200% current recommendation	29.2		

Trials conducted in Bibile

Experiment conducted at the Bibile estate to determine the fertilizer requirement of new clones was continued (Table 18). Girth data collected at the end of 3rd year did not indicate significant differences between the clones RRISL 203 and RRIC 121. Increasing the fertilizer level beyond the currently recommended level did not show any significant improvement in girth at this age (R S Dharmakeerthi, S N Silva and C K Maheepala).

Table 18. *Effect of fertilizer levels and clone on the girth of* Hevea *plants at 3 years after planting*

Fertilizer level	Girth (cm)	Clone	Girth (cm)
No fertilizer	9.2	RRISL 203	9.8
50% current recommendation	10.1	RRIC 121	10.9
100% current recommendation	10.8		
150% current recommendation	10.3		
200% current recommendation	11.7		

Organic fertilizers

Immature stage

Two more experiments are in progress at Pitiyakanda estate, Mawathagama in a 2003 replanting and at Bibile estate, Bible in a 2004 replanting, respectively. Organic manures evaluated in these experiments are paddy straw, EM treated paddy straw, burned paddy husk, coconut husk, and green manure. Growth measurements and leaf N and K at 6½ years after planting in experiment at Pitiyakanda estate and girth at five years after planting in experiment at Bibile estate are presented in Tables 19 and 20, respectively (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 19. *Effect of different treatments on growth of rubber plants*

Treatment	Girth (cm)
Nil (control)	55.8[a]
EM treated paddy straw	59.1[a]
Burned paddy husk	57.5[a]
Coconut husk	58.6[a]

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

Table 20. *Effect of different treatments on growth of rubber plants*

Treatment	Girth (cm)
Nil (control)	28.3[b]
Burned paddy husk	28.7[ab]
Paddy straw	31.2[ab]
Green manure	32.2[a]

(Means with same letter are not significantly different)

Organic rubber

An experiment is in progress to develop a sustainable and commercially viable system for plantations as well as for smallholders to produce an environmentally

friendly new grade of rubber (organic rubber) to meet the increasing demand for "bio-market". Yield data of this experiment is given in Table 21 (Lalani Samarappuli, P Karunadasa and T Dissanayake).

Table 21. *Effect of different treatments on yield of rubber*

Treatment	2006 (g/t/t)	2007 (g/t/t)
Chemical fertilizer only	25.4	33.8
Organic fertilizer only	26.5	27.8

Micronutrient requirement of mature rubber plants

Under this experiment three major soil series (*i.e.* Boralu, Parambe and Homagama) were selected to measure the micronutrient status in both soil and plants at different age categories. This experiment was in progress to study the micronutrient level under different soil groups as sufficient or deficient (R P Hettiarachchi, L Samarappuli, U Mitrasenea and T Gunathilake).

Soil microbiology

The use of soil microorganisms to increase nutrient availability and to enhance soil fertility in rubber plantations has been sparsely investigated. Few projects were initiated to evaluate the effectiveness of commercially available biofertilizers while developing new technologies.

Evaluation of the effectiveness of commercially available biofertilizers in rubber nurseries

The effectiveness of Bio-Gold and Bio-Phos microbial biofertilizers on growth and mineral composition of young budding nursery plants will be evaluated in this experiment. This project will be carried out in collaboration with the Plant Pathology and Microbiology Dept. Following treatment combinations will be evaluated in an experiment set-up at the Dartonfield estate (R P Hettiarachchi, R S Dharmakeerthi and V Edirimanna).

Treatments	Design
1	S+C+H
2	S+C+H+F
3	S+C+H+F (DAP completely cut + excess SA) + BP
4	S+C+H+F (SA completely cut) + BG
5	S+C+H+F+BG+BP
6	S+C+H+BG+BP
7	S+C+H+F (half of the normal recommendation)+BG+BP
8	S+C+H+F(DAP and SA completely cut) +BG+BP
9	S+C+H+F(DAP and SA completely cut) +BG

S = Soil C = Compost (50g/bag) H = HERP(50g/bag)
F = Normal fertilizer application (SA, DAP, SOP, ES)
BG = (Bio-Gold) biofertilizer Nitrogen
BP = (Bio-Phos) Phosphorus solubility bacteria in liquid formulation

Biofilmed biofertilizers for improved plant growth

Certain microbes can attach to the surfaces and differentiate to form complex, multi-cellular communities called biofilms. They can be engineered *in-vitro* for various biotechnological applications and have a unique pattern of gene expression which is different from their non biofilm forming stages. Some biofilms have found to be very efficient P solubilizar from phosphate rock sources and N fixers. If an effective biofilm could be produced and it could be used to increase the fertilizer use efficiency in rubber plantations. Some biofilms have found to be very efficient P solubilizer from phosphate rock sources and N fixer. If an effective biofilm could be produced, it could be used to increase the fertilizer use efficiency in rubber plantations.

Isolation of beneficial microbes

Bacterial and fungal biofilm forming spp. associated with roots of major cover crops (*Pueraria* and *Mucuna*), roots of widely grown rubber clones (RRIC 100, 121, RRISL 203) and in major rubber growing soils will be isolated. Initially, root samples were collected from rubber field of the Dartonfield estate, and the isolations of pure cultures are being done at the Institute of Fundamental Studies, Hantana, Kandy. The isolated microbes consisted of 10 bacterial and 05 fungal spp. Further isolations from different sites are in progress (R P Hettiarachchi, G Seneviratne and R S Dharmakeerthi).

Site-specific fertilizer recommendation by soil and foliar survey program

Under this programme about 4000 hectares of mature rubber fields were surveyed and fertilizer recommendations were given for the next three years (L Samarappuli, R S Dharmakeerthi, R P Hettiarachchi and all the staff of the department).

Land selection and suitability for rubber cultivation

Under the routine land selection programme 265 hectares of land were surveyed for the suitability of rubber cultivation (L Samarappuli, R P Hettiarachchi and all the staff of the department).

An approach towards sustainable development and economics of the smallholder rubber sector

This is a collaborative study with the Biometry section and Advisory Services Department together with Ruhuna and Wyamba Universities. The soils and Plant Nutrition Department is responsible for assessing the land suitability in rubber growing areas of Moneragala and adjacent parts of Badulla and Ampara districts (L Samarappuli, P Karunadasa, U Mithrasena, Anoma Thewarapperuma and T Gunathilake).

Analytical techniques and lab instrumentation

Chemical analysis of plant, fertilizer and soil samples involves the use of very sophisticated instruments such as Auto Analyzer and Atomic Absorption Spectrophotometer.

A quality assurance programme was conducted to promote confidence in analytical results through achieving accurate and reliable analytical results. A good quality control programme was conducted throughout the year 2009 which includes documentation and implementation of good laboratory practices and procedures. Analytical values particularly of fertilizer samples were checked according to the guidelines offered by the Sri Lanka Standard Institution (R P Hettiarachchi and L Samarappuli).

Analytical services

The Department analyzed approximately 4000 samples (15,000 parameters) for outside organizations including more than 500 fertilizer samples for rubber growers to assure application of good quality fertilizers to their rubber lands (L Samarappuli, R S Dharmakeerthi and all the staff of the department).

BIOCHEMISTRY AND PHYSIOLOGY

V H L Rodrigo

SUMMARY

Newly developed low frequency harvesting systems, *i.e.* tapping a tree once in 4 (d4) and 7 (d7) days, were tested in large scale. A tentative recommendation on d4 harvesting systems was issued to the plantations. Whilst continuing the testing of wide range of low intensity harvesting (LIH) systems on base panels with shorter cuts, large scale application of S/4 d3 and S/4 d4 LIH systems was commenced. Different working principles were being tested to develop a digital system for dry rubber determination in latex. Head of Department was offered the General Research Committee Award - 2009 by the Sri Lanka Association of Advancement of Science.

DETAILED REVIEW

Staff

Dr V H L Rodrigo, Head of the Department, and Mrs K V V S Kudaligama, Assistant Biochemist, were on duty throughout the year. Mrs G V L Nilmini, Assistant Biochemist was on study leave overseas to pursue her PhD programme in the University of Maine, USA. Experimental Officer, Mr P D J Rodrigo was on duty throughout the year. Mr D Ramawickrama, Experimental Officer, retired from duty with effect from 3rd November, 2009. Mr R P S Randunu assumed duties as a Technical Officer with effect from 2nd February, 2009.

Research students

- Mr R P S Randunu worked as a temporary Research Assistant of a research project on low frequency tapping systems funded by the National Science Foundation Grant No: RG/2006/AG/07 until he was offered a permanent position in the department. Then, Mr D S Hewamanage was recruited to this position with effect from 18th May, 2009.

Seminars/Conferences/Workshops/Exhibitions conducted

Officer/s	Subject/Theme	Beneficiary/Client
VHL Rodrigo, KVVS Kudaligama, PDJ Rodrigo, D Ramawickrama and RPS Randunu	Centennial Rubber Conference, 2009	All stakeholders of the rubber industry

Seminars/Conferences/Workshops/Exhibitions attended

Officer/s	Subject/Theme	Organization
VHL Rodrigo	National Forestry Research Symposium	Forest Department
VHL Rodrigo	Workshop on Rubber based Farming Systems	SPEnDP
VHL Rodrigo KVVS Kudaligama	Conference on Global Climate Change and its Impacts on Agriculture, Forestry and Water in the Tropics	University of Peradeniya
VHL Rodrigo	Intercropping Workshop	SPEnDP
	Inauguration of 65th Annual Scientific Session of SLAAS	SLAAS
VHL Rodrigo	IRRDB Annual Conference	IRRDB

Visits

Advisory - 28 visits
Experimental - 118 visits
Miscellaneous - 31 visits

Special events

Dr V H L Rodrigo was offered the General Research Committee Award–2009 by the Sri Lanka Association of Advancement of Science for his contribution in rubber based farming systems, harvesting latex, carbon sequestration and expanding the rubber cultivation to the marginal areas of the country.

LABORATORY AND FIELD INVESTIGATIONS

Studies on dry rubber determination in latex

Effect of low temperature on Metrolac reading BCP/LT&M/2003/1

This research project aims to address the problems associated with latex weighing by Metrolac under varying temperature conditions. In order to check the accuracy of newly developed ready reckoner with temperature correction against the existing chart, 75 latex samples taken from Sanquahar estate and Keppitigala division of Nottinghill estate were tested and the deviation from the laboratory tested percentage dry rubber content (% DRC) were calculated. Samples were taken during the month of December when the temperature of the environment was very low (21 – 27°C). Although newly developed temperature corrected ready reckoner was able to reduce variation (*i.e.* 11% against 24% in existing chart) (Table 1), Metrolac failed to provide an accurate reading on % DRC (Fig. 1). Free movement of the metrolac was restricted by the high viscosity in latex; hence, further studies are required to solve this low temperature associated problems (K V V S Kudaligama, V H L Rodrigo, G V L Nilmini, P D J Rodrigo and D Ramawickrama).

Table 1. *Mean % deviation in the estimated percentage of Dry Rubber Content (%DRC) in latex using Metrolac from the laboratory determined %DRC for the samples taken from Sanquhar and Keppetigala estates*

Location	Samples tested	% Deviation with existing ready reckoner (without temperature correction)	% Deviation with newly developed temperature corrected ready reckoner	Temperature range (°C)
Sanquhar estate	34	-29	-17	23.5 (min.) 27.0 (max.)
Keppetigala estate	41	-18	-5	21.0 (min.) 26.0 (max.)
Mean		-24	-11	

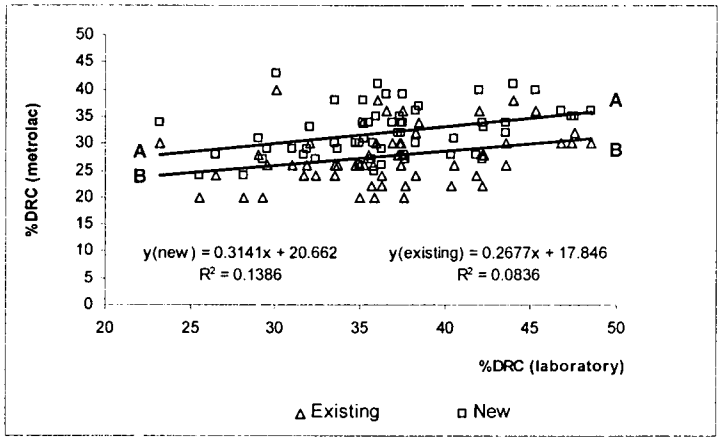


Fig. 1. Variation of metrolac measured percentage dry rubber content (% DRC) from the laboratory tested % DRC value (A A - readings from newly developed reckoner with temperature correction, B B – readings from existing ready reckoner with no temperature correction)

Portable digital system to measure the dry rubber content in latex BCP/LT&M/2006/I

The research project was aimed to develop an electronic appliance to measure the dry rubber content of latex digitally. Since the appliance developed by the NERD centre failed to measure the percentage dry rubber content in latex (% DRC) accurately, potential of using alternative systems were investigated. In order to identify the relationship between latex density and % DRC, several latex samples were measured using a specific gravity bottle (Fig. 2). It is too early to comment on the practical use of this relationship as latex samples from different geographical

areas and genotypes are yet to be analysed. Also, possibility of using the absorbance of a specific wave length for %DRC determination was investigated in the collaboration with University of Sri Jayawardhanapura. Within the visible range, blue light would be appropriate for this exercise (Fig. 3) (V H L Rodrigo, K V V S Kudaligama and R P S Randunu).

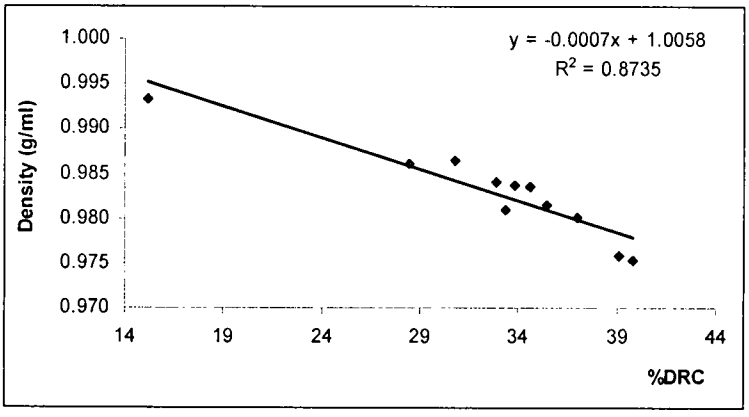


Fig. 2. Association of latex density with laboratory dry rubber content (%)

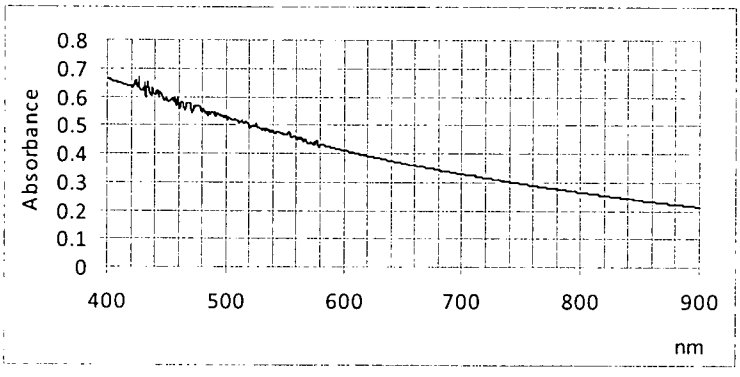


Fig. 3. Absorption curve of field latex within the visible range

Rainguard sealant with industrial wastes
BCP/RGS/2005/1

This project aims to develop new rainguard sealants with desired characteristics such as easy application and reduced cost, particularly with industrial wastes. Two new recipes tried out in Pitiakanda estate, Mawathagama using used engine oil performed well in a limited scale. Therefore, arrangements were made to apply those in two commercial scale tapping blocks in Dartonfield estate in the year

2010 (K V V S Kudaligama, V H L Rodrigo, G V L Nilmini, P D J Rodrigo and D Ramawickrama).

Low frequency tapping with gaseous stimulation

RRIMFLOW method

BCP/LFT(G)/2005/1

Determination of the suitable gassing interval for ethylene in Control Upward Tapping (CUT) of Sri Lankan clones was the main focus in this experiment. New trail was established with 15 and 30 days gassing intervals using the clone RRIC 100 in Gallewatta division of Dartonfield estate. Two experiment blocks were set out for two gassing intervals and another block for Ethephon based CUT as the control treatment. Latex volume, % DRC and scrap weight were monitored on each tapping day (Table 2). However, assessments were affected by rain interference.

Table 2. *Performance of RRIMFLOW at different gassing intervals and CUT (ET) system during year 2009*

Stimulation system	g/t/t	% DRC
RRIMFLOW with 15 days gassing interval	54	38
RRIMFLOW with 30 days gassing interval	58	38
CUT with 30 days ET application interval	44	34

G-Flex method

The trail established by A. Baurs and Co. Ltd. in Gallewatta division of Dartonfield estate to test a new gaseous stimulating system introduced to Sri Lanka, G-Flex, were monitored. Commercial scale testing of the system was also commenced in three estates, namely Pitiyakanda in Mawathagama, Mahawela in Rathnapura and Udapola in Deraniyagala. Two gassing intervals *i.e.* 15 days and 30 days were being tested. Technical Assistant appointed by A. Baurs & Co. Ltd. was in the process of analysing yield data (V H L Rodrigo, K V V S Kudaligama, P D J Rodrigo, R P S Randunu in collaboration with A. Baurs & Co. Ltd. and Mackwoods Ltd.).

Low frequency tapping with liquid stimulation

BCP/LFT(L)/2006/1

This project aims to sustain the productivity of rubber lands using Low Frequency Tapping systems with Ethephon based liquid stimulants whilst addressing the problems of tapper shortage and high tapping cost. Details of treatments, field layout and locations are given Annual Review 2008.

The yields given by the d4 and d6 tapping frequencies were not comparable (except in RRIC 130) with the yield given by d2 frequency (Table 3a & 3b). Hence, the stimulation protocols of the both frequencies were revised since October 2009.

Table 3a. *Average monthly yield per tree (YPT) and number of tapping days for different tapping frequencies in each site (before the revision of Ethephon application protocol)*

Site	d/2		d/3		d/4		d/6	
	YPT (kg)	Tapping days	YPT (kg)	Tapping days	YPT (kg)	Tapping days	YPT (kg)	Tapping days
Dartonfield (RRIC 100)	0.37	10	0.3	7	0.27	6	0.23	4
Dartonfield (RRIC 102)	0.35	11	0.33	8	0.29	6	0.24	4
Dartonfield (RRIC 121)	0.21	10	0.2	7	0.22	6	0.20	4
Dartonfield (RRIC 130)	-	-	0.36	7	0.45	6	0.37	4
Kuruwita (RRIC 100)	0.35	14	0.31	9	0.28	7	0.28	5
Udapola (RRIC 102)	0.36	11	0.30	7	0.31	5	0.19	4
Nottinghil (RRIC 121)	0.46	13	0.44	9	0.37	7	0.42	5
Nottinghil (RRIC121) Com	0.47	14	0.45	10	0.4	7	0.31	5
Overall mean	0.37	12	0.34	8	0.32	6	0.28	4

Table 3b. *Average yield per tree (g/t/t) and Intake per tapper (IPT) for different tapping frequencies in each site (before the revision of Ethephon application protocol)*

Site	d/2		d/3		d/4		d/6	
	g/t/t	IPT	g/t/t	IPT	g/t/t	IPT	g/t/t	IPT
Dartonfield (RRIC 100)	34.51	10.4	40.32	12.1	46.45	13.9	58.62	17.6
Dartonfield (RRIC 102)	32.18	9.7	44.94	13.5	51.33	15.4	58.27	17.5
Dartonfield (RRIC 121)	20.59	6.2	27.72	8.3	35.78	10.7	56.53	17.0
Dartonfield (RRIC 130)	-	-	48.72	14.6	77.75	23.3	86.79	26.0
Kuruwita (RRIC 100)	24.34	7.3	33.58	10.1	39.64	11.9	59.97	18.0
Udapola (RRIC 102)	28.87	8.7	36.48	10.9	51.83	15.5	48.29	14.5
Nottinghil (RRIC 121)	35.3	10.6	46.05	13.8	56.03	16.8	89.61	26.9
Nottinghil (RRIC121) Com	32.78	9.8	46.33	13.9	52.96	15.9	63.1	18.9
Overall mean	29.80	9.0	40.52	12.2	51.47	15.4	65.15	19.6

Concentration of Ethephon and number of its applications per year for d4 tapping was changed to 3.3% and 12 rounds per year, respectively (except in RRIC 130). In d6 tapping, only the application frequency of Ethephon was increased to one application per three tappings. Average yield figures obtained from different sites after the revision of Ethephon application are given in tables 4a & 4b. The above revision for d4 was not applied in Udapola site where yield of d4 system was comparable with that of d2. On average, yield given in d4 system was 98% from that in d2 after the revision of stimulation protocol whilst the yield given in d6 was 89% (Table 5).

Table 4a. *Average monthly of yield per tree (YPT) and number of tapping days for different tapping frequencies in each site (after the revision of Ethephon application protocol)*

Site	d/2		d/3		d/4		d/6	
	YPT (kg)	Tapping days	YPT (kg)	Tapping days	YPT (kg)	Tapping days	YPT (kg)	Tapping days
Dartonfield (RRIC 100)	0.52	13	0.43	8	0.42	7	0.39	5
Dartonfield (RRIC 102)	0.50	13	0.45	9	0.41	6	0.39	5
Dartonfield (RRIC 121)	0.33	12	0.30	8	0.30	6	0.37	5
Dartonfield (RRIC 130)	-	-	0.50	9	0.84	7	0.58	5
Kuruwita (RRIC 100)	0.52	15	0.53	10	0.54	8	0.40	5
Nottinghil (RRIC 121)	0.62	10	0.57	7	0.53	5	0.66	3
Nottinghil (RRIC121) Com	0.68	10	0.74	7	0.58	5	0.53	3
Overall mean	0.53	12	0.50	8	0.52	6	0.47	4

Table 4b. *Average yield per tree per tapping (g/t/t) and Intake per tapper (IPT) for different tapping frequencies in each site (after the revision of Ethephon application protocol)*

Site	d/2		d/3		d/4		d/6	
	g/t/t	IPT	g/t/t	IPT	g/t/t	IPT	g/t/t	IPT
Dartonfield (RRIC 100)	39.73	11.9	52.69	15.8	62.48	18.7	81.69	24.5
Dartonfield (RRIC 102)	37.79	11.3	52.46	15.7	65.29	19.6	78.91	23.7
Dartonfield (RRIC 121)	25.96	7.8	37.68	11.3	47.56	14.3	74.02	22.2
Dartonfield (RRIC 130)	-	-	54.02	16.2	114.82	34.4	115.78	34.7
Kuruwita (RRIC 100)	34.6	10.4	52.84	15.9	69.95	21.0	74.64	22.4
Nottinghil (RRIC 121)	42.57	12.8	56.32	16.9	71.15	21.3	132.28	39.7
Nottinghil (RRIC121) Com	45.42	13.6	70.21	21.1	77.26	23.2	105.49	31.6
Overall mean	37.68	11.3	53.75	16.1	72.64	21.8	94.69	28.4

Table 5. *The yield given (average of all sites) by each low frequency system with respect to yield of the standard d2 system before and after the revision of stimulation protocol*

	Before revision			After the revision		
	d3	**d4**	**d6**	**d3**	**D4**	**d6**
Yield response against d2 system (%)	91	88	76	95	98	89

(V H L Rodrigo, K V V S Kudaligama, P D J Rodrigo and R P S Randunu)

Low intensity tapping systems

BCP/LIT/2007/1

This experiment was commenced at Kuruwita substation to investigate the possibility of minimising the bark consumption with short cuts and reduced tapping frequency to sustain latex yield with increasing the economical life span of the rubber tree. Practically potential nine combinations of tapping frequencies, *i.e.* d2, d3, d4 and d6 (once in two, three, four and six days), stimulant concentrations (2.5% and 5% of Ethephon) and tapping cut lengths (1/2, 1/4 and 1/8 of the spiral) were setup to test their feasibility. Each system was imposed on three replicates consisting ten trees per each (Details are given in Annual Review 2009). Yield data were monitored during the period. Most of low intensity tapping systems gave comparatively low yields hence their stimulation protocols were changed as given in Table 6b from October, 2009 onwards.

In view of developing a tapping system which enables smallholders who are mainly engaged in off-farm activities, to harvest their rubber fields during weekends, investigations were geared to develop a d7 stead of d6 tapping system. Also, practically potential two low intensity tapping systems with shorter cuts were selected (*i.e.* S/4 d3 and S/4 d4) in view of harvesting only the virgin bark during 30 year economic rotational age of rubber. These systems were applied in commercial scale tapping blocks (one for each system) of RRIC 121 clone in Kuruwita substation of the Rubber Research Institute. Details of stimulation protocols are given in the Table 7. After the preliminary work on selecting appropriate stimulation schedules (during August - September), the experiment began in October, 2009. Data for 3 months showed that latex yield in d7 differed only by 14% from the value recorded for d2 (Table 7). Investigations were in progress to obtain comparable yields.

Table 6a. *Average yield per tree (GTT) and percentage dry rubber content (%DRC) in latex in low intensity tapping systems (before the revision of stimulation protocol)*

Ethephon %	-	2.5%	2.5%	2.5%	5%	2.5%	5%	5%	5%	5%
Frequency applied	-	bimonthly	monthly	Every 2 weeks	monthly	monthly	monthly	Every 2 weeks	monthly	Every 2 weeks
Tapping intensity	S/2 d2	S/2 d3	S/4 d3	S/8 d3	S/8 d3	S/2 d4	S/4 d4	S/8 d4	S/2 d6	S/4 d6
GTT	20.09	29.06	23.22	18.03	15.39	31.94	22.94	14.90	40.32	26.34
DRC%	38.40	38.52	39.20	39.66	39.64	38.06	39.30	39.83	37.91	38.97
Monthly YPT	0.27	0.26	0.21	0.16	0.14	0.21	0.15	0.10	0.19	0.12
% yield given	100	96	78	59	52	78	56	37	70	44

Table 6b. *Average yield per tree (GTT) and percentage dry rubber content (%DRC) in latex in low intensity tapping systems (after the revision of stimulation protocol)*

Ethephon %	-	2.5%	5%	5%	3.3%	5%	5%	5%	5%
Frequency applied	-	bimonthly	monthly	In every 3 tappings	monthly	In every 3 tappings	In every 2 tappings	In every 3 tappings	In every 2 tappings
Tapping intensity	S/2 d2	S/2 d3	S/4 d3	S/8 d3	S/2 d4	S/4 d4	S/8 d4	S/2 d6	S/4 d6
GTT	41.63	52.59	40.99	38.8	64.47	52.96	34.07	91.22	53.82
DRC%	38.86	38.8	39.8	40	38.14	39.8	40	39.8	40
Monthly YPT	0.64	0.53	0.41	0.39	0.49	0.4	0.26	0.43	0.25
% yield given	100	83	64	61	77	63	41	67	39

Table 7. *Progress of low intensity tapping systems established in Kuruwita Sub-station in a commercial scale*

Tapping intensity	S/2 d2	S/4 d3	S/4 d4	S/2 d7
Ethephon %	-	5%	5%	5%
Frequency applied	-	Monthly	After 3 tappings	Weekly
g/t/t	25.44	26.36	41.12	81.62
%DRC	37	39	40	39
Monthly YPT (kg)	0.37	0.26	0.31	0.33
Yield given (%)	100	68	82	86

In order to investigate the appropriate Ethephon concentration for each low frequency tapping system, a short-term experiment was conducted in Rubber Research Institute Sub station, Kuruwita. A series of Ethephon concentrations was applied on trees tapped on S/2 panel with d4 and d7 frequencies (five trees for each concentration). Ethephon were applied without disturbing the usual stimulation frequency of each tapping system (monthly in d4 and weekly in d7). Latex yield of the trees was recorded between two Ethephon applications. It appeared that Ethephon concentrations of 3.3% is suitable for both d4 and d7 tapping frequencies, respectively (V H L Rodrigo, K V V S Kudaligama, P D J Rodrigo and R P S Randunu).

a). S/2 d4 **b).** S/2 d7

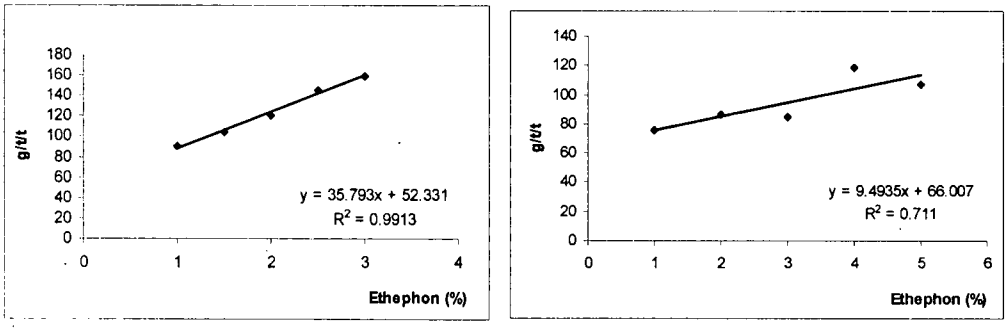


Fig. 8. Yield (grams per tree per tapping, GTT) response of different tapping frequencies to the Ethephon concentrations. Expected latex yield at given tapping system is also shown

Variation of non rubber constituents of latex in different *Hevea* genotypes and their impact on latex weighing with Metrolac and raw rubber properties BCP/LD/2007/1

This study is aimed to investigate the effect of organic and inorganic non rubber constituents of latex on raw rubber properties in different clones and their impact on latex weighing using Metrolac. Initially, 22 clones in 4 estates were

selected for this study and assessments were made on monthly basis. Clones were grouped according to the value of their Mooney viscosity, PRI, and Lovibond colour index (Table 8a, b & c). As the sampling procedure per clone was limited to single location, multilocational study was planned for 2010.

Table 8. *Classification of clones based on Mooney viscosity (in 8a), PRI (in 8b) and Lovibond colour index (in 8c)*

a. Classification of clones based on Mooney viscosity

Group	Range	Clone
Very low	<55	-
Low	55-65	RRISL 215, RRISL 226
Moderate	66-75	RRISL 217, RRISL 220
High	76-85	RRIC100, RRIC 102, RRISL 201, RRISL 205, RRISL 208, RRISL 211, RRISL 219, RRISL 221, RRISL 222, RRISL 223, RRISL 2000, RRISL 2001
Very high	>85	RRIC 121, RRIC 130, RRISL 203, RRISL 206, RRISL 216

b. Classification of clones based on plasticity retention index

Group	Range	Clone
Low	<60	-
Moderate	61-70	RRIC 121, RRIC 102, RRISL 203, RRISL 216, RRISL 220, RRISL 221, RRISL 223, RRISL 2000
High	71-80	RRIC 100, RRIC 130, RRISL 201, RRISL 205, RRISL 206, RRISL 208, RRISL 211, RRISL 215, RRISL 217, RRISL 219, RRISL 222, RRISL 226, RRISL 2001
Very high	>80	-

c. Classification of clones based on Lovibond colour index

Group	Range	Clone
Low	<1.5	RRIC 130, RRISL 215, RRISL 217, RRISL 220, RRISL 223
Moderate	1.5-3.0	RRIC 100, RRIC 121, RRIC 102, RRISL 201, RRISL 203, RRISL 205, RRISL 208, RRISL 211, RRISL 216, RRISL 219, RRISL 222, RRISL 226, RRISL 2000, RRISL 2001
High	>3.0	RRISL 206

(K V V S Kudaligama, V H L Rodrigo, D Ramawickrama and P D J Rodrigo)

ADVISORY SERVICES

A Dissanayake

SUMMARY

Increasing the productivity and income levels of rubber growers through transfer of technologies by extension and advisory services were continued and several important projects were carried out at national and regional level to achieve the objectives of the ASD. Four major activities, *i.e.* exhibitions, farmer training programmes, seminars on current challenges and skill development training classes were conducted at several locations under the theme of **"Isurubara Hetak Sandaha Asrimath Gasak Samaga"** (ඉසුරුබර හෙටක් සඳහා අසිරිමත් ගසක් සමඟ)-to mark the centennial calibrations of Rubber Research Institute of Sri Lanka. Around two thousand general visits and over one thousand advisory visits on special requests from farmers were made by Rubber Extension Officers (REOO) to increase the adoption rates of recommended practices. REOO guided growers in up grading 426 immature rubber holdings and 287 mature rubber holdings as models. Advisory and extension support services were provided to rehabilitate 426 substandard rubber holdings. Forty awareness programmes were conducted successfully to educate nearly two thousand rubber smallholders on recommended agronomic and processing practices.

DETAILED REVIEW

Staff

The Head of the Department, two Regional Advisory Officers, eight Divisional Rubber Extension Officers (DREOO) and twenty one Rubber Extension Officers (REOO) were on duty throughout the period. Mr H H Jayasinghe, Mr D Pdoimahaththaya and Mr U L R A Perera continued covering up duties of Regional Advisory Officers in Galle, Kegalle and Kalutara regions respectively. Mr W Siriwardana, Rubber Extension Officer (Kalutara) continued in covering up duties of the post of Assistant Training Officer. Mr D Jayathilaka, Office Assistant of the RAO Office, Kegalle, was retired from services with effect from 30th July 2009. Mr S B S Silva, Rubber Extension Officer, Ratnapura was expired, after a short illness. Services of four Divisional Extension Officers, three Rubber Extension Officers, two Typist/Clerks and one Office Assistant, were extended for a period of one year. Mr L Premadasa Office Assistant attached to the Head Office of the ASD was transferred to Agalawatta office with effect from 5th November 2009 on disciplinary action.

Training programmes/Seminars/Workshops/Meetings attended

Officer	Subject	Organization
A Dissanayake AH Kularathna PKKS Gunaratna	Centennial Celebrations of the Rubber Research & Development programme in Sri Lanka	Hilton Hotel, Colombo
AH Kularathna PKKS Gunaratna	Agricultural Extension Conference - 2009	PGRC, Gannoruwa, Peradeniya
A Dissanayake AH Kularathna	Scientific Committee Meetings	Rubber Research Institute of Sri Lanka

Training programmes/Seminars/Workshops/Meetings addressed

Officer	Subject	Organization
A Dissanayake	Strategies for effective technology transfer in Rubber Smallholder Sector	Hilton Hotel, Colombo
AH Kularathna A Dissanayake	Experiences and Challenges in Agricultural Extension Service of the Rubber Smallholder Sector in Sri Lanka	PGRC, Gannoruwa, Peradeniya

PROJECTS AND SERVICES

Centenary Celebrations of the Rubber Research Development Programme in Sri Lanka

Under the theme of "**Isurubara Hetak Sandaha Asirimath Gasak Samaga**" (ඉසුරුබර හෙටක් සඳහා අසිරිමත් ගසක් සමඟ)- five large scale Technology Transfer programmes (TOT) comprised with exhibitions, farmer training programmes, seminars, skill development programmes and awareness programmes were conducted in Kegalle, Kalutara, Monaragala, Rathnapura and Colombo districts to educate all stakeholders of the rubber industry, on technologies and recommendations of the RRISL, as a part of the centenary celebrations of the Rubber Research and Development Programme of Sri Lanka. The ASD played the major role in organizing these programmes with the assistance of all research departments of the RRISL. Rubber Development Department and other government departments in the rubber industry and private sector organizations participated with their mobile service units.

Advisory visits

Advisory visits on requests of rubber smallholders

One thousand and thirty six advisory visits were conducted by extension officers on requests of rubber small holders to meet their requirements on technology adoption practices related to rubber cultivation and processing (Table 1).

Table 1. *No. of Advisory visits made by REO on requests of rubber smallholders*

Region	Total No. of advisory visits	No. of reports submitted
Colombo	138	138
Kegalle	377	377
Kalutara	327	129
Rathnapura	141	113
Galle/Matara	53	53
Total	1036	810

Projects related advisory visits made by Extension Officers

Two thousand one hundred and twenty nine advisory visits were made by Rubber Extension Officers to increase the adoption rates of recommended practices to improve the productivity of mature and immature rubber smallholdings. Also, 124 advisory visits were made by REOO in relation to processing aspects and smoke houses (Table 2).

Establishment of model rubber holdings and model rubber processing centers

Model rubber holdings (Mature and Immature)

REOO attended in up grading of 426 immature rubber holdings and 287 mature rubber holdings, as model rubber holdings, during the year. Present status of these holdings are shown in Tables 3 & 4.

Model rubber processing centres

Eighty six number of rubber processing centres which have the production capacity of over 38000 kgs. have been successfully up graded to meet the required standards and maintained as model processing centers for the benefit of 465 rubber producers. REOO have made 299 advisory visits to up grade the production of these model processing centres (Table 5).

Table 2. *No. of Advisory visits made by extension officers to increase the adoption rates of recommended agronomic practices*

REGION	Advisory visits																	
	Immature upkeep									Mature upkeep						Smoke houses		
	Lining	Planting	Fertilizer applications	Branch induction	Control of WRD	Soil conservation works	Introduction of *Mucuna*	Introduction of Intercropping	Control of other diseases	Panel marking	Fertilizer application	Rain guards	TPD	WRD	Introduction of new tapping knife	Introduction of Alternate FW sources	Repair of rollers	Processing
COL.	7	10	13	19	21	8	30	16	13	20	10	6	11	22	25	6	4	12
K'GALE	21	38	100	68	61	61	84	28	31	57	14	17	19	26	36	6	6	9
K'TARA	21	26	66	56	18	41	56	11	11	36	22	7	23	17	140	15	2	1
R'PU	18	16	23	14	19	19	33	7	12	61	18	7	11	15	19	7	9	15
GALLE	13	22	54	42	5	42	20	13	7	19	40	7	8	9	93	8	11	13
TOTAL	80	112	256	199	124	171	223	75	74	193	104	44	72	89	313	42	32	50
	Total -2129															**Total - 124**		

The project is in progress

Table 3. *Status of Model rubber holdings (immature) as at 31st December 2009. (only the most important parameters are shown in the Table)*

Region	No. of Holdings	No. of advisory Visits made	Extent (ha)	No. of Holdings							
				Filling vacancies completed	Branch induction completed	Boundary shading cleared	fencing satisfactorily completed	Record of girth measurements	Colour branding completed	Soil conservation Works completed	No. of Trees successfully treated for WRD
COLOMBO/GAM	43	113	27.7	42	32	38	43	28	26	42	18
KEGALLE	144	731	97.9	128	98	105	125	73	62	118	80
KALUTARA	122	814	97.29	103	87	116	120	86	83	115	24
RATNAPURA	74	382	72.6	66	62	67	70	48	39	70	04
GALLE/MATARA	43	197	30.7	40	31	41	41	30	20	42	13
Total	426	2237	326.1	379	310	367	399	265	230	387	139

REOO conducted 2237 advisory visits to up grade these holdings to required growth standards.

The project is in progress.

Table 4. *Status of model rubber holdings (Mature) as at 31st December 2009 (only the most important parameters are shown in the table)*

Region	No. of Holdings	No. of advisory visits made	Extent (Ha)	No. of Tappers employed	No. of Holdings					No. of trees	
					No. of Tapping training programmes conducted	Marking for tapping Guidelines completed	Introduction of mew tapping knives	Promotion of fertilizer applications	Maintenance of yield records	No. of trees successfully treated for WRD	No. of trees successfully treated for panel Disease
COLOMBO	30	85	20.8	34	26	28	26	21	27	03	0
KEGALLE	96	480	92.8	117	91	74	46	41	86	44	74
KALUTARA	81	453	93.7	105	66	68	55	42	65	59	78
RATNAPURA	50	279	82	84	49	44	43	37	41	11	212
GALLE	30	134	20.8	34	30	27	20	30	27	07	0
Total	287	1431	300.6	374	262	241	190	171	246	124	364

Under this project, tappers employed in these mature holdings were educated on quality of tapping (QOT) and the use of new tapping knife.

The project is in progress.

Table 5. *Status of Model Rubber Processing Centers as at 31st December 2009*

Region	Total No. of Processing Centers up graded	No. of Rubber Producers Benefited	No, of Advisory Visits conducted by REOO	Total Capacity Kg	Daily Production capacity	Introduction of record maintenance systems
COLOMBO	9	20	21	2175	540	9
KEGALLE	30	238	90	9650	4105	30
KALUTARA	24	135	112	12314	10790	23
RATNAPURA	14	62	38	11400	1280	14
GALLE	9	10	38	2675	396	9
Total	86	465	299	38214	17111	85

The project is in progress.

Combinations of immature and mature model holdings with Model Processing Centers

To demonstrate the value of adoption of recommended agronomic and processing practices for the sustainable management with increased land productivity of rubber small holdings REOO promoted the concept of combined model holdings in their ranges. Each of these combined model holdings were consisted with immature and mature rubber cultivations and a model processing centre in one location. Ten such combinations have been successfully established during the year 2010 (Table 6).

Table 6. *Combinations of mature and immature Model rubber holdings with Model Rubber Processing Centers*

Region	Total No. of combinations of model holdings	Extent of the holding (ha.)		Capacity of the model Smoke House (Kg)	No. of advisory visits conducted by REO	Daily production capacity (Sheets)
		Immature	Mature			
Colombo	1	0.8	0.8	61	3	100
Kegalle	3	2.8	4.2	550	19	150
Kalutara	2	1.6	1.2	1200	12	150
Ratnapura	4	6.4	7.8	2560	21	580
Galle	0	0	0	0	0	0
Total	10	11.6	14	4371	55	980

The project is in progress.

Rehabilitation of substandard rubber holdings

REOO conducted advisory and extension support services to rehabilitate 426 substandard rubber holdings selected from their ranges. One thousand and seventy four advisory visits have been conducted by REOO to improve the growth standards and general conditions of their substandard holdings. REOO were able to successfully rehabilitate more than 70% of the selected holdings (Table 7).

Table 7. *Progress of rehabilitation of substandard rubber holdings*

Region	No. of substandard holdings selected for rehabilitation	Extent (ha)	No. of Advisory visits conducted by REOO	No. of holdings						No. of trees	
				Filling vacancies completed	Branch induction completed	Boundary shedding cleared	Fertilizer application	Fencing satisfactory	Soil Conservation works completed	Nutrition deficiencies	No. of trees successfully treated for WRD
Colombo	45	49.6	98	44	39	42	45	43	45	2	13
Kegalle	147	92.8	592	110	75	97	90	108	96	7	105
Kalutara	120	89.1	444	90	69	105	99	114	107	7	41
Ratnapura	74	61.4	201	59	54	60	66	64	67	18	4
Galle	40	35.9	141	31	29	37	33	40	38	2	2
Total	426	328.8	1474	334	266	341	333	369	355	36	165

The project is in progress.

Establishment of Mucuna

REOO have motivated 252 rubber small holders to plant Mucuna cover crop in their immature holdings selected from 2007, 2008 and 2009 clearings. Nine hundred and eighty seven advisory visits were conducted by REOO to educate these farmers on Mucuna propagation and establishment methods and Mucuna was successfully established in 242 holdings (Table 8).

Table 8. *Progress of establishment of Mucuna cover crop*

Region	No. of Rubber Smallholdings selected for introduction of Mucuna	Total Extent (Ha)	No. of Advisory Visits	No. of planting points introduced	Source of planting materials		Rate of success of establishment of the cover crop in the filed		
					Own	Other sources	> 50%	25%-50%	< 25%
Colombo	30	16.2	74	778	23	7	12	18	0
Kegalle	89	55.4	361	997	24	65	19	19	51
Kalutara	77	62.7	322	1295	5	72	15	14	48
Ratnapura	37	38.1	171	573	16	21	05	6	26
Galle	19	16.5	59	343	0	19	01	10	8
Total	252	188.9	987	3986	68	184	52	67	133

The project is in progress

Promotion of intercropping systems

REOO continued their extension programmes to popularize rubber based intercropping systems, among rubber smallholders. Forty nine demonstration plots of intercropping were set up with inter crops such as Banana, Pineapple and Vegetables. These intercropping demonstration holdings were maintained by REOO in their ranges to educate farmers is rubber based intercropping systems (Table 9).

Table 9. *Promotion of Rubber based intercropping systems*

Region	No. of intercropping holdings	Total extent (ha)	No. of advisory visits	Source of planting materials	
				Own	Outsides
Colombo	6	11.4	12	5	1
Kegalle	15	8.2	67	2	13
Kalutara	15	9.6	44	7	8
Ratnapura	9	5	51	3	6
Galle	4	2.1	18	2	2
Total	49	36.3	192	19	30

The project is in progress.

Promotion of rain guard fixing technology among rubber smallholders

As a short term strategy to increase the productivity of mature rubber holdings, rubber extension officers were able to motivate rubber smallholders to establish 29 demonstration holdings to popularize rain guard fixing technology among other rubber smallholders (Table 10).

Table 10. *Promotion of rain guard fixing*

Region	No. of demonstration plots established	Total extent (ha)	No of advisory visits	No of trees fixed with rain guards
Colombo	7	28.8	17	11280
Kegalle	3	3.8	14	1625
Kalutara	11	57	34	23225
Ratnapura	4	8	14	4000
Galle	4	11.2	15	5600
Total	29	108.8	94	45730

The project is in progress.

Technology transfer for construction and repair of rubber processing centers

Advisory visits were carried out to provide extension and technical support services to help rubber producers to construct new processing centers and to upgrade their substandard processing centers. Accordingly, Extension Officers successfully provided technical advices to complete the construction of 45 new processing centers and to up grade 22 processing centers (Table 11 & 12).

Table 11. *Progress of the construction of new rubber processing centers*

Region	No. of processing centers constructed	No. of smallholders benefited	No. of advisory visits conducted by REOO	Total capacity (Kg)	Daily production (No of sheets)
Colombo	10	10	18	725	184
Kegalle	13	67	50	1440	540
Kalutara	10	33	49	6060	4540
Ratnapura	4	33	23	3850	620
Galle	8	14	25	1625	245
Total	45	157	165	13700	6129

Table 12. *Progress of the upgrading of substandard rubber processing centers*

Region	No. of substandard centers upgraded	No. of smallholders benefited	No. of advisory visits conducted by REOO	Total capacity (Kg)	Average daily production (No of sheets)
Colombo	2	7	6	375	100
Kegalle	3	18	14	750	90
Kalutara	4	3	5	1850	3190
Ratnapura	3	20	21	2200	290
Galle	10	10	18	1310	311
Total	22	58	64	6485	3911

The project is in progress.

Farmer training programmes

Knowledge dissemination and improvement of skill levels of rubber small holders to increase their land productivity were considered as the thrust area of activities of the ASD. Six different types of farmer training programmes were designed after analyzing the training needs of rubber small holders. Accordingly 148 farmer training programmes were successfully conducted in REOO ranges for the benefit of 3384 rubber smallholders (Table 13).

Table 13. *Farmer Training Programmes*

Region	AWP (Self)		AWP (Joint)		TSD (in models)		TSD (General)		QRSS		WRD	
	No. of programmes	No. of participants	No. of programmes	No. of participants	No. of programmes	No. of participants	No. of programmes	No. of participants	No. of programmes	No. of participants	No. of programmes	No. of participants
Colombo	3	50	6	211	1	21	5	118	4	82	0	0
Kegalle	8	382	8	295	0	0	14	276	4	63	2	52
Kalutara	1	200	7	120	29	150	8	178	3	26	0	0
Ratnapura	4	218	1	85	0	0	9	157	13	223	0	0
Galle	2	249	0	0	1	6	8	126	4	50	3	48
Total	18	1099	22	711	31	177	44	855	28	444	5	98

AWP (self) - General awareness programmes organized by individual REOO
AWP (Joint) - General awareness programmes organized by group of REOO
TSD - Tapping skill development programmes
QRSS - Quality improvement programmes of RSS
WRD - Programme conducted on control of white root diseases

Eighteen awareness programmes organized by individual REOO and 22 general awareness programmes organized by groups of REOO were conducted successfully during the year 2010. Theses programmes were consisted with lectures and practical demonstrations. In every programme the key note address was delivered by the Head, ASD highlighting the importance of adopting recommended technologies for the improvement of land productivity. Participants were grouped according to their knowledge levels tested by using a PRA pocket voting technique and training and demonstration programmes were conducted accordingly. All these training programmes were sponsored by the private sector agro chemical companies. The Rubber Development Department assisted in organizing these farmer training programmes.

Distribution of utensils for improvement of the quality of tapping

The ASD involved in distribution of the new tapping knife introduced by the RRISL and the tapping panel guidelines marking stencils on the request of rubber smallholders. The district wise summary is given in Table 14.

Table 14. *Distribution of tapping utensils*

Region	Tapping knife	Tapping guidelines marking plates
Colombo	296	83
Kegalle	106	242
Kalutara	190	70
Ratnapura	313	89
Galle	88	94
Total	**993**	**578**

Forest stewardship council certification (FSC) projects

ASD continued to participate as a key stakeholder in the Forest Stewardship council (FSC) certification project which was launched by the FSC secretariat of IUCN Sri Lanka. As a requirement of the project "Sri Lanka Rubber Smallholders Timber Certification Society" was formed and the Head of the ASD continued in serving as the Group Manager. A final group of 413 medium scale farmers were selected from over 800 initially registered farmers subjected to fulfilling the basic requirements of FSC.

Auditing on maintaining FSC guidelines was done by the appointed Auditors, and the Control Union. A sample comprised with forty two (42) rubber lands were selected for the final auditing which is to be completed during the months of January and February 2010. Details of farmers are given in Table 15.

Table 15. *Distribution of lands for FSc*

Region	Range	No. of farmers	Extent (ha)
Colombo	Gampaha	14	123.6
	Kosgama	20	202.3
	Homagama	11	100.8
Total		**45**	**426.7**
Galle/Matara	Galle	26	368.9
	Akkuressa	34	187.4
	Hakmana	16	71.7
Total		**76**	**628**
Ratnapura	Eheliyagoda	11	12.1
	Karawita	7	85.1
	Opanayaka	8	47.1
	Nivitigala	10	196.1
	Ratnapura	6	35.6
	Pelmadulla	20	222.4
	Kuruwita	24	188.2
Total		**86**	**875.6**
Kalutara	Matugama	23	197
	Ittepana	15	116.3
	Bulthsinghala	24	379.5
	Bandaragama	8	62.4
	Agalawatta	14	34.2
	Horana	15	85.1
	Millaniya	12	89.5
	Kalutara	11	216.8
Total		**122**	**1240.8**
Kegalle	Deheowita	7	74.8
	Galigamuwa	5	94
	Kegalle	6	35.7
	Polgahawela	7	85.4
	Mawanella	11	134.9
	Ruwanwella	7	99
	Warakapola	10	62.61
	Kandy/Matale	18	328.18
	Yatiyantota	13	251.5
Total		**84**	**1166.09**
Total		**413**	**4337.19**

RUBBER TECHNOLOGY AND DEVELOPMENT

Dilhara Edirisinghe

SUMMARY

Physico-mechanical property results of tyre tread compounds produced with ribbed smoked sheet rubber (RSS) incorporated with modified Ground Rubber Tyre (GRT) and natural rubber (NR) latex revealed that the modified GRT in RSS can be used as a partial replacement for carbon black in a tyre tread compound to reduce the cost.

Research aimed at improving the storage stability of prevulcanized latex was carried out for the second time for confirmation of the results. The results confirmed that replacement of 40% of the prevulcanized latex with field latex followed by re-centrifuging is the best technique for the manufacture of prevulcanized latex, which possesses good tensile properties.

Puncture strength of cast films of the 87/13 NR:PVAc (Polyvinyl acetate) latex blend was tested and the results appeared to be superior to that of the cast films prepared with 100% NR latex.

A latex foam compound developed using NR latex blended with a small percentage of a synthetic polymer latex appeared to be suitable as a coating for the special socks worn by disabled soldiers.

A latex compound was developed with centrifuged latex with the aim of improving the durability of nursery bags. A study on the variation of thickness and tensile properties of examination gloves with few different dipping techniques was conducted.

Compatibilization effect of neoprene rubber (CR) in NR/nitrile rubber (NBR) blends was studied and the optimum level of CR required to achieve best properties was determined.

A study on evaluating the effect of replacement of china clay with nano clay in NR compounds was initiated.

A NR/NBR blend suitable for rice huller rollers was developed.

Properties of blends of virgin NR incorporated with treated foam waste were evaluated and compared with those of virgin NR/untreated foam waste blends.

Initial trials were conducted on the development of a rubber compound suitable for barrier cords used in poultry farm houses. Trials were initiated to develop a rubber compound suitable to produce corrugated drainage sheets, used as a rubber based medical product in Sri Lanka.

Extraction of rubber seed oil for production of bio-diesel, using a cost effective technique was continued.

Rubber compound and product testing services were provided to the industry and several small and medium scale entrepreneurs were given advice and assistance for establishing rubber based cottage industries. Several workshops on "Rubber based Products Manufacture at Cottage Level" were conducted in collaboration with Vidatha Centres, Rubber Development Department and the National Institute of Education. Further, the staff was actively involved in training students and organizing stalls at various exhibitions and trade fairs.

DETAILED REVIEW

Staff

Mrs D G Edirisinghe, Acting Head of the Department was on duty, whilst continuing her PhD studies at the Department of Chemical and Process Engineering, University of Moratuwa, Sri Lanka. Mrs G D D Seneviratne, Assistant Rubber Chemist resumed duties at the institute, after completing her MSc (by Research) Degree in Polymer Engineering at the University Sains Malaysia, Penang, Malaysia.

Mrs M K Mahanama, Mrs S I Yapa, Mrs P C Wettasinghe, Mr S L G Ranjith, Mr P L Perera and Mr T A A I Siriwardena, Experimental Officers were on duty throughout the year.

Mrs Priyanthi Perera, Research and Development Assistant reported for duty on 30th March after maternity and no pay leave from 25th August 2009.

Research students

- Miss Damitha Kumarihamy, a BSc (Chemistry Special) undergraduate student and Miss Sasika Bandara, BSc (General) undergraduate student from the Faculty of Applied Science, Sabaragamuwa University completed a three month research project under the supervision of Dr W M G Seneviratne and Mrs D G Edirisinghe, respectively.

- Mr Amal Jayasinghe, a BSc (Polymer) final year undergraduate student from the University of Sri Jayewardenepura completed his research project on "Development of a rice huller roller compound based on a natural rubber/synthetic rubber blend" under the supervision of Mrs D G Edirisinghe.

- Miss Champani Premachandra, a MSc (Analytical Chemistry) postgraduate student from the University of Colombo initiated her research project on "Evaluation of suitability of rubber seeds for production of bio-diesel" under the supervision of Mrs D G Edirisinghe.

- Miss Maheshi Perera, a MSc (Polymer Science & Technology) postgraduate student from the University of Sri Jayewardenepura initiated her research project on "Development of NR/BR/reclaimed rubber composites for tyre treads" under the supervision of Mrs D G Edirisinghe.

- Mr W D M Sampath, a BSc (Chemistry Special) undergraduate student from the Sabaragamuwa University of Sri Lanka, completed his research project on "Property improvement of NR/NBR blends by compatibilizing with neoprene rubber (CR)" under the supervision of Mrs G D D Seneviratne.

- Miss Malkanthi Karunananda, a BSc (Chemistry Special) undergraduate student from the University of Kelaniya, Sri Lanka, completed her research project on "A study on the variation of the mechanical properties of blends of virgin natural rubber and modified foam waste" under the supervision of Mrs D G Edirisinghe.

- Miss Kanchana Wijesekera, a BSc (Chemistry Special) undergraduate student from the University of Sri Jayewardenepura, Sri Lanka, carried out her research project on "Study of the variation in thickness, % elongation at break and tensile strength of examination gloves based on the dipping technique used" under the supervision of Dr W M G Seneviratne.

- Mr Sanjaya Athapattu, a BSc (Chemistry Special) undergraduate student from the University of Sri Jayewardenepura, Sri Lanka, carried out his research project on "Development of a nano clay filled, NR based tyre tread compound" under the supervision of Mrs G D D Seneviratne.

- Mr R P I M Ruwanpathirana - Lalan Rubbers (Pvt.) Ltd. and Mr P K D Padmathilaka - Ansell Lanka (Pvt.) Ltd., DPRI students of the Plastics & Rubber Institute of Sri Lanka initiated their short term research projects under the supervision of Mrs D G Edirisinghe.

- Mr O D U Kumara (Elastomeric Engineering Co.) a DPRI student carried out their research projects under the supervision of Mrs G D D Seneviratne.

- Mr F Doole - Ansell Lanka (Pvt.) Ltd., DPRI student carried out his research project under the supervision of Mrs M K Mahanama.

- Mrs D G Edirisinghe acted as an examiner to evaluate the thesis of two MSc (Polymer Science and Technology) students of the University of Sri Jayewardenepura.

Seminars/Training/Conferences/Workshops/Meetings attended

Officer/s	Subject/Theme	Organization
DG Edirisinghe	Workshop on "Barriers to Young Scientists"	Young Scientists Forum of the NASTEC
	Seminar on "Cleaner production"	NCPC
	Sectoral Committee Meetings on Chemical and Polymer Technology	SLSI

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

Officer/s	Subject/Theme	Organization
MK Mahanama	Workshop on "Rubber based Products Manufacture"	• Ladies College, Colombo 7 • National Institute of Education • Small/medium scale entrepreneurs in Walallawita/ Matugama – Vidatha Centres
MK Mahanama	Six workshops on "Rubber based Products Manufacture at Cottage Level"	Rubber Development Department
Department staff	Practical training on "Rubber Technology"	MSc (Polymer Science and Technology) students of the University of Sri Jayewardenepura
Department staff	"Deyata Kirula" National Development Exhibition (4^{th} -9^{th} February)	Ministry of Plantation Industries
DG Edirisinghe, PC Wettasinghe, TAAI Siriwardena and Priyanthi Perera	"Vidatha Vidu Dekma 2009", Science and Technology Exhibition, Dodangoda (17^{th} -18^{th} September)	Kalutara District Vidatha Centre
DG Edirisinghe, S LG Ranjith, PLPerera and TAAI Siriwardena	Exhibition and Fair - Diamond Jubilee celebrations (8^{th} - 11^{th} October)	Joseph Vaz College, Wennappuwa

Industrial visits

The following industries/organizations were visited during the year for collaborative research project work.

Officer	Industry/Organization
DG Edirisinghe and Priyanthi Perera	Medical Supplies Division, Ministry of Health
DG Edirisinghe	Loadstar (Pvt.) Ltd.
MK Mahanama	Ceylon Rubbers, Padukka

LABORATORY INVESTIGATIONS

Latex technology

Development of a tyre tread compound using ribbed smoked sheet rubber (RSS) prepared with modified Ground Rubber Tyre (GRT) incorporated NR latex

The aim of this research is to minimize environmental pollution during the conventional compounding process and to reduce the cost of tyre treads by replacing part of the carbon black with GRT, while maintaining the important mechanical properties.

In this research, GRT was added to natural rubber (NR) latex in the form of a dispersion in order to reduce environmental pollution.

GRT particles were soaked in a chemical solution and by changing the time of soaking a series of samples was prepared prior to preparation of the dispersion. After the preparation of RSS incorporated with GRT, raw rubber properties were determined. Samples were compounded thereafter, according to a tyre tread compound formulation by varying the ratio of GRT to carbon black, which was added during the compounding process. Mechanical properties such as tensile properties, tear strength, abrasion resistance, *etc.* were evaluated and the properties of tyre tread compounds prepared with GRT incorporated RSS were compared with those of the compounds prepared with conventional RSS.

Results revealed that the modified GRT incorporated to NR in the latex stage can be used as a part replacement for carbon black in a tyre tread compound, which results in reducing the cost of the tyre tread (D G Edirisinghe, S L G Ranjith and Sasika Bandara - BSc undergraduate student, Sabaragamuwa University).

Improvement of quality and storage stability of pre-vulcanized NR latex concentrates

The aim of this study conducted for the second time was to prevent over vulcanization and thereby improve storage stability of pre-vulcanized latex. Three different processing methodologies were used in the preparation of pre-vulcanized lattices with a view to achieve long term storage stability. Latex quality parameters and tensile properties of the films were evaluated. The results revealed that one of the methods, *i.e.* technique 1 (replacing 40% of the pre-vulcanized latex with field latex

and re-centrifuging) yields the best stability compared to the others and this technique exhibited good tensile properties in comparison with the other methods (W M G Seneviratne, M K Mahanama and Damitha Kumarihamy, BSc undergraduate student, Sabaragamuwa University).

Natural rubber/polyvinyl acetate latex blends for dipped products

It was reported in 2006, that 87/13 NR:PVAc blends exhibit high tensile and tear strength properties however, puncture strength was not been able to test during those trials. As such, centrifuged latex was prepared once again at Dartonfield in order to test the puncture strength and to carry out a factory trial of the blend of 87/13 NR:PVAc. The results of the test performed at Workwear (Pvt.) Ltd., Katunayake on cast films revealed that the puncture strength of the blend is superior to that of the 100% NR compound. The project will be continued with an industrial scale trial to ascertain the commercial viability of the use of the blend to manufacture gloves (D G Edirisinghe, P C Wettasinghe and Priyanthi Perera).

Development of a polymer coating for socks worn by the disabled soldiers

Several trials were performed in order to develop a polymer coating for the special socks worn by disabled soldiers as a replacement for highly expensive imported socks. These trials were carried out in collaboration with Brandix College of Clothing Technology and the Department of Textile & Apparel Technology, Open University of Sri Lanka. A latex foam compound developed using NR latex, blended with a very small percentage of a synthetic polymer appeared suitable for the purpose. Further trials were performed out of foam rubber, using a newly fabricated metal mould (A Nugawela, W M G Seneviratne, D G Edirisinghe, P C Wettasinghe, S I Yapa, R Kuruppu - Brandix College of Clothing Technology and G B Delkumburewatte - The Open University of Sri Lanka).

A study of the variation of properties of examination gloves based on the dipping technique used

Examination gloves were produced by means of the techniques based on straight dipping, coagulant dipping and heat sensitive dipping and physical properties of gloves were tested in accordance with ISO Standards. The objective of this study is to ascertain whether there are any observable differences of properties among those techniques. The project will be continued (W M G Seneviratne, L M K Tillekeratne - Dept. of Chemistry, University of Sri Jayewardenepura, Priyanthi Perera and Kanchana Wijesekera - BSc undergraduate student, University of Sri Jayewardenepura).

Development of cost effective nursery bags for rubber nurseries

In the initial trials, field latex was used in the development of a suitable latex compound to produce low cost nursery bags using waste cement bags. Certain modifications were carried out by replacing field latex with centrifuged latex with the aim of improving the durability of the bags. Preparation of nursery bags with the modified latex was started to conduct field trials (P Seneviratne, S L G Ranjith and D G Edirisinghe).

Dry rubber technology

Property improvement of NR/NBR blends by compatibilizing with neoprene rubber (CR)

The objective of the project was to investigate the property improvement of NR/NBR blend by compatibilizing with CR. Three blends were prepared initially by varying the composition of the blend (70/30, 50/50 and 30/70 NR/NBR) and the physical properties were studied in comparison with controls of 100% NR and NBR compounds.

As expected, tensile strength, tear strength hardness and % swelling increased with increasing amount of NR in the blend, whereas abrasion resistance showed the opposite trend. Out of the three blends studied, 70/30:NR/NBR blend showed the best properties and it was selected for further work.

In the second stage, three 70/30 NR/NBR compounds were prepared by adding 3, 5 and 7 phr of neoprene rubber (CR) in order to study the effect of CR as a compatibilizing agent in the blend. Results obtained revealed that the addition of 3 phr of CR in the blend improved tensile strength, tear strength and hardness (Figs. 1, 3 and 4, respectively). Further, results show that the abrasion resistance (Fig. 2) and % swelling in solvent and oil (Fig. 5) of the blends improved in the presence of 3 phr of CR. However, addition of higher amounts of CR (more than 3phr) into the blend reduces the properties. Therefore, it can be concluded that 3 phr of CR would be the best quantity that can be used to compatibilize NR/NBR blends. The research was successfully completed and the dissertation was submitted to the University of Sabaragamuwa.

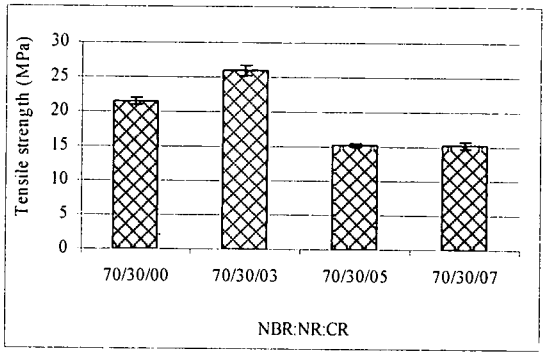


Fig. 1. Tensile strength of compatibilized NBR/NR blends at different CR contents

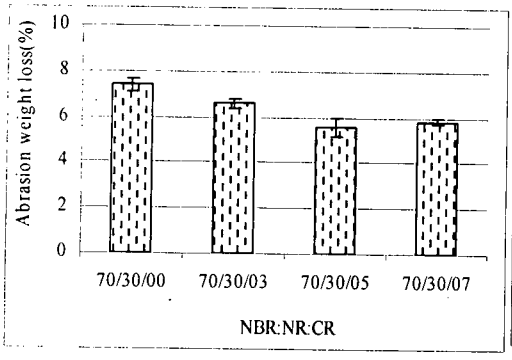


Fig. 2. Abrasion resistance of compatibilized NBR/NR blends at different CR contents

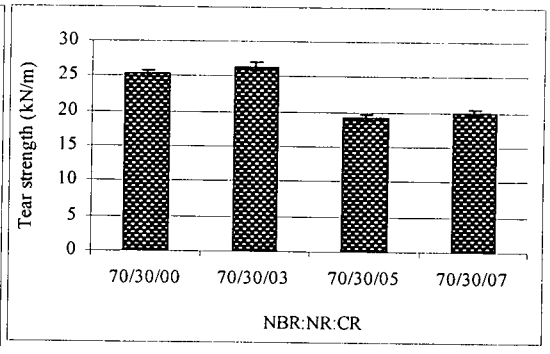


Fig. 3. Tear strength of compatibilized NBR/NR blends at different CR contents

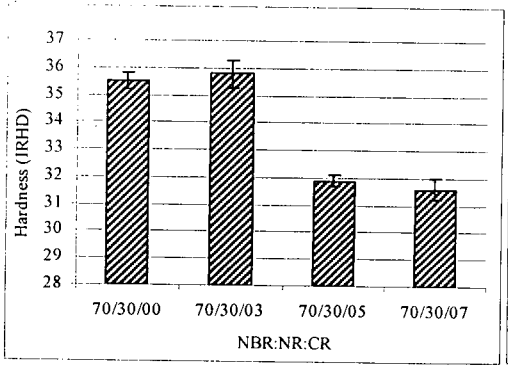


Fig. 4. Hardness of compatibilized NBR/NR blends at different CR contents

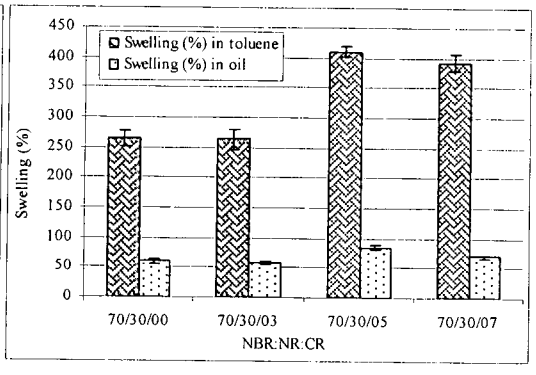


Fig. 5. Percentage swelling of compatibilized NBR/NR belnds at different CR contents in toluene and oil

(G D D Seneviratne and W D M Sampath - BSc undergraduate student, Sabaragamuwa University of Sri Lanka)

Development of a rice-huller roller compound

A suitable compound for rice-huller rollers was developed based on natural rubber/nitrile rubber blend after conducting several trials and having studied the

mechanical properties of several compounds with NR as well as with SBR and NBR and their blends.

This development was initiated on a request made by Wijesuriya Marketing Services (Pvt.) Ltd.

Rice huller rollers were produced using the developed rubber blend compound and it is expected to produce more rollers using a fabricated mould, to be supplied by the Company (D G Edirisinghe, S L G Ranjith and Amal Jayasinghe - BSc undergraduate student, University of Sri Jayewardenepura).

A study on the variation of properties of blends of virgin natural rubber and modified foam waste

This project was initiated with the aim of studying the effect of chemically treated foam waste on mechanical properties of blends with virgin NR to manufacture floor mats.

Stearic, lauric (saturated fatty acids) and oleic (unsaturated fatty acid) acids were used for the chemical treatment of foam rubber.

Cure characteristics, physico-mechanical properties and ageing properties of the blend compounds prepared based on blend compositions 100:0, 90:10, 80:20, 70:30 and 60:40, virgin NR : foam waste (treated with stearic acid (SA)/oleic acid (OA) or untreated) were evaluated and compared. Results indicated that the blend compounds containing untreated foam waste vulcanizes (cures) faster than that of the blends containing treated foam waste (Figs. 6 and 7).

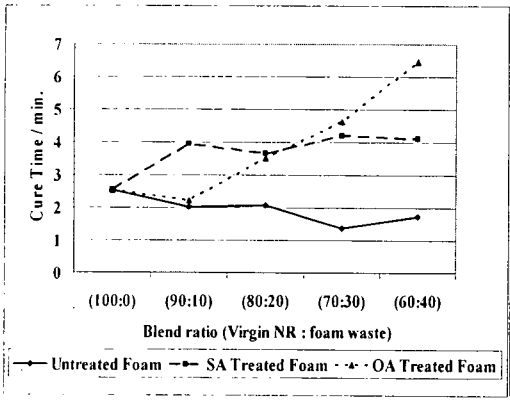


Fig. 6. Variation of cure time of blends containing fatty acid treated/ untreated foam waste

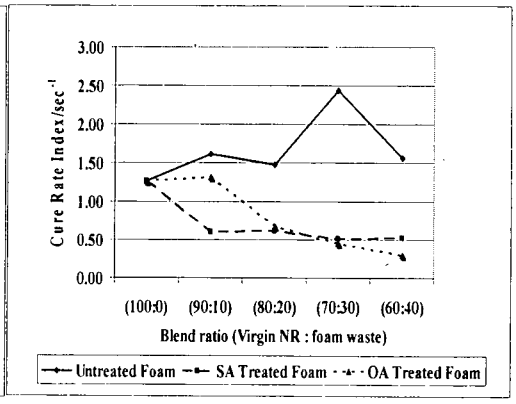


Fig. 7. Variation of cure rate index of blends containing fatty acid treated/ untreated foam waste

Minimum torque, which is related to the stock viscosity and processability is lower in blend compounds containing treated foam waste in comparison to that of untreated foam waste (Fig.8), which means processability of treated foam waste containing blends is superior.

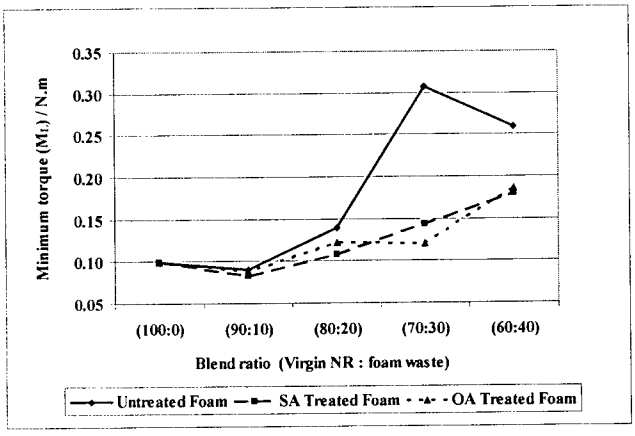


Fig. 8. Variation of minimum torque (M_L) of blends containing fatty acid treated/untreated foam waste

Tensile strength, tear strength, elongation at break of the blends containing treated foam waste were found to be lower than those of the blends containing untreated foam waste, whereas the 100% modulus of the former was higher than that of the latter. Hardness and modulus at 100% elongation were highest in the blend containing virgin NR and stearic acid treated foam waste. Abrasion resistance decreases with the increase in the percentage of treated/untreated foam waste in the blend (Fig. 9). However, abrasion resistance of 70:30 and 60:40 virgin NR:oleic acid treated foam waste is higher than that of the virgin NR:stearic acid treated or untreated foam waste, probably due to lower elongation at break of the former.

Further, percentage retention of tensile and tear strength after ageing at 70°C for 72 hours is greater in the blends of virgin NR/fatty acid treated foam waste in comparison to those of the virgin NR/untreated foam waste blends at most of the compositions studied (Figs. 10 and 11). It is more likely that the polysulphide crosslinks may break into shorter crosslinks during fatty acid treatment and hence, higher heat resistance could be expected in treated foam rubber blends.

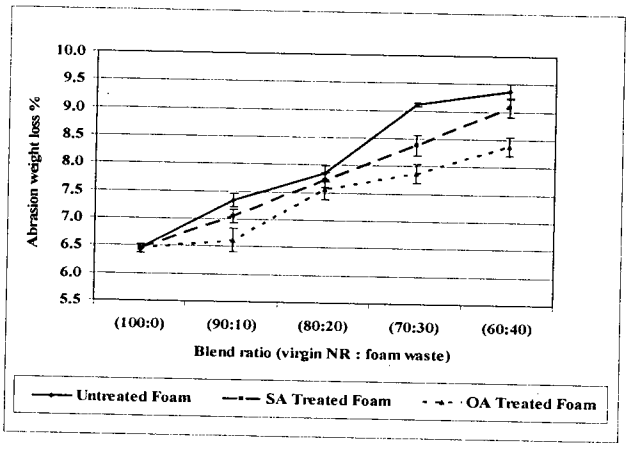


Fig. 9. Variation of abrasion resistance of blends containing fatty acid treated/untreated foam waste

Reversion resistance shown by the rheographs of the virgin NR/treated foam waste blends is in agreement with the percentage retention of strength properties.

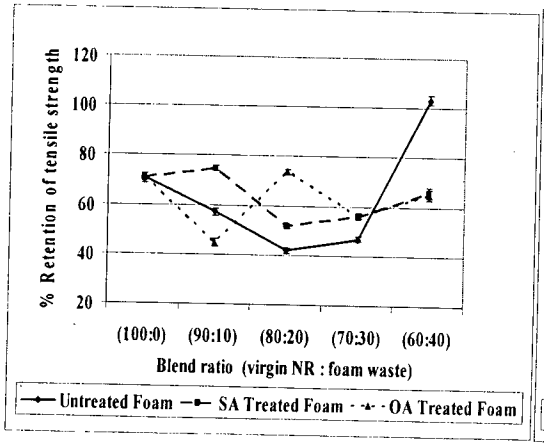


Fig. 10. Variation of % retention of tensile strength of the blends containing fatty acid treated/untreated foam waste

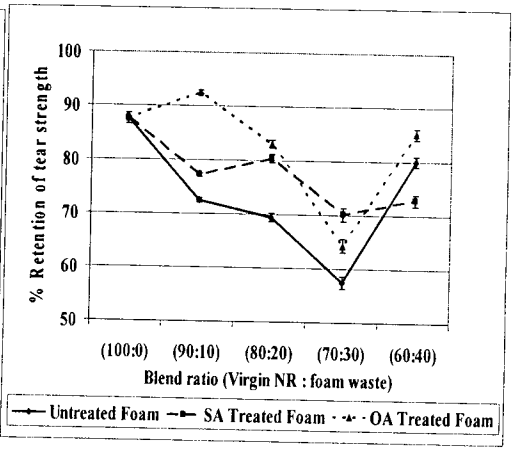


Fig. 11. Variation of % retention of tear strength of the blends containing fatty acid treated/untreated foam waste

As such, it could be concluded that the treatment of foam waste with fatty acid improves processability, reversion resistance, abrasion resistance and ageing resistance of blends of virgin NR/foam waste (D G Edirisinghe, P C Wettasinghe and Malkanthi Karunananda - BSc undergraduate student, University of Kelaniya).

Development of a rubber compound suitable for barrier cords

Trials were initiated on a request from New Zealand to develop a rubber compound suitable to produce barrier cords (315 mm in length and hardness 40-45 Shore A units) used in poultry farm houses. A suitable compound was developed, which possesses required properties and expected hardness. Further developments will be carried out (A Nugawela, D G Edirisinghe and M K Mahanama).

Development of rubber components for bio-medical applications

Ten imported rubber based medical items were purchased from the Medical Supplies Division, Colombo with the aim of developing compounds and appropriate processing techniques to produce these items in Sri Lanka. Trials were initiated to develop a rubber compound suitable to produce corrugated drainage sheets used in hospitals (D G Edirisinghe and Priyanthi Perera).

Development of a cost effective technique to produce bio-diesel using rubber seeds

Development of a cost effective technique to produce bio-diesel using rubber seeds was continued in collaboration with the Department of Chemistry, University of Colombo.

Oil extraction from rubber seeds was carried out using a specially designed low cost method (Ramani Wijesekera - Dept. of Chemistry, University of Colombo, D G Edirisinghe, W M G Seneviratne, M K Mahanama and Champani Premachandra - MSc (Analytical Chemistry) student, University of Colombo).

Development of a nano clay filled, NR based tyre tread compound

The objective of this project is to compare the effect of addition of nano clay as a replacement for china clay in NR compounds. Four composites were prepared separately using 60 phr of china clay and 3, 5 and 10 phr of nano clay. Testing of these compounds for physico-mechanical properties is being carried out to determine the effect of nano clay incorporation in rubber compounds (G D D Seneviratne, L M K Tillekeratne - Dept. of Chemistry, University of Sri Jayewardenepura, Sanjaya Athapattu - BSc undergraduate student, University of Sri Jayewardenepura).

Industrial extension

The following services were provided to a number of rubber companies at their request.

Service	No. of companies
Physical properties of rubber compounds	5
Physical properties of rubber products	4
Hardness of sole crepe samples	3

In addition to the services rendered to rubber industries, a large number of entrepreneurs were provided with advice and assistance for setting up NR latex based cottage industries as well as dry rubber based industries.

Six leaflets titled manufacture of balloons, manufacture of rubberized-coir mattresses, manufacture of cast products, රබර් කිරි ආශ්‍රිත බැලූන් නිෂ්පාදනය, අච්චු භාවිතයෙන් භාණ්ඩ නිෂ්පාදනය, රබර් කිරි ආශ්‍රිත කොහු මෙට්ට නිෂ්පාදනය were produced during the year for the benefit of small and medium scale entrepreneurs.

A video titled "රබර් කිරෙන් රන් කහවනු", as a guide for production of rubber based products at cottage level was produced to mark the celebrations of 100 years of excellence in natural rubber research.

POLYMER CHEMISTRY

A H L Renuka Nilmini

SUMMARY

A low cost rain guard sealant based on bitumen incorporated with waste rubber and waste engine oil was developed successfully.

Fluid resistance properties of NR/NBR/PVC blends containing NR, NBR and PVC were tested against car engine oil and the blend NR:NBR:PVC 50:35:15, showed good oil resistance properties. Other physical properties of the blend are yet to be investigated.

A digital metrolac was developed in collaboration with Sri Lanka Institute of Information Technology.

$Al(OH)_3$ was found be quite effective in the reduction of leachable protein from natural rubber latex. Even though extractable protein content was low in $Al(OH)_3$ treated latex, some physical properties such as tensile strength was adversely affected by $Al(OH)_3$ treatment. Possible reasons for this effect yet to be analyzed.

Environmental friendly preservative system is being developed to preserve natural rubber latex.

NR based soaker hose developed by the department was experimented in a rubber plantation in Moneragala area as an efficient water supply system.

DETAILED REVIEW

Staff

Dr (Mrs) Champa Wellappilli, vacated her post as a Senior Research Officer from the institute from 26th April 2009. Dr (Mrs) A H L Nilmini, Research Officer resumed duties on the 23rd August 2009, after completing her postgraduate studies successfully at the University of Cardiff, UK. Mr H N K K Chandralal, Research Officer was on duty throughout the year. Mrs Indra Denawaka, Mrs Chitra Kuruppu, and Mr Ananda Samarakoon, Experimental Officers were on duty throughout the year.

Mr S S Warnapura, Experimental Officer was transferred to Dartonfield Rubber Factory with effect from November 2009.

Research students

- Miss Thushari, completed the post graduate research on "Effect of resin and solvent systems on polychloroprene/rubber based adhesives" as a partial fulfillment for the Masters Degree of Polymer Science & Technology, University of Moratuwa in 2009 under the supervision of Dr C J Wellappilli.

- Mr Ruwan Weerasekera completed writing of the thesis of his post graduate research on "Development of an environmental friendly preservative system for NR latex" as a partial fulfillment for the Masters Degree of Polymer Science and Technology, University of Jayawardanepura in 2009 under the supervision of Dr (Mrs) C J Wellappilli.

- Mr Chamara Gunethilaka, completed writing of the thesis of his post graduate research on "Development of a cost effective rain guard sealant" as a partial fulfillment for the Masters Degree of Polymer Science & Technology, University of Jayawardanepura in 2009 under the supervision of Mr H N K K Chandralal.

- Mr Dammika Weerathunga, final year Chemistry (Special) student from University of Sri Jayawardenapura commenced a three months research project on "Low allergenic NR latex" during the second quarter under the supervision of Mr H N K K Chandralal.

Dr Renuka Nilmini served as an External Examiner to evaluate the thesis of two MSc (Polymer Science and Technology) students of the University of Sri Jayawardenapura.

Mr H N K K Chandralal served as an External Examiner to evaluate two MSc (Polymer Science and Technology) students of the University of Sri Jayawardenapura.

Seminars/Training/Workshops/Conferences attended

Officer/s	Subject	Organization
A H L R Nilmini	Wood cluster quarterly discussions with furniture Manufacturers Organization	National Enterprise Development Authority

Seminars/Training/Workshops/Exhibitions conducted

Officer/s	Subject/Theme	Beneficiary/Client
A H L R Nilmini and H N K K Chandralal	Preparation of rain guard sealant	Group General Managers, Supervisors and Field Officers of Lalan Rubbers (Pvt) Ltd.

Advisory visits

The following estates were visited during the year in connection with rubber wood treatment and development of low cost rain guard sealant.

Officer/s	Subject	Organization
AHLR Nilmini HNKK Chandralal and A Samarakoon	Preparation of rain guard sealant	• Aitken Spence Plantations. • Dartonfield Estate, RRI Kuruwita Sub Station • Mahaoya, Sapumalkande and Udapola Estate – Lalan Rubbers (Pvt) Ltd
AHLR Nilmini and HNKK Chandralal	Rubber wood treatment	Aitken Spence Plantations

LABORATORY INVESTIGATIONS

Preparation of low cost sealant for rainguard

A low cost rain guard sealant was prepared by blending bitumen with waste engine oil, china clay and NR. Main objective was to incorporate considerable amount of china clay without undue effects on water repellant and adhesive properties of the bitumen. Ductility and handling of the compound was maintained by the use of appropriate quantities of china clay. Large sample of the sealant was prepared and field investigations were carried out at Dartonfield estate. According to the field trial, properties of the sealant such as elasticity, adhesion, water proofing ability and softness were found to be superior compared with the sealant which is being used at present.

A workshop was conducted at Sapumalkande estate of the Lalan group to introduce the new sealant to plantation companies.

Few other trials were initiated to find out the possibility of replacing china clay by other forms of readily available waste materials such as wood dust and burnt paddy husk. Field trails on sealant incorporated with wood dust were found to be not satisfactory. However, suitability of paddy husk is yet to be experimented. Specific type of bituminous waste material available in the Dockyard Ltd., Colombo to replace a considerable amount of the bitumen in the sealant is now being explored with a view to reduce the cost (A H L Nilmini, H N K K Chandralal, Ananda Samarakoon, S S Warnapura).

Studies of fluid resistance property in blends based on natural rubber with NBR and PVC

Natural rubber is not resistant to mineral oils or fuels, while resistance is good for a whole series of organic and inorganic chemicals such as non-mineral oil based brake fluids, silica oils and grease, glycol, alcohols, water and non oxidizing water solutions of acids, alkali and salts. Acrylonitrile butadiene Rubber (NBR) is excellent in oil resistance and aromatic solvent resistance due to the presence of polar acrylonitrile groups.

As such, NBR could be blended with plastic materials such as Poly Vinyl Chloride (PVC) and also with phenolic resins which would further improve oil resistance with a suitable plasticizer.

The use of nitrile rubber in oil seals is quite common while other applications include flexible fuel tanks, oil resistant hoses and printing rollers.

Following NR/NBR/PVC blends were prepared using crepe rubber as the NR raw material and compounded and cured based on a conventional sulphur vulcanization and compared the solvent resistance.

	Blend 1	Blend 2	Blend 3	Blend 4	Blend 5	Blend 6
NR	100	90	80	70	60	50
NBR	-	07	14	21	28	35
PVC	-	03	06	09	12	15

Room temperature and accelerated ageing solvent resistant tests were performed to measure the changes in the rubber vulcanizate at elevated service temperatures (70^0C for 22 hours) in the given fluid system.

Blend No.	Wt uptake % at RT	Wt uptake % at 70^0C
1	82.35	131.47
2	48.17	119.30
3	37.55	115.13
4	28.74	92.50
5	21.24	71.71
6	21.02	58.20

It was observed that NR:NBR:PVC; 50:35:15 blend possesses good oil resistant properties as per the swelling test carried out at room and elevated temperatures. Evaluation of other physical properties such as compression set, hardness, tensile strength and tare strength is being carried out (Champa Wellappilli, A H L Nilmini and Indra Denawaka).

Development of digital metrolac

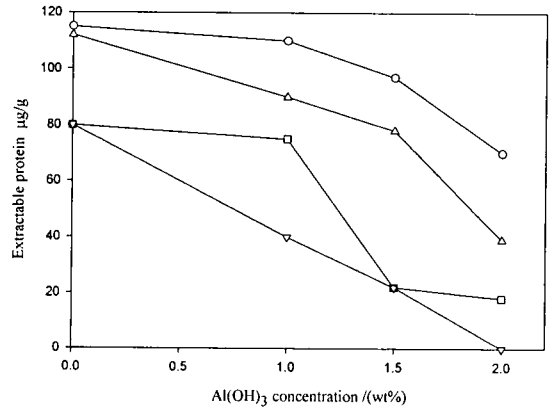
Main objective of the project was to develop a digital metrolac to measure the dry rubber content of the latex accurately. Group of students from Sri Lanka Institute

of Information Technology has started this project as their final year project under the RRISL guidance and supervision. The specific gravity of natural rubber latex varies with the dry rubber content and as such, development of a suitable programme for a microprocessor to determine the specific gravity of latex in relation to its voltage has been examined. They were finally able to develop a programme along with the equipment and its commercial viability is yet to be assessed (H N K K Chandralal).

Preparation of low protein natural rubber latex

An attempt has been made to reduce leachable allergenic proteins present in natural rubber latex by incorporating $Al(OH)_3$ into the latex. Addition of $Al(OH)_3$ was carried to examine the effect of protein leachability prior to centrifugation and after centrifugation with latex.

Latex samples were tested for Volatile Fatty Acid (VFA) and Mechanical Stability Time (MST) as well. VFA value increases while MST value decreases with increasing concentrations of $Al(OH)_3$. Lowering of VFA could be due to catalytic activity of Al^{3+} in forming volatile fatty acids. However, the exact explanation for the reduction of MST is yet to be ascertained. Extractable protein content of the vulcanized latex films were checked according to the modified Lowry method (ASTM 5712) and it was observed that protein content of the $Al(OH)_3$ treated latex were less compared to the untreated samples.



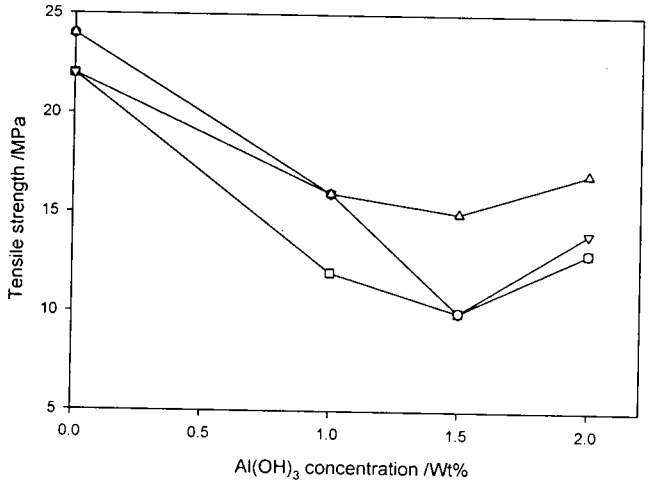
The effect of $Al(OH)_3$ concentration on extractable protein of different latex films. circle: $Al(OH)_3$ added prior to centrifuged; square: chlorinated sample - $Al(OH)_3$ added prior to centrifuged ; triangle up: $Al(OH)_3$ added after centrifuged;triangle down: chlorinated sample-$Al(OH)_3$ added after centrifuged

Fig. 1. Variation of extractable protein content against $Al(OH)_3$ concentration

According to extractable protein (EP) results shown in the above figure, only a slight difference in EP content was observed in $Al(OH)_3$ treated latex films, with and without chlorination.

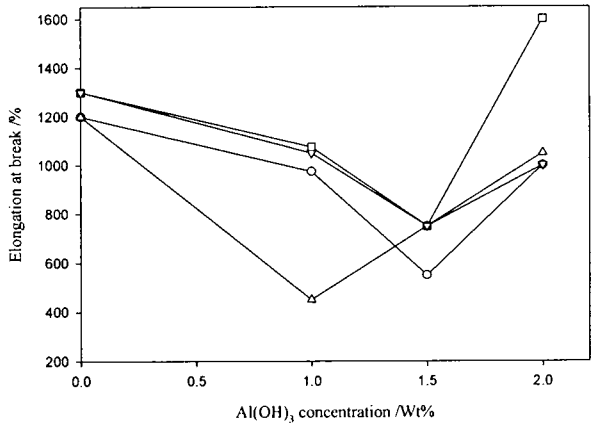
However, it could be seen a considerable decrease in EP levels with increasing $Al(OH)_3$ concentrations which suggests that $Al(OH)_3$ is quite active in the reduction of EP in natural rubber latex. The possible mechanism for the process could be that Al^{3+} forms a complex with protein present in the latex and subsequently denaturing the proteins in the complex due to conformational changes. The denatured proteins with Al^{3+} atoms are expected to be more leachable than the proteins in original native state.

As per the results in Fig. 2, it is observed that the tensile strength of the samples reduced by chlorination, in both batches, where $Al(OH)_3$ was added before and after centrifugation. Tensile strength decreases with the increase of $Al(OH)_3$ concentration as well, which can be identified as a major drawback of the treatment eventhough $Al(OH)_3$ is effective in reducing EP in latex. To ascertain possible reasons for this needs further investigations. Fig. 3 shows the variation of elongation at break against $Al(OH)_3$ concentration (Champa Wellappilli, A H L R Nilmini, H N K K Chandralal, A Samarakoon and Indra Denawaka).



The effect of $Al(OH)_3$ concentration on tensile strength of different latex films. circle: $Al(OH)_3$ added prior to centrifuged; square: chlorinated sample - $Al(OH)_3$ added prior to centrifuged ; triangle up: $Al(OH)_3$ added after centrifuged;triangle down: chlorinated sample-$Al(OH)_3$ added after centrifuged

Fig. 2. Variation of tensile strength against $Al(OH)_3$ concentration



The effect of $Al(OH)_3$ concentration on elongation at break of different latex films. circle: $Al(OH)_3$ added prior to centrifuged; square: chlorinated sample - $Al(OH)_3$ added prior to centrifuged ; triangle up: $Al(OH)_3$ added after centrifuged;triangle down: chlorinated sample-$Al(OH)_3$ added after centrifuged

Fig. 3. Variation of elongation at break against $Al(OH)_3$ concentration

Variation of compound viscosity in latex

A project was initiated to examine the variation of compound viscosity with ammonia and varying soap concentrations in collaboration with Dipped products (Pvt) Ltd. Low and high ammonia preserved centrifuged NR lattices were prepared with normal stabilizer systems and basic latex quality tests such as VFA, MST and KOH numbers were performed. Project will be continued by incorporating variable concentrations of stabilizer systems provided by Dipped products Ltd. (A H L Nilmini, H N K K Chandralal, Chitra Kuruppu and A Samarakoon).

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

The main objective of this project was to replace toxic TMTD from the conventional preservative system which is used at present. Possibility of using series of concentrations of Preventol, a well known leather processing chemical, as a replacement for TMTD was investigated. One type of Preventol was found to be very effective in the preservation of latex since there was a significant reduction of VFA against the traditional preservative system. Series of trials have been conducted with the selected grade of Preventol in order to maximize the latex parameters and consistency of the procedure. In addition to Preventol, various other suitable

chemicals for natural rubber latex preservation are being examined. Project is in progress (A H L Nilmini, H N K K Chandralal, Indra Denewaka and A Samarakoon).

Soaker hose for drip irrigation

Efficient irrigating system for rubber plantations in drought areas using RRISL developed porous tube (**Soaker hose)** was introduced. A circular porous tube was buried around each tree and a plastic bottle (2 liters as a water resoviour) was connected to it by a T joint. Two liters of water in the bottle made sure that the gradual water penetration through the porous tube takes place throughout the day.

Trials have been carried out in a small holder rubber plantation in Moneragala which was said to be satisfactory. Few of those models were given to Coconut development authority (CDA) for trials to be carried out in coconut plantations as well. The model was exhibited in few exhibitions for the benefit of the rubber smallholders (A H L Nilmini, H N K K Chandralal and A Samarakoon).

Development of pesticide emulsion for pruned tea plants

The objective is to develop a cost effective fungicide oil emulsion to be sprayed in pruned tea plantations as against presently used water soluble expensive fungicide.

Fungicide was dissolved in oil and a stable emulsion was prepared using a potassium oleate as the soap. Activity of the fungicide was not found to be affected by the formation of emulsion. It was found that the emulsion was very effective as per the field trial carried out at TRI substation Ratnapura and the application of it is found to be convenient as well.

The other request was to develop environmental friendly fungal inhibitor for the same application instead of using commercially available fungicides. Trails were carried out with two different naturally occurring oils and the results of the field trails are yet to be evaluated (H N K K Chandralal and Keerthi Mohotti - TRI).

Industrial extension

Company	Analytical services
Plant Science Dept/Dartonfield	Analysis of melting point of PE samples
Ansell Lanka	Analysis of purity of TMTD samples by FTIR
Water Board, DSI, IDB, Textrip	Polymer analysis using FTIR

Miscellaneous

A meeting was conducted at RRISL with the Managers of Lanka Walltile Meepe (Pvt) Limited in order to solve a problem related to fungal growth on the pallets, use for tiles transport.

A meeting was held at RRISL to transfer knowledge on rubber wood treatment process for two industries and solved the problems related to the treatment procedure of one of those industries.

A chemical toxicity report was issued for Lak Methodic Company regarding the toxicity levels of different chemicals present in rubber strips formulation comparing FDA approved levels of each chemical.

Training programme was conducted at Polymer Chemistry Department on casting of latex toys to people from B & W Engineering Private Limited at RRISL.

Comprehensive report was submitted to BATA Shoe Company, analyzing causes for discoloration of sport shoes made out of plasticized PVC.

RAW RUBBER AND CHEMICAL ANALYSIS

Anusha Attanayake

SUMMARY

214 TSR samples and 450 samples of other forms of processed dry rubber were tested for raw rubber properties and certificates were issued for purposes such as grading/quality assessment, export and local consumption.

370 numbers of latex samples were analyzed for their latex properties in accordance with ISO standards.

81 Numbers of rubber chemicals were tested for their percentage purity assessments and rubber content of many rubber products were also analyzed.

Preliminary studies on the variations of dry rubber properties of rubber grown in wet and dry zones were conducted to ascertain any differences under different climatic regions.

A project was initiated to study any physical property differences in NR latex in rubber obtained from trees with and without etherel stimulation. Results showed that there are observable differences in latex properties such as DRC, TSC and VFA number between these two.

A project on analysis of physical property differences of nitrile latex gloves incorporated with cellulose and acrylic viscosity modifiers was completed.

DETAILED REVIEW

Staff

Ms A P Attanayake, Assistant Rubber Chemist was on duty as in charge of overall activities of the department through out the year.

Experimental Officers, Ms H S Weeraman, L Wanigatunga, H V K Gamage, C Lokuge, L P Vitharana, M Wijesekera, B Gunasiri, N Karunatilaka, W Vithanage, and Clerk/Typist Mrs I Wijesinghe were on duty throughout the year.

Instrument Technician Mr L G P Lelwela, was on duty through out the year.

Research students

- Miss Buddhika Bandaragoda, BSc undergraduate from University of Sri Jayawardenapura completed her short term research project during her vacation training period.

Seminars/Training/Workshops/Conferences attended

Officer/s	Subject/Theme	Organization
A P Attanayake	Dissemination Seminar on cleaner production at JIC Hilton, Colombo 2	National Cleaner Production Centre
A P Attanayake	IRRDB Training Programme	Rubber Research institute of Malaysia, Kuala Lumpur, Malaysia Indonesian Rubber Research Institute, Sungei Putih Research Centre, Medan IRRI, Simbawa Research Centre, Palembang
A P Attanayake	IRRI-IRRDB International Rubber Conference 2009 Bogor, Indonesia	

Seminars/Training/Workshops/Exhibition conducted

Departmental staff was involved in conducting following progrmmes.

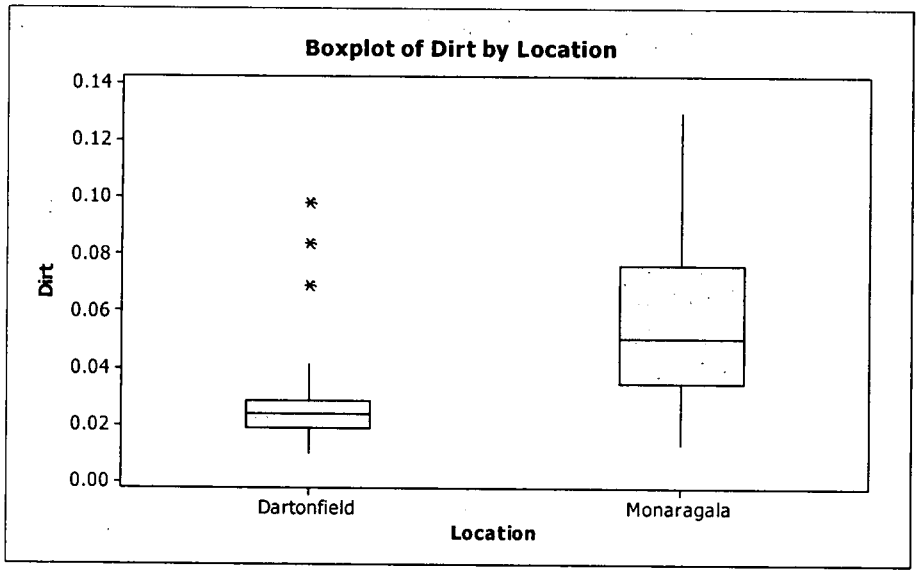
Subject/Theme	Beneficiary/Client
One week training on Laboratory Management, Instrumentation and Latex Analysis	Yasanka Senanayake, Ellawala Rubber Factory
Latex testing	Shashi Sameera Gallage, Rajarata University
Raw Rubber Testing	B G W Kumara, University of Sabaragamuwa S A I G Samarathunga, Sandagiri Rubber Factory Group of students NDT (Polymer) University of Moratuwa
Latex quality Characteristics and sampling techniques/Sampling and testing of raw rubber and latex	C Fernando, Executive Director, Malwatte Valley Plantation Mr Mangala Gunasekera, Miss Suvineetha Sooriaarachchi and Miss Rasangi Dinushika, Textrip Ltd. Mr S A Jayaratne Bandara, SRMC Mawanella

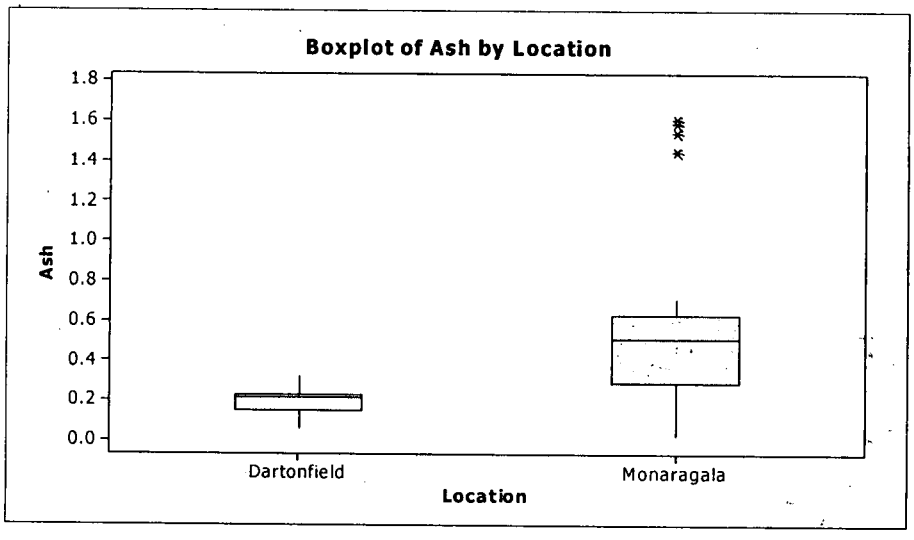
LABORATORY INVESTIGATIONS

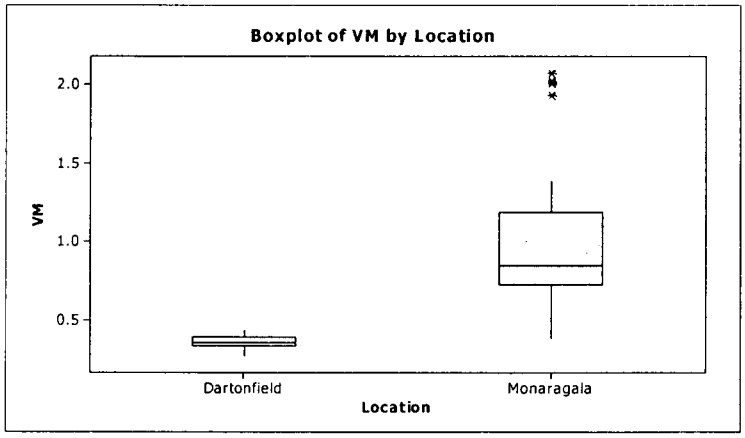
Preliminary studies on variations of dry rubber properties of raw rubber grown in wet and dry zones (RR&CA/09/R/01)

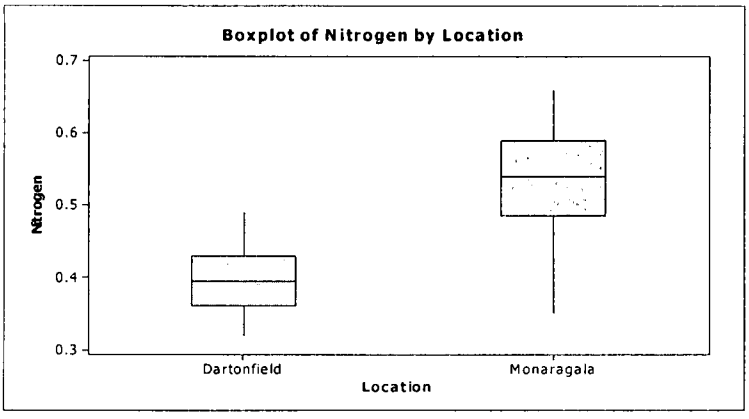
The objective of the project is to analyze and compare raw rubber properties in rubber grown under different climatic regions.

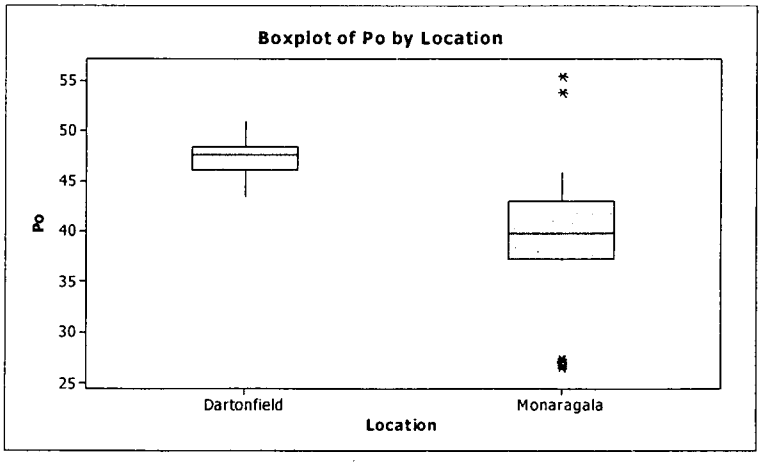
RSS samples were collected from several smallholders from Badalkubura area in the district of Moneragala classified as a dry zone area. Fifteen samples out of them were randomly selected and analyzed for raw rubber properties. Similarly, RSS sample collected from Dartonfield, a wet zone rubber growing area, were analyzed for comparison.

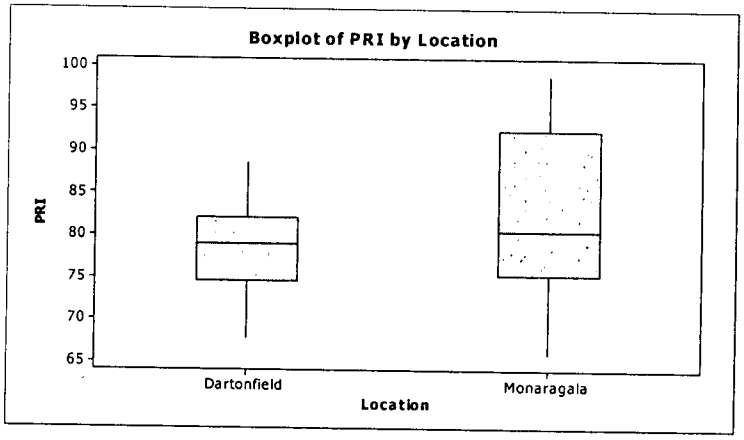


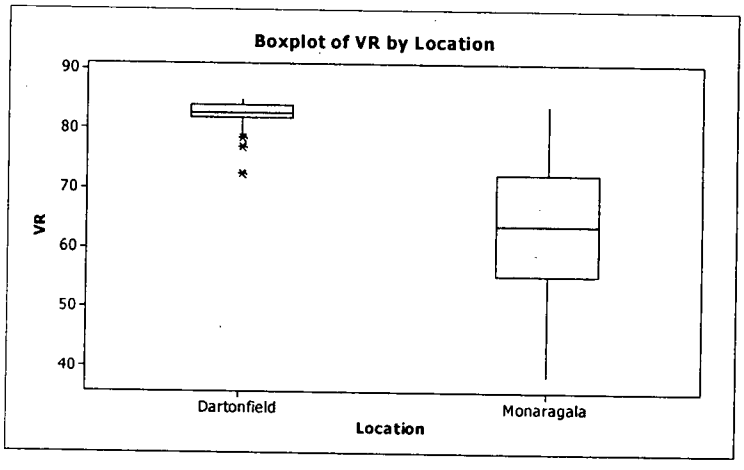



Boxplot of VM by Location
VM
2.0
1.5
1.0
0.5
Dartonfield
Monaragala
Location


Boxplot of Nitrogen by Location
Nitrogen
0.7
0.6
0.5
0.4
0.3
Dartonfield
Monaragala
Location


Boxplot of Po by Location
Po
55
50
45
40
35
30
25
Dartonfield
Monaragala
Location





Results revealed that a significant difference in raw rubber properties was observed between the RSS made in Dartonfield and Badalkumbura.

It was noted that the RSS in Dartonfield was processed by skilled persons whereas RSS in Badalkumbura was prepared by smallholder farmers with lack of required facilities and knowledge.

The project will be continued with the analysis of more number of samples to arrive at a justifiable judgment of the quality of rubber grown in wet and dry zones with respect to raw rubber properties.

Comparison of NR latex properties from etherel stimulated and non stimulated trees (RR&CA/09/L/01)

The objective of the project was to investigate the quality variation of latex and rubber with etheral stimulation (2.5%) and non stimulation.

Latex from the clones RRIC 100, RRIC 121, and RRIC 102 and RRIC 130 were subjected for the study. Two series of latex samples from stimulated and non stimulated trees from each clone were analyzed for latex properties such as dry rubber content, total solid content and volatile fatty acid number.

Results are given in Figs. 1 to 3. DRC and TSC of latex of non stimulated trees are slightly higher than that of the stimulated trees in all clones. Volatile fatty acid formation in latex as specified by the VFA number appeared to have increased slightly with stimulation which means that the latex is slightly unstable in ethereal stimulated trees. The project will be continued over a reasonable period with the analysis of more number of samples to ascertain and arrive at a reasonable judgment of the effect of stimulation on the property variations of latex in the above clones.

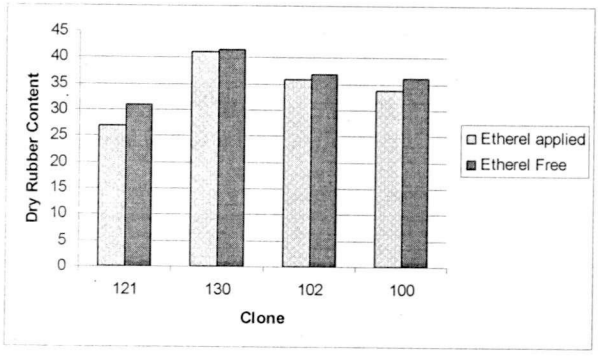


Fig.1. Variation of Dry Rubber Content (DRC) in different rubber clones with and without etherel stimulation

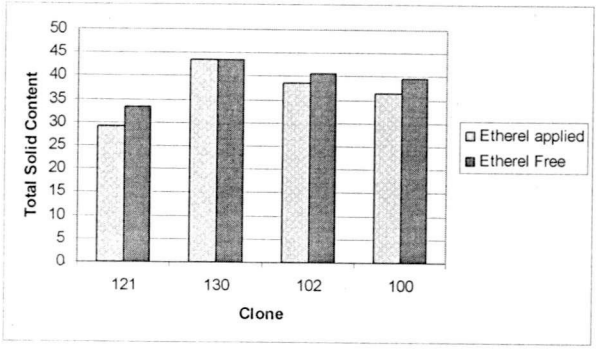


Fig.2. Variation of Total Solid Content (TS) in different rubber clones with and without etherel stimulation

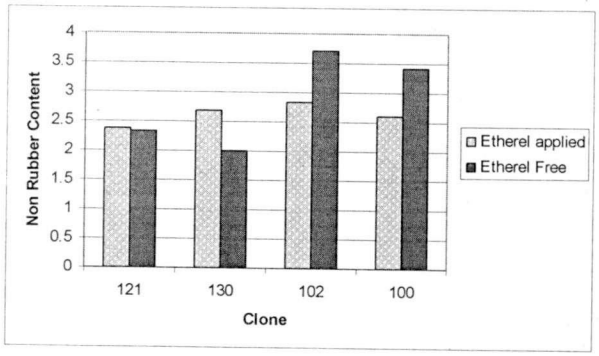


Fig.3. Variation of Non Rubber Content in different rubber clones with and without etherel stimulation

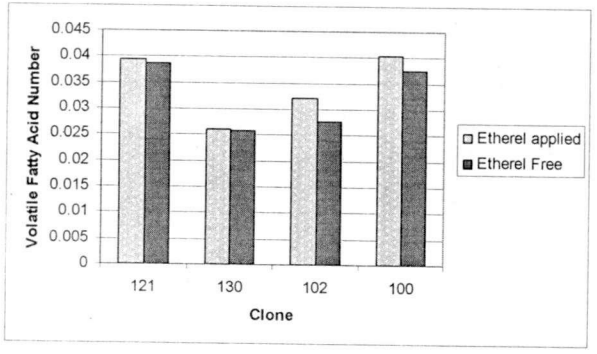


Fig. 4. Variation of Volatile Fatty Acid Number in different rubber clones with and without etherel stimulation

(A P Attanayake, LWanigathunga and Buddhika Bandaragoda)

Determination of the strength of DAHP

A titrimetric method was introduced to investigate the strength of DAHP in order to prevent the use of low quality DAHP in the centrifuged latex industry which is detrimental to the quality of centrifuged latex and prevent any subsequent quality issues (A P Attanayake and C Lokuge).

Comparison of cellulose and acrylic thickener in nitrile latex

The project was carried out as a partial fulfillment for the Diploma in Rubber Technology (DPRI) of the PRI by a student from Ansell Lanka (Pvt) Ltd in collaboration with the Rubber Research Institute.

The objective is to analyze physical property differences of Latex gloves made from nitrile latex incorporated with viscosity modifiers, based on Cellulose and Acrylic thickeners.

Culminal (Methyl Hydroxy Propyl Cellulose MHPC) 50 and Acrysol G-111E (Ammonium Polyacrylate solution) were used as viscosity modifiers for Sinthomer brand Nitrile latex.

This comparison of these gloves produced from special designated compounds of the two modified lattices was made by analyzing physical properties such as glove weight, thickness, ware weight, stiffness and abrasion resistance. Variation of compound viscosity with time was studied as well. Final conclusions of the project are as follows;

- Acrysol solution needed nearly three times more than that of the amount of culminal solution to achieve the required viscosity of nitrile latex.
- Increase in viscosity of the Acrysol incorporated latex compound is slow in the beginning and thereafter increases gradually with time while viscosity of the culminal incorporated latex compound increases rapidly in the beginning and become constant subsequently.

Following properties of the gloves made from Acrysol incorporated latex compound are superior than that of the gloves made from Culminal incorporated latex compound.

- Glove weight, glove thickness and weight
- The peal-off point of finished gloves
- Abrasion resistance as well as the stiffness

Based on these results the use of Acrysol G-111E (Ammonium Polyacrylate solution) is found to be superior than that of Culminal (Methyl Hydroxy Propyl Cellulose MHPC) 50 as a viscosity modifier for nitrile latex (A P Attanayake, Manju Perera and Dihan Geeganage).

Services

Calibration of latex tanks

Calibration of latex tanks carried out as per the requests made by the following companies for accurate measurements of the quantity of latex.

1. Pitiyakanda Estate, Mawathagama
2. Lalan Rubber, Warakapola

(L P Vitharana)

Analytical services

Samples tested during the year were as follows:

Service	No. of samples
TSR analysis	
Le-Ferne TSR Factory, Getahetta, Avissawella	30
Sandagiri TSR Factory, Dompe	120
C W Mackies TSR Factory, Nathupana	64
Miscellaneous analysis	
Raw rubber samples	450
Latex samples	370
Chemical samples	23
Bleaching agent samples	58
Testing certificates	1115

RAW RUBBER PROCESS DEVELOPMENT AND CHEMICAL ENGINEERING

S Siriwardena

SUMMARY

Revised standards were proposed for critical metal ions concentration that could be present in crepe rubber without detrimental effects on quality and the allowable limits for raw rubber processing water. New recommendations for preparation of latex blends of centrifuged latex with low VFA and high VFA were made.

Raw rubber property value range of the Sri Lanka scrap rubber grades FAB 1-3 was established by analyzing a series of scrap rubber samples from various scrap millers.

Design for mechanization of the certain steps of the crepe rubber manufacturing process was completed.

Priority was given on experiments related to drying of all grades raw rubber with the intention of reducing the drying period at least by 50%. Special attention was given to introduce alternative drying systems for skim rubber and scrap rubber using bio gas and smoke respectively as main sources of heat.

Kinetic studies of aerobic and anaerobic digestive processes were initiated using the existing treatment plant at Pallegama crepe rubber factory and a laboratory scale model with a view to determine existing treatment efficiencies of both anaerobic and aerobic processes of the RRI developed method. Designs and advice on installation of new wastewater treatment plants for raw rubber processing factories were extended.

DETAILED REVIEW

Staff

Dr Susantha Siriwardane, Head of the department and Mr P H Sarath Kumara, Assistant Rubber Chemist were on duty throughout the year. Dr Upul Rathnayake, Rubber Chemist was granted no pay leave for a period of one year from 01st June 2009 to take up a research assignment at Sri Lanka Institute of Nano Technology (Pvt.) Ltd. (SLINTEC).

Messrs Chandana Senanayake, T A S Siriwardane and A K D Warnajith Prasad, Mrs Chandrika Nalini, Mrs Shirani Priyanka and Mrs C Rohanadepa, Experimental Officers, Mrs Ruckmani Liyanage, Store Keeper and Mrs Anusha Paranavithana, Typist/Clerk were on duty throughout the year.

Research students

- Mr Indrajith Rathnayake completed his post graduate research on "Estimation of efficiency of Single day Smoke drying system as a partial fulfillment for MSc degree in chemical engineering at the University of Moratuwa under the supervision of Dr Susantha Siriwardena.

- Messrs G M S V Weeraratne and K Geeth Kumara, final year undergraduate students of the Department of Chemistry, University of Sri Jayewardenapura completed their final year industrial research projects on "A comparative study of properties of skim rubber dried at different drying conditions" and "A study on blends of low grade natural rubber" respectively under the supervision of Dr Susantha Siriwardena.

- Miss K H G B A Kariyawasam, a final year undergraduate student from the Department of Chemistry, University of Sri Jayewardenapura carried out and completed her final year industrial research project on "Comparison of test methods using Colourimeter and Atomic Absorption Spectrophotometer to analyse copper and iron content in NR latex" under the supervision of Mr Sarath Kumara, from 26th January to 26th May.

- M D Kumarihamy, a final year undergraduate student from the Department of Physical sciences and Technology of University of Sabaragamuwa completed her final year 3 months project and produced a research report on "Improvement of quality and storage stability of pre-vulcanized natural rubber latex concentrates" under the supervision of Dr W M G Seneviratne, between the period of January and March 2009.

- Miss J A D H G Jayasinghe, a final year undergraduate student from the Department of Chemistry of University of Colombo underwent her final year training and produced a report on "Studies on anaerobic digestion of desiccated coconut mill effluent" during the period between October and November 2009 under the supervision of Dr W M G Seneviratne.

- Miss Amisha Vidanapathirana, a final year undergraduate student from the Department of Chemistry, University of Kelaniya carried out her final year training for three months and produced a report on "Performance of lower grades of natural rubber in tyre tread compounds" under the supervision of Dr W M G Seneviratne in Collaboration with Ms Loadstar (Pvt) Ltd.

- Mr E M K B Ekanayake, completed the post graduate research on "Improvement of quality and storage stability of pre-vulcanized natural rubber latex concentrates" as a partial fulfillment for the Masters degree of Polymer Science & Technology, University of Sri Jayewardenapura, 2009 under the supervision of Dr W M G Seneviratne.

- Mrs M G K Pushpakumari, completed her post graduate research on "Performance of lower grades of natural rubber in tyre tread compounds" as a partial fulfillment for the Masters Degree of Polymer Science & Technology, University of Sri Jayewardenapura in the year 2009 under the supervision of Dr W M G Seneviratne.

- Mrs M Rajasinghe, commenced a one year post graduate research on "Performance optimization of the adaptation of microbiological wastewater treatment for rubber effluents" from March 2009 required as a partial fulfillment for Masters degree in Agricultural Bio Technology at the University of Colombo.

Lectures/Seminars/Workshops/Meetings attended

Officer/s	Subject	Organisation
WMG Seneviratne	Two ISO guide 17025 Laboratory assessors workshops	Sri Lanka Accreditation Board (SLAB)
	Seminar on Cleaner production in rubber sector held at JIAC Hilton, Colombo	National Cleaner Production Center (NCPC)
	ANRPC expert group meeting on "NR Demand and Supply" held in Kuala Lumpur, Malaysia, 20th and 25th April 2009	ANRPC, Malaysia
	Seminar on "Leveraging high end technology for national development in Sri Lanka" with Dr R A Mashelkar, a World Bank Consultant	NSF
	Half day workshop-Consultative meeting on Development of professional ethics for Scientific bodies in Sri Lanka	NSF
	National Research Council (NRC) Annual Seminar	NRC
	Seminar on 'Applications of Nano Technology' held at ITI	SLINTEC
	Seminar on "Drafting policies on the development of University - Institute linkage	NASTEC

Officer/s	Subject	Organisation
	Participated as a Technical Consultant at several meetings conducted by the MPI on evaluation of joint venture partnership proposals of the idling factories belonging to SRMC	MPI
	Served the PRI in followings; As a board member of PRI committee of Management in eight meetings, three Board of Study meetings, Five Educational subcommittee meetings	PRI
	Eight Board meetings of the Ceyesta and Five Technical and Production Sub Committee meetings	Ceyesta
	Seminar on "Chemical leasing" organized by the Chamber of Commerce in association with the National Cleaner Production Center	NCPC
S Siriwardane & PH Sarath Kumara	Seminar on 'Applications of Nano Technology' organized by SLINTEC	ITI
Upul Ratnayake, PH Sarath Kumara & SMS Priyanka	Workshop on 'Numbers in Science- The Right way to handle Quantitative data' held at Institute of Engineers	NASTEC and SLAAS

Lectures/Seminars/Workshops/Meetings addressed

Officer/s	Subject	Beneficiary/Organisation
W M G Seneviratne	Presented a paper on "Research and Development towards sustainable development of the rubber product industry" at the Centenary celebration conference of the RRI	RRISL
	Served as a Technical assessor in internal Audit of the Sri Lanka Accreditation board (SLAB) based on ISO 9001, Quality Management System (QMS)	SLAB
	Served as the Chairman of the review panel appointed by the NASTEC to review the CRI, on research, advisory and all other activities between 02nd and 05th November, 2009 and produced a comprehensive review report	NASTEC/CRI

Officer/s	Subject	Beneficiary/Organisation
S Siriwardena	Lectures on manufacture of RSS and introduction to SS drying system at a one day workshop	Factory staff and the Rubber farmers, Maryland Estate Badalkumbura
	Technical presentation on SS drying system and adaptation of the technology	Plantation executives Malwatte Valley Plantations
S Siriwardane & U Ratnayake	Presentations on "Advance in Research & Development Needs in Raw Rubber Processing Industry" and "Quality consistency in raw rubber" respectively at Centennial International Rubber Conference held at Colombo Hilton	RRISL
S Siriwardane & AKD Warnajith Prasad	Lectures on "Manufacture of RSS and new drying system" and "DRC Estimation of NR latex by the use of Metrolac", A training programme organized by Seylan Bank	A group of smallholders at Bulathkohupitiya
S Siriwardane, PH Sarath Kumara & Shirani Priyanka	Lectures on Raw Rubber Processing at a one day Workshop	Plantation Managers, Kotagala Plantations Ltd.
AKD Warnajith Prasad	A demonstration on "Centrifuged latex manufacture" at Glenross Rubber Factory and "Crepe and RSS Manufacture" at Dartonfield Factory	Students, Uva Wellassa University

Advisory visits

Sample collection - Waste water

Industry	No. of Factories/visits				
	1 Quarter	2 Quarter	3 Quarter	4 Quarter	Year total
Rubber industries	02	Nil	10	30	42
Non rubber industries	05	03	04	15	27

Experimental visits

1 Quarter	2 Quarter	3 Quarter	4 Quarter	Year total
Nil	06	04	04	14

Factory development

Table 1. *Factory development visits and services provided*

Services provided	No of factories/visits				
	1 Quarter	2 Quarter	3 Quarter	4 Quarter	Year total
Process and quality improvements	04	02	5	02	13
Advices on waste water treatment	07	04	08	10	29
New ETP designs	03	Nil	02	01	06
Designs for Modifications of ETPs	Nil	01	01	01	03
Introducing SS drying system	01	02	04	05	12
Inspection for other purposes	01	02	02	03	08

Several requests for designing RSS factories and construction/modification of existing sheet rubber drying systems were received during the year. Plans and technical advices were given for the construction of SS drying units and a brief summary of them is given in Table 2.

Table 2. *Number of plans given for construction/modification of sheet rubber drying units*

	Number
No. of plans given for construction of new SS drying system with capacity less than 100 kg	42
No. of plans given for construction of new SS drying system and modifications/conversion of existing systems to new SS drying system of capacity less than 250 kg	14
No. of plans given for construction/modifications of drying units for estate sector	09

Sample testing

Table 3. *Sample testing and certificates issued*

Samples tested	Number of samples				
	1 Quarter	2 Quarter	3 Quarter	4 Quarter	Year total
Waste water	23	19	43	30	115
Processing water	Nil	02	Nil	Nil	02
Rubber samples for protein content	03	04	01	Nil	08
Certificates issued	**Number of certificates**				
	1 Quarter	2 Quarter	3 Quarter	4 Quarter	Year total
Waste water	11	13	34	16	74
Processing water	Nil	01	Nil	Nil	01
Rubber samples for protein content	03	02	01	02	08
Certificates of epidemic prevention	11	10	11	16	48

LABORATORY AND FIELD INVESTIGATIONS

Mechanization of crepe rubber manufacturing process (Project No. **RRPD/D/MCM/2006/01**)

A mechanically operated coagulum partitioning unit was designed. Discussions were held with a plantation company and they have principally agreed to provide financial assistance to fabricate the unit (S Siriardena, T A S Siriwardena and Lionel Perera).

Effect of metal ions on quality of latex crepe (Project No. RRPD/D/EMC/2001/05)

Investigations were continued to examine the effects of the presence of critical levels of total iron (Fe), copper (Cu) and manganese (Mn) ions on the quality of crepe rubber.

Repeated experiments with different concentrations of metal ions confirmed that the critical levels of Fe, Cu and Mn could be present in rubber without any adverse effects as given in Table 4. Similarly, maximum allowable limits of total iron, Copper and Magnesium for crepe rubber processing water were established as new standards (maximum allowable limits).

Table 4. *Revised standards for metal ions in crepe rubber processing water and in crepe rubber*

	Total iron (ppm)	Copper ions (ppm)	Manganese ions (ppm)
Processing water	5	0.6	15
Crepe rubber	30	1.3	15

(U Ratnayake, P H Sarath Kumara, T A S Siriwardena, A K D Warnajith Prasad and V C Rohanadeepa).

Study of quality of blends of Low VFA and High VFA centrifuged latex (Project No. RRPD/L/QLT/2006/14)

Project was completed. A research paper was written based on the outcome of the studies and was submitted to a reputed international journal.

Important findings of the studies are as follows:

VFA number of unblended centrifuged latex and certain blend compositions were remained constant up to a period of 40-50 days when kept in air-tight containers and thereafter gradually increased. VFA development after 40-50 days was faster in the blends containing high VFA latex probably due to the release of enzymes from

dead bacteria cells contained in high VFA latex component as revealed by the literature.

Final recommendation

High VFA latex can be blended with low VFA latex in order to upgrade the quality of high VFA latex without any detrimental effect on the overall properties of the blend. The proportion of high VFA latex blending with low VFA latex depends on the standards expected by the buyer. The following equation was developed and recommended to estimate and achieve targeted VFA number of the latex blends prepared from two different latex concentrates having different VFA numbers.

$$\mathbf{VFA_b = \varphi_h VFA_h + \varphi_l VFA_l}$$

Where,

VFA_b = VFA number of latex blend
VFA_h = VFA number of high VFA latex concentrate
VFA_l = VFA number of low VFA latex concentrate
φ_h = Weight fraction of high VFA latex concentrate in the blend
φ_l = Weight fraction of low VFA latex concentrate in the blend

The VFA values of the blends analyzed by the ISO test method and the predicted values calculated using the above equation, are shown in Table 5. The percentage deviations of actual VFA numbers from the predicted values are shown in Table 6. It is clear that percentage deviation of the actual value from the predicted value is less than 5% and hence, the prediction and the equation derived are fairly accurate.

Table 5. *Actual and predicted VFA values of latex blends just after blending*

Sample Label	High VFA/ low VFA (by weight)	VFA Number					
		Trial 1		Trial 2		Trial 3	
		Actual	Predicted	Actual	Predicted	Actual	Predicted
A	100/0	0.067	0.067	0.059	0.059	0.109	0.109
B	60/40	0.051	0.050	0.050	0.045	0.075	0.078
C	40/60	0.043	0.042	0.043	0.038	0.065	0.062
D	20/80	0.036	0.033	0.038	0.031	0.053	0.047
E	10/90	0.031	0.029	0.032	0.028	0.042	0.039
F	0/100	0.025	0.025	0.024	0.024	0.031	0.031

Table 6. *Deviation of VFA number of latex blends from predicted values*

Sample Label	High VFA/low VFA (by weight)	VFA Number					
		Trial 1		Trial 2		Trial 3	
		Deviation	% Deviation	Deviation	% Deviation	Deviation	% Deviation
A	100/0	0.000	0	0.000	0	0.000	0
B	60/40	+0.001	+1	+0.005	+5	-0.003	-3
C	40/60	+0.001	+1	+0.005	+5	+0.003	+3
D	20/80	+0.003	+3	+0.007	+7	+0.006	+6
E	10/90	+0.002	+2	+0.004	+4	+0.003	+3
F	0/100	0.000	0	0.000	0	0.000	0

(P H Sarath Kumara, A K D Warnajith Prasad and V C Rohanadeepa)

Portable small scale solar assisted dryer for drying of sheets (Project No. RRPD/D/PSD/2006/11)

A study was carried out to estimate the drying efficiency of the newly introduced single day drying system. It was found that the drying efficiency of this system, defined as the ratio of energy consumed for drying of rubber to the total energy input is 60.2% (S Siriwardena, T A S Siriwardane and A K D Warnajith Prasad and Indrajith Rathnayake).

Development of an uninterrupted drying system for crepe rubber (Project No. RRPD/D/UDS/2007/17

Preliminary trials carried out on uninterrupted drying of crepe rubber during the last year (2008) shown that the laces could be dried within a day. As such, it was decided to carry out pilot scale trial at Dartonfield crepe rubber factory. Appropriate design was prepared to modify the existing drying tower and the modification work was in progress during the latter part of the year (Susantha Siriwardena, T A S Siriwardane and A K D Warnajith Prasad).

Rubber toughened thermoplastic nanocomposites based on layered silicates (Project No. RRPD/D/RTN/2007/05)

A research project titled "Rheological and mechanical properties of rubber toughened polypropylene-clay nanocomposites" submitted to National Science Foundation (NSF) was approved for funding. The funds are yet to be released by the NSF to commence the project (Upul Ratnayake and H N N K Chandralal).

Characterization of non - conventional grades of natural rubber (Project No. RRPD/D/CNR/2006/06)

The results of raw rubber properties of 419 visually graded scrap crepe rubber samples were analyzed statistically by the Biometry section of the RRISL. The analysis of raw rubber properties showed that dirt content is less in 1X grade compared to that in grade 2X and 3X. The dirt content in 1X grade was less than 0.5% in all 7 factories investigated under this study while samples from two of those factories showed even less than 0.2%.

The dirt content of 2X grade was found to be less than 0.7% while that of 3X was around 1% but shown to be highly variable.

The results for dirt content are presented in box plots given in Fig. 1 for comparison of variability of the parameter.

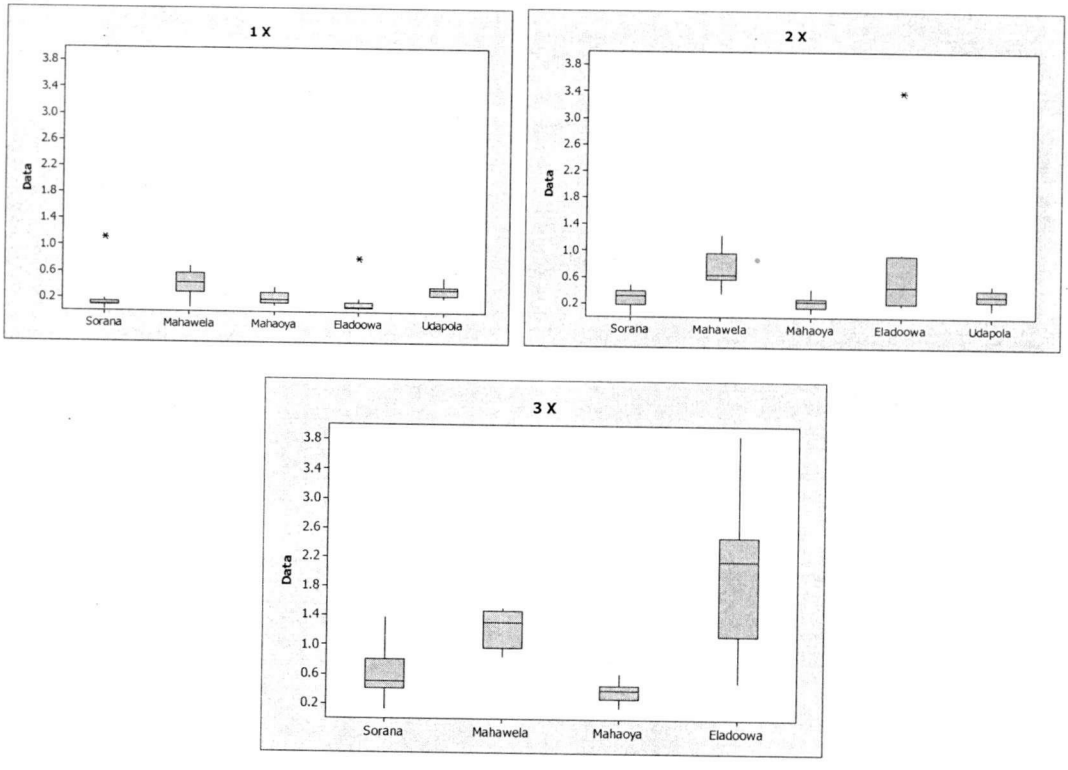


Fig. 1. Box plots for dirt content of different grades of scrap crepe

Depending on the median values of the parameters, the general values obtained for each parameter tested is given in Table 7.

Table 7. *Summary of raw rubber properties of scrap crepe*

Property	Scrap grade			
	1X	2X	3X	FB
Dirt content	< 0.5%	< 0.7%	< 3%	< 0.5%
Po	50-70	50-60	30-50	30-50
PRI	30-60	20-60	35-50	20-45
Ash content	0.4 - 0.7%	< 1%	< 1%	0.5 – 0.7%
Volatile matter content	< 1%	< 1%	< 1%	< 1%
N content	0.2-0.4%	0.2-0.5%	< 1%	0.2-0.4%
Mooney viscosity	90-100	80-100	70-90	80-90 (only one factory)

(S Siriwardena, P H Sarath Kumara, Wasana Wijesooriya, Shirani Priyanga, L P Vitharana, Nimal Karunathilake and W D Wimaladasa)

Wastewater treatment for rubber process effluents

Designs with complete sketches and plans for installation of wastewater treatment plants for several rubber processing factories based on anaerobic and aerobic treatment principle were submitted as per the site locations. Among the raw rubber factories which were provided with the above mentioned services by the RRI are three Scrap rubber factories, three crepe rubber factories and a latex centrifuging factory.

Existing ETP at Parambe crepe rubber factory which was in operation for nearly ten years was found to have many defects and appropriate modifications were proposed to increase the efficiency.

Similar modifications/repairs were proposed to ETP at Ellakanda crepe rubber factory which was constructed in the year 1995 and in operation satisfactorily until recently. Modifications are now in progress.

Summary of work carried out in connection with the wastewater treatment of rubber effluents is given in the Table 8 (W M G Seneviratne).

Kinetic studies of the anaerobic - aerobic process

Following kinetic studies were undertaken using the existing treatment plant at Pallegama.

Crepe rubber factory and the specially designed laboratory scale anaerobic digester at Ratmalana Laboratories in order to develop the treatment efficiencies of the RRI developed microbiological rubber effluent treatment process.

Table 8. *Summary of the work on the treatment of rubber process effluents*

Estate/Factory	Type of raw rubber	Service provided	Present status	Treatment efficiency
Amugoda Rubber Mills, Elpitiya	Scrap	Designs of ETP	Plant is in operation	Comply with CEA standards
Debo Rubber Technologies, Eheliyagoda	Scrap	Designs of ETP	Construction in progress	-
Lanka Rubber Mills, Kotiyakumbura	Scrap	Designs of ETP	Plant is in operation	Comply with CEA standards
Kiribathgala Esatate	crepe	Designs of ETP	Not yet started	-
Culloden Estate	crepe	Designs of ETP	Not yet started	-
Sapumalkanda Estate	crepe	Designs of ETP	Not yet started	-
Udapola Esate	Latex centrifuging	Designs for modifications	Modifications are completed	Comply with CEA standards
Parambe crepe rubber	crepe	Repairs/Designs for Modifications	Not yet started	
Ellakanda crepe rubber	crepe	Repairs/Designs for Modifications	Modifications are in progress	

Kinetic behaviour of rubberized coir as the support medium for microorganism in an anaerobic digester treating rubber effluents

The kinetics of anaerobic digestion of rubberized coir were investigated using a semi continuous flow bioreactor and a continuous flow bioreactor which contained rubberized coir as support medium, in which microorganisms become immobilized. Kinetic behaviour for five different loading rates (300 ml, 400 ml, 500 ml, 600 ml and 700 ml) was investigated with Hydraulic retention times (HRT) ranging from 0.75 to 1.16 days at an average influent chemical oxygen demand (COD) concentration of 4.8 g/l.

Using standard kinetic formulas followings were determined for semi continuous bioreactor.

The maximum substrate utilization rate (k)	= 1.75 kg COD $_{removed}$/kg VSS day
The half saturation constant (K_L)	= 1.53 kg COD/kg VSS day
The yield coefficient (Y)	= 0.08 kg VSS/kg COD $_{removed}$
Sludge decay coefficient (K_d)	= 0.06 day $^{-1}$

Substantial quantity of bio gas generated from the anaerobic digestion of rubber effluents and it was found to be dependant on the loading rate of effluent into the digester. Biogas yield ranged between 0.27 l/g COD (HRT = .75 days) and 0.73 l/g COD (1.16 days)

Determination of the above constants and coefficients for raw rubber process effluents are quite important in designing anaerobic digesters for the treatment of rubber effluents.

[VSS (Volatile Suspended Solids) is measure of bacterial sludge concentration generates during digestive process of effluents]

A kinetic study of a combined anaerobic-aerobic system for treatment of rubber effluents

The kinetics studies of the rubberized coir filled anaerobic digestion process of the existing crepe rubber effluent treatment plant at Pallegama were carried out using the samples withdrawn from the anaerobic tank at specified time intervals. This is to determine the kinetic parameters at commercial scale rubber effluent treatment plants which are quite important in designing treatment plants to yield optimum treatment efficiencies.

Five different effluent volume loadings per day (21.54m^3, 26.45m^3, 23.7m^3, 25m^3 and 38m^3) with a hydraulic retention times (HRT) ranging from 0.14 to 0.185 days at an average influent chemical oxygen demand (COD) concentration of 1.99/l were studied to estimate the kinetic coefficients.

Following results were obtained;

The maximum substrate utilization rate (k)	= 0.92 kg COD $_{removed}$/kg VSS day
The half saturation constant (K_L)	= 1.24 kg COD/kg VSS day
The yield coefficient (Y)	= 0.14 kg VSS/kg COD $_{removed}$
Sludge decay coefficient (K_d)	= 0.16 day $^{-1}$

In the investigation of aerobic kinetic performance of the same plant, the crepe rubber effluent from an anaerobic tank outlet and an aeration tank outlet were subjected for the analysis. Five different feeding rates were selected to obtain five different runs with distinct mean cell residence times (MCRT) for the determination of kinetic coefficients.

Following kinetic parameters of the aerobic digestion stage of the ETP were determined and given as below;

Maximum rate of specific substrate utilization	= 1.61 d^{-1}
Half velocity constant	= 65.1 mg/L
Maximum yield coefficient	= 3.34 mg VSS/mg BOD
Endogenous decay coefficient	= 5.54 d^{-1}
Maximum specific growth rate	= 11.23 d^{-1}

Overall treatment efficiency of each parameter was calculated by considering raw effluent and final discharge values of the treatment plant.

The overall COD and BOD removal efficiencies of the ETP are above 90% during the monitoring periods with little fluctuations under slightly different loading rates and different hydraulic retention times. Similarly, all other removal efficiencies such as Total Suspended Solids (TSS), Total Solids (TS), Total Nitrogen, Total Ammoniacal Nitrogen (TAN), Sulphides were quite satisfactory.

All the above effluent quality parameters of the treated effluent are lower than the regulatory standard limits stipulated by the CEA. These results indicate that the treatment system based on high rate anaerobic coupled aerobic treatment system is quite satisfactory to treat the effluent discharged from crepe rubber factory at Pallegama estate (W M G Seneviratne, M Rajasinghe - MSc student in Agriculture Microbiology, University of Colombo).

ADAPTIVE RESEARCH

V H L Rodrigo and S M M Iqbal

SUMMARY

Awareness programmes on soil conservation and fertility management were conducted along with the fertilizer distribution to smallholders in Mahaoya and Padiyathalawa in Eastern province. Feasibility study on growing exotic plants with rubber was initiated in Kuruwita substation. A new experiment to assess the impact of branch induction in immature rubber was established in Polgahawela sub-station. An experiment to assess the impact of late planting in the intermediate zone was established together with rubber/sugarcane intercropping demonstration in Monaragala sub-station. Effectiveness of new wild boar repellents developed by the Plant Pathology and Microbiology Department was under investigation at Polgahawela sub station and few smallholdings in Kegalle region. Nectar flow assessment in major rubber clones was repeated. In situ evaluation on smallholder intercropping practices was commenced. Poor trading affected selling of anthurium flowers. Centennial clones of RRISL were introduced to Eastern province.

DETAILED REVIEW

Staff

Dr V H L Rodrigo coordinated the activities of this unit. Dr S M M Iqbal (Agronomist), Assistant Agronomists Mr W A D D S Wettasinghe, Mrs B M D C Balasooriya, Mrs E S Munasinghe, Experimental Officer Mr E A T Senadheera (in substation Polgahawela) and Account Clerk Mrs C Weeramanthree (in substation Polgahawela) were on duty throughout the year. Mr A M C P Jayawardana, a Temporary Field Assistant of Moneragala substation was on duty only upto the end of the third quarter of 2009. Mr J Prasanna, Temporary Technical Assistant of Nagenahira Navodaya project was on duty up to 10th July 2009. Mr P Udayakumara and Mrs N A A S Nallaperuma were on duty throughout this year as a Temporary Technical Assistant under the NSF/2005/AG/14 and NSF/2008/AG/02 projects respectively.

Seminars/Training/Workshops/Exhibitions conducted

Officer/s	Subject/Theme	Beneficiary/Client
SMM Iqbal	A lecture on mixed cropping systems under rubber	Undergraduates of the Sabaragamuwa University, Sri Lanka
	A lecture on mixed cropping systems under rubber	Students of National Institute of Plantation Management
	Workshop on planting of rubber, field demonstration and fertilizer application	Rubber smallholders of Padiyathalawa and Mahaoya, Ampara district
WADDS Wettasinghe	Practical training programme on rubber cultivation	Students of Agriculture Farm School, Ratnapura

Seminars/Training/Workshops/Meetings/Conferences attended

Officer/s	Subject/Theme	Organization
SMM Iqbal	Ten day training course on translation at the National Institute of Language Education and Training	National Institute of Language Training and Education
SMM Iqbal	Presented a working paper on 'Expansion of rubber cultivation in the Eastern province' at the Research Committee of NSF	NSF
SMM Iqbal	Presented a paper on Technology refinement to cater the smallholder needs. Centennial Rubber Conference, RRISL, Hilton Colombo, Sri Lanka, 12th and 13th May 2009	RRISL
ES Munasinghe	Climate Change Awareness Programme conducted by Ministry of Environment and Natural Resources	Ministry of Environment and Natural Resources
ES Munasinghe	Workshop on Handling of Research Data	NASTEC
SMM Iqbal, VHL Rodrigo ES Munasinghe	Presented a poster on 'Planting rubber in Eastern Province: A potential venture under CDM' at the Conference on Global Climate Change and its Impacts on Agriculture, Forestry and Water in the Tropics	Ministry of Environment and Natural Resources
VHL Rodrigo & ES Munasinghe	Presented a paper on 'Potential monitory gain through rubber cultivation for its contribution to mitigate the climate change' at the Conference on Global Climate Change and its impacts on Agriculture, Forestry and Water in the Tropics	Ministry of Environmental and Natural Resources

Officer/s	Subject/Theme	Organization
VHL Rodrigo & ES Munasinghe	Presented a research paper titled "Rubber based forestry for timber and carbon markets; yield tables under Sri Lankan conditions" at the National Forestry Research Symposium 2009	Forest Department of Sri Lanka
VHL Rodrigo, SMM Iqbal, ES Munasinghe & BMDC Balaooriya	Workshop on rubber – cocoa intercropping	IFAD

Visits

Experimental visits - 127

Advisory visits - 22

FIELD INVESTIGATIONS

Adaptive Research Programme

***Beekeeping in rubber plantations* (ARU/BK/2004/1)**

Few new bee colonies were introduced in January 2009 and total number of bee colonies introduced under mature rubber, absconded and available at Dartonfield/RRISL and Kuruwita substation are given in Table 1.

Table 1. *Details of the bee colonies available at Dartonfield and Kuruwita substation*

Site	Wooden boxes				Clay pots				Kithul logs
	As at Jan 2009	Introduced	Absconded	As at Dec 2009	Introduced	As at Jan 2009	Absconded	As at Dec 2009	As at Dec 2009
Dartonfield	5	5	7	3	-	2	1	1	-
Kuruwita	10	3	11	2	3	3	4	2	1

Artificial feeding with sugar was carried out in wooden boxes during the dearth period. Twenty two colonies were absconded in the mid of the year due to the wax moth infestation and one colony at Kuruwita was absconded due to settlement of Kanawe bee (*Trigona irripendis*) (Table 1).

Nectar production in different rubber clones

Data collection on seasonal variation of the nectar flow of clones RRIC 100, RRIC 121 and RRIC 102 was repeated for the fourth year at Kuruwita substation from February to April 2009. All the leaves of selected branches in the trees were covered with polythene to avoid any rain driven wash off of honey and the data collection procedure was as same as the previous year. The period recorded for nectar flow was 33 days in RRIC 100, 39 days in RRIC 121 and 43 days for RRIC 102 (Table 2).

Table 2. *Details of nectar flow production in clones RRIC 100, RRIC 121 and RRIC 102 at Kuruwita sub-station*

Clone	Nectar flow period (days)	Nectar flow volume (µl/day/petiole)	Sugar concentration of nectar (%)
RRIC 100	33	4.27	6.25
RRIC 121	39	4.02	10.07
RRIC 102	43	3.67	5.33

(W A D D S Wettasinghe, S M M Iqbal, V H L Rodrigo in collaboration with the University of Ruhuna).

***Expansion of rubber cultivation to Eastern province* (ARU/RCEP/2004/1)**

Objectives and the initial approach taken to establish rubber in this region appeared in Annual Review 2004.

In brief, main activities conducted during the year were,

- Priority was given for infilling the casualties in 2008 planted fields affected by the severe drought recorded high for over 20 years. New planting of rubber was undertaken only in 5 ha.
- Assessment of photosynthetic performance of rubber leaves.
- Soil moisture measurements during dry spell.
- Leaf chlorophyll a fluorescence emission *(Fv/Fm)* of rubber leaves.
- Monthly assessments of rubber growth.
- Recording of daily rainfall.
- Workshops on planting practices, mulching and fertilizer application for smallholders in Padiyatalawa and Mahaoya region.
- Collection of leaf and soil samples for nutrient analysis.
- Installation of Wet and Dry bulb and Maximum Minimum thermometers in Komana village at Padiyatalawa.
- Land selection and identification of farmers for the rubber cultivation in 40 ha.

- Newly recommended centennial clone was planted in a smallholding of Mahaoya region.

Rainfall measurement

Daily rainfall was monitored from June 2006 onwards using a rain gauge installed in a smallholding of Komana village. According to the rainfall data collected during the trial period (Fig. 1), total rainfall received during the year 2007, 2008 and 2009 was 1167mm, 2529mm and 618mm, respectively. There was a distinct dry period from May to September showing rather unimodel rainfall pattern in the area. The highest rainfall of 457mm was received in the month of January 2008 whilst the lowest of 5mm recorded in May 2009, if rainy months are considered. Virtually, there was no any rain in the month of June in 2009. Average rainfall per month was 138 mm during the study period.

Growth of rubber

Annual girth data of the rubber trees in 20 sites established in 2003, 2004, 2005 and 2006 was plotted against the time. The fitted model to the girth data showed a marginal increase growth rate with time. However, assuming a linear growth during the study period, annual average girth expansion rate of 7.35 cm was observed (Fig. 2).

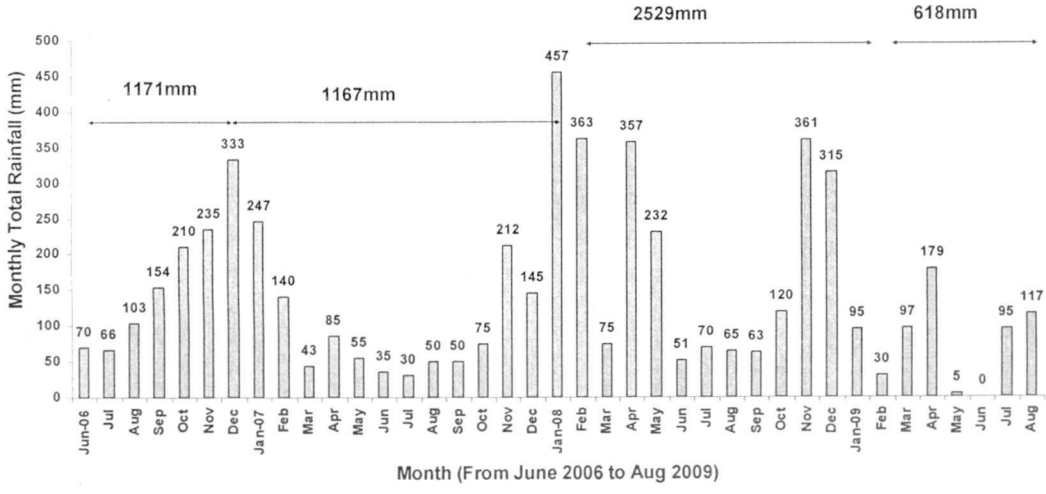


Fig. 1. Monthly rainfall distribution in Komana village, the centre village for rubber cultivation in Eastern province. Total rainfall received in different calendar years of the study period is shown above the graph

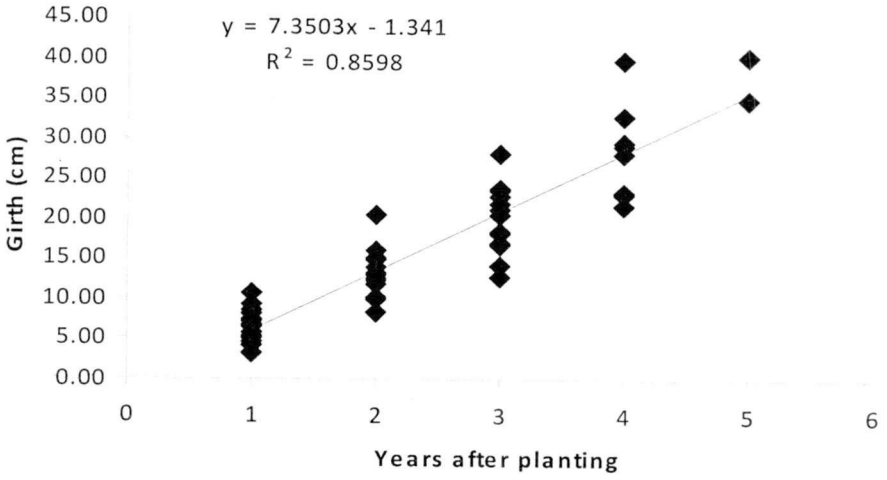


Fig. 2. Girth development of the rubber plants in 20 sites established in the intermediate zone of Eastern Province in 2003, 2004, 2005 and 2006. The model fitted assuming linear girth expansion rate of rubber is also shown

[S M M Iqbal, V H L Rodrigo, R S Dharmakeerthi, K B A Karunasekera, A Nugawela and P K W Karunathilaka. In collaboration with Rubber Development Department. This project is jointly funded by Negenehira Navodaya programme (MPI) and NSF/2005/AG14].

Polgahawela Sub-station **(ARU/RCWP/2005/1)**

Expansion of rubber cultivation in Wayamba region (North Western Province)

New planting rubber

Rubber was planted in one hectare of land with RRISL 2004 and centennial clones. SALT system was introduced using Gliricidia as a soil conservation method.

Management of wild boar damages in rubber

Wild boar repellents recently developed by Plant Pathology and Microbiology Department were applied on rubber trees for testing in the 2005 clearing of the substation and two smallholdings in Kegalle area. Details were presented under the report of the Plant Pathology and Microbiology Department. Out of 750 trees treated in the substation, 15 were damaged by wild boars three weeks after application.

Branch induction experiment

An experiment on branch induction was set up with clone RRIC 121 in 2008 clearing. Objective of this study is to assess the effect of artificial branch induction on growth and development of rubber plant. Plant growth in terms of tree girth was periodically monitored under four categories, *i.e.* naturally branched, unbranched,

artificial branched trees and naturally branched lately in the category of unbranched. In addition to plant girth, number of branches, branching height and number of branches in the first branching point were assessed. Branch induction was done in July 2009 and it is too early to comment on results (Table 3). In addition, branching habit and its relation to plant growth was assessed in the rubber clearings planted in 2005-7. Unbranched trees were generally poor in growth (Table 4, 5 & 6), however detail analyses are required to assess the effect of artificial branching on plant growth.

Table 3. *Growth of rubber plants with branch induction in the tree planted in year 2008*

	Average girth (cm)	**Girth increment (cm/month)**
Artificially induced	10.22	0.62
Naturally branched (one year after planting)	11.42	0.68
Naturally branched (late -18 months after planting)	8.96	0.60
Not branched	6.5	0.50

Table 4. *Relationship between branching height and girth of the tree planted in year 2005*

Branching height	**Average girth (cm)**	**% of trees**
Up to 10 feet	36.80	58.35
11' to 15'	36.95	36.65
16'to 20'	37.22	4.14
Above 20'	-	-
Not branched	30.93	0.87

Table 5. *Relationship between branching height and girth of the tree planted in year 2006*

Branching height	**Average girth (cm)**	**% of trees**
Up to 10 feet	25.45	51.33
11' to 15'	25.68	32.68
16'to 20'	25.27	14.27
Above 20'	25.77	1.09
Not branched	22.66	0.62

Table 6. *Relationship between branching height and girth of the tree planted in year 2007*

Branching height	Average girth (cm)	% of trees
Up to 10 feet	13.34	73.12
11' to 15'	16.24	22.58
16'to 20'	14.20	0.54
Above 20'	15.07	1.61
Not branched	10.20	2.15

Upkeep of crops

General maintenance of rubber/banana and rubber/cinnamon intercrops and also of, cashew and pineapple were done. The second harvest of cinnamon planted 2005 clearing was done. Harvests made in subsidiary crops with the income are shown in Table 7. In total, it was possible to generate an income of Rs.324,185/= during the year.

Awareness programmes on rubber cultivation

An awareness programme was conducted for the smallholders in Polgahawela area with the collaboration of RDO/Polgahawela.

General maintenance

Renovation of the retention wall of the 'U' bent of the internal road was completed.

A new gate was fixed to the estate entrance. Fencing along the boundary of the estate was partly completed.

Table 7. *Yield and income status of banana, pineapple and coconut in Polgahawela substation*

Crop	Yield	Income (Rs)
Banana	958 (bunches)	196,570.00
Pineapple	452 (fruits)	12,050.00
Coconut	1426 (nuts)	16,428.00
	15 kg (copra)	1,020.00
	38 (trees uprooted)	38,760.00
Old rubber	Contract tapping on 500 trees	29,355.00
Cinnamon	(C4 grade 84kg, Rough 05kg and low grade 10kg)	30,002.50

(V H L Rodrigo, S M M Iqbal, B M D C Balasooriya and E A T Senadeera in collaboration with all biological departments of RRISL).

***Monaragala substation* (ARU/RCMR/2006/1)**

Following activities of the estate were in progress.

- Due to the unsatisfactory progress, the contract given on construction activities of the office building was terminated. Thereafter, construction activities began with direct involvement of the RRISL's staff and only the labour contracts were given out. A committee was set up representing all relevant department and sections under the direct supervision of the Director for progress monitoring.
- Mr N Gunaseela, Field Assistant was transferred from Kuruwita to Moneragala on temporary basis to undertake the ground supervisory activities in the sub-station.

Rubber/Sugarcane intercrop - Experiment on planting time (ARU/RS/2009/1)

A demonstration plot (2.09 ha) with rubber/sugarcane intercropping was established in Moneragala sub-station with the assistance of the Palwatta Sugar Industries Ltd. In total, 1136 rubber plants of clone RRIC 121 and 17 MT of M 438/60 and SL 8306 varieties of sugarcane were established in this plot. Within this demonstration plot, a field experiment was set up to examine the impact of late planting on growth and development of rubber plants in the intermediate zone. Experiment comprises six main treatments of planting time points. First one was at the beginning of Maha season (on 27/10/2009) and thereafter in every two weeks. As planting season delayed due to the delay in rainy season, last set of planting was undertaken in the first week of January 2010. Two types of planting material *i.e.* one and two leaf whorl rubber plants, were planted with split plot arrangement in an overall plot size of 580 m^2 (sub plot size is 290 m^2). Main treatments were replicated in four experimental blocks.

Growth parameters such as girth and height, leaf count and average leaf area per plant were obtained just after the planting. Also soil samples were taken for the assessment on soil moisture. Further, plant establishment in terms of survival rates was recorded (V H L Rodrigo, S M M Iqbal and E S Munasinghe).

***Assessment of different farming systems practiced in the smallholder sector* (ARU/FSSH/2009/01)**

An adaptive research experiment was commenced to identify the level of deviation from recommended agronomic practices in intercropping under smallholder condition and their impact on growth and productivity. It is expected to assess all principal intercropping systems such as, rubber - cocoa, rubber - banana, rubber - pineapple and rubber - cash crops. In the initial step, only the rubber - pineapple intercropping system was considered.

Intercropping pineapple is recommended during the immature phase of rubber. Two rows of pineapple are recommended between two rows of rubber. However,

several other systems which deviate from the recommended spacing were observed. Of these systems, depending on the land type and ownership, there were two to four double rows of pineapple between two rows of rubber.

In sloped lands, farmers have grown two double rows of pineapple between two rubber rows while most of the contract farmers have practiced even four double rows of pineapple (high density planting system of pineapple).

Distribution of different systems among 17 smallholdings surveyed in Hanwella, Dompe and Kosgama areas are given in the Table 8.

Table 8. *Distribution of different pineapple growing systems*

System	No. of smallholdings
Two double rows	2
Three double rows	5
Four double rows	10

Mature rubber fields, which have been intercropped with pineapple during the immature phase, were also assessed in the study. Also ten immature rubber smallholdings, which were not intercropped, were assessed as the control.

Girth variation of rubber plants in different systems planted in year 2005, 2006, 2007 and 2008 is given in Fig. 3.

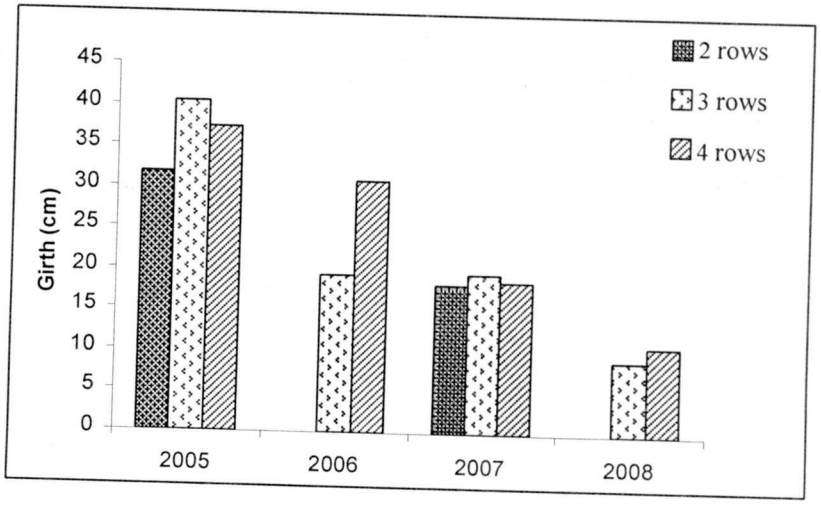


Fig. 3. Mean girth of rubber plants among different pineapple planting systems. Data have been grouped according to the planting year (15 smallholdings were considered)
(B M D C Balasooriya, E S Munasinghe, V H L Rodrigo and S M M Iqbal)

Anthurium culture under mature rubber **(ARU/AC/2004/1)**

Number of flowers harvested during the year in both Dartonfield and Kuruwita estates is shown in the Table 9. Mite infestation on flowers was very severe in both sites. A locally produced neem seed extract, 'Paribhadra', 25 ml/litre was sprayed to control mites. Due to the poor control of mites infestation by the Paribhadra, spraying of wettable Sulphur (Thiovit) 40g/gallon was carried out in weekly intervals for one month. Poor export trading affected selling of flowers during the 2nd quarter of 2009.

In addition to general maintenance, the following activities were carried out.

- Quality assessments of flowers (Table 10). Quality of flowers was in acceptable level with the majority in large flower size category. (See Table 11 of standard measurements for comparison).
- In addition, 50 plants of "tropical" anthurium under 70% artificial shade net was included as the control quality assessments of flowers. Rate of flowering was assessed with weekly measurements (Table 10).

Diurnal variation of light saturated rate of photosynthesis (A_{max}) in 'Tropical' anthurium plants was assessed with the plants grown under mature rubber of RRIC 100, RRIC 121 and under an artificial shade net at Dartonfield during the dry period, January (Table 13). Diurnal variation of F_v/F_m ratio also was monitored (Table 14). A_{max} was comparatively lower in the afternoon than in morning hours and this was common to all shade categories. However, within these measurements, anthurium planted under shade net showed higher values of A_{max} in morning hours (Table 13). The values of F_v/F_m ratio were greater in morning and in afternoon compared to the mid day under the two clones tested. In most occasions, F_v/F_m ratio was above 0.7.

Table 9. *Flower production in anthurium (Tropical Red) under rubber*

Site	No. of flowering plants	Flowers damaged (physical)	Flowers damaged (by thrips)	Total flowers harvested
Dartonfield	2208	963	2190	5887
Kuruwita	148	92	146	423

Table 10. *Mean dimensions of anthurium flowers under rubber*

Site	Flower length (cm)	Flower width (cm)	Stalk length (cm)
Kuruwita (Under rubber)	8.25	11.24	34.66
Dartonfield (Under rubber)	6.75	10.07	33.99
Dartonfield (Under shade net)	7.42	10.55	37.58

Table 11. *Standard measurements of anthurium flower*

Flower size	Flower width(cm)	Stalk length (cm)
Small	7.5-8.75	>30 cm
Medium	7.5-10	>30 cm
Large	>10	>30 cm

Weekly assessment of rate of flowering of anthurium was done (Table 12).

Table 12. *Assessment of rate of flowering of anthurium*

Site	Total No. of flowers	Average No of flowers/pot/year
Kuruwita (Under rubber)	205	5
Dartonfield (Under rubber)	220	5
Dartonfield (Under shade net)	121	5

Table 13. *Diurnal variation of photosynthesis in anthurium ($\mu mol\ m^{-2}\ s^{-1}$)*

Anthurium under the shade of,	Morning	Midday	Evening
RRIC 100	2.758±0.204	1.853±1.059	0.928±0.164
RRIC 121	2.212±0.340	1.953±1.174	1.033±0.446
Shade net	3.318±0.756	1.398±0.531	1.142±0.108

N= no. of samples= 03

Table 14. *Diurnal variation of F_v/F_m ratio in anthurium*

Treatment	Morning	Midday	Evening
RRIC 100	0.787±0.010	0.597±0.105	0.726±0.048
RRIC 121	0.781±0.015	0.528±0.141	0.737±0.084
Shade net	0.778±0.016	0.753±0.030	0.767±0.200

N= no. of samples= 10

(W A D D S Wettasinghe, S M M Iqbal and V H L Rodrigo)

***Identification of suitable species and genotypes for cut foliage and flower production in rubber lands* (ARU/AC/2008/1)**

Details of the project appear in the Annual Review of 2008. Two experiments were lying under this study.

Experiment 1: *Planting systems of foliage under immature rubber plants*

Immature replanting of 0.82 ha (1986 RP) was selected at the estate of RRISL substation, Kuruwita at Ratnapura district. Rubber was planted on the system of avenue planting at 8' x 27' (*i.e.* 2.4m x 8.1m).With the gap of 8.1 m between two rows of rubber, foliage plants were incorporated leaving 2.4m on each side for intercultivation activities of rubber (3.3m).

Experiment design: 04 planting systems with 3 replicates under Complete Randomized Design

System 1: Multiple cropping systems (Cane palm, Croton and Polycia with rubber)
System 2: Cane palm with rubber
System 3: Croton with rubber
System 4: Polycia with rubber

For standardization of mix planting systems in experiment 1, sole crops of cane palm, croton and polycia were established in separate plots under rubber and also as sole crops.

Experiment 2: *Planting systems for foliage and flower plants under mature rubber*

This experiment was carried out in parallel to the experiment 1. Mature replanting of 1ha (1993 RP) was selected from the same estate, RRISL substation Kuruwita. Rubber had been planted with the same spacing of 8' x 27' (*i.e.* 2.4m x 8.1m). Between two rows of rubber (8.1m), foliage plants were incorporated leaving 2.4m on each side for intercultivation activities of rubber (3.3m). Anthurium will be tested separately in the shade of mature rubber.

Design: 05 plating systems with 3 replicates under Complete Randomized Design
System 1: Multiple cropping systems (Cane palm, *Dracaena massangeana* and Chinese grass with rubber)
System 2: Cane palm with rubber
System 3: *Dracaena* with rubber
System 4: Chinese grass with rubber
System 5: Anthurium with rubber

For standardization of mix planting systems in experiment 2, sole crops of *Dracaena massangeana* and Chinese grass established in separate plots. Anthurium will be established under artificial shade of 70%.

Light measurements were undertaken to assess the light availability under mature rubber field using Ceptometer on a sunny day in January 2009 (Table 15). The light intensity recorded under mature rubber was 27%.

Table 15. *Light penetration through the mature rubber canopy (n = 50)*

Plot no	Average light intensity µmol m^{-2} s^{-1} (under rubber)	Average light intensity µmol m^{-2} s^{-1} (open area)	% of light intensity under rubber
1	206	1250	16.48
2	310	1260	24.60
3	412	1265	32.57
4	518	1249	41.47
5	532	1230	43.25
6	238	1235	19.27
7	364	1300	28.00
8	262	1280	20.47
9	258	1250	20.64
10	379	1290	29.38
11	206	1150	17.91
12	465	1350	34.44
Average	**346**	**1259**	**27.37**

Two applications of fertilizer were done in these two experiments.

First application - 3:2:1 (N:P:K ratio) - 28th July
- For Croton - 10g/plant
- For Cane palm and *Dracaena massengiana* - 20g/plant

Second application - 1:2:1 (N:P:K ratio) - 3rd September
- For Croton, Polyscia - 10g/plant
- For Cane palm and *Dracaena massengiana* - 20g/plant

One applications of Dolomite - 9th October
- For Cane palm and *Dracaena massengiana* - 10g/plant
- Other all plants - 5g/plant

One spraying of Albert solution (5g/gallon)
- For Croton and Polyscia

Cement pots were purchased for the establishment of the Anthurium. Tissue cultured anthurium plants of Tropical Red variety were brought to Kuruwita Sub Station in August 2009. However, most of them were affected by a pathogen. Yellowing of leaves and root rot were observed. About 75% of the plants have succumbed to this disease. However, the supplier agreed to replace the affected plants after an inspection. HORDI and Department of Agriculture, Peradeniya confirmed that this is due to a bacterial disease (Anthurium blight). Although several fungicides and antibiotics were sprayed, there was no success delaying the establishment of anthurium.

Rabbit attack on the Cane palm was detected. This was controlled by fencing with mosquito net. Termite attack was noticed in Cane palm plants and 5g Carbofuran per plant was applied around the plant (S M M Iqbal, W A D D S Wettasinghe, V H L Rodrigo and N A A S Nallaperuma. This project is funded by the NSF under the grant no RG/2008/AG/02).

***Assessments of different tapping systems practiced in the smallholder sector* (ARU/TSPSH/2005/1)**

This study was extended to assess different tapping systems practised under smallholder conditions in non-traditional areas of the country. Fifteen sites in Moneragala district were assessed for tapping quality parameters. Also, seasonal variation of latex yields was monitored for about one year and social information of smallholders was gathered through structured interviews.

In all sites observed in non-traditional rubber growing areas, the bark consumption rate was over the expected level. None of the farmers had used a stencil to mark tapping guidelines; hence, tapping cut lengths were not properly maintained. Tapping angle was found correct only in 20% sites. The depth of tapping cut was reasonably good in 67% sites. Spouts were available in most of the sites (93%); however their placement was correct only in 67% (Table 16). Placement of cups was poor (13%) due to unavailability of cup hangers.

Table 16. *Summary of the tapping quality assessment in fifteen sites in non-traditional rubber growing areas. For each parameter, sites with over 80% trees were correct, were considered as good*

Status of the quality of tapping system	Guide line	Tapping angle	Depth of the cut	Length of cut	Bark consumption	Cup hangers	Placement of cups	Spouts	Placement of spouts
Good	0	3	10	3	0	4	2	14	10
Poor	15	12	5	12	15	11	13	1	5

(E S Munasinghe, V H L Rodrigo and S M M Iqbal)

Economical assessment of environment benefits of rubber crop under different cropping systems with special emphasis on carbon sequestration (ARU/CS/2003/1)

A benefit-cost analysis was carried out using the estimated costs and benefits under different scenarios of rubber cultivation. Thereafter, financial and economic viability of the rubber cultivation under each of these scenarios were tested using the standard criteria such as Net Present Value (NPV), Internal Rate of Return (IRR) and Benefit-Cost Ratio (BCR) (Table 17a & b). Accordingly, rubber cultivation was found

to be more viable at national level than that of the farmer level. Inclusion of carbon values and intercrops (tea and banana) increased the financial/economic viability by *ca.* 6% and *ca.* 60%, respectively.

Table 17a. *Summary of financial analysis of the rubber cultivation under different scenarios*

Scenario	NPV (Rs./ha)	IRR	BCR
• **SC1**	1,660,752.00	22%	1.44
• **SC2**	1,632,699.00	23%	1.43
• **SC3**	1,759,284.00	23%	1.47
• **SC4**			
Tea	3,005,557.00	28%	1.42
Banana	2,699,037.00	84%	1.66
• **SC5**			
Tea	2,285,919.00	28%	1.42
Banana	2,670,904.00	84%	1.65
• **SC6**			
Tea	3,074,529.00	28%	1.43
Banana	2,797,569.00	84%	1.68

Table 17b. *Summary of economic analysis of the rubber cultivation under different scenarios*

Scenario	NPV (Rs./ha)	IRR	BCR
• **SC1**	3,948,082.00	34%	2.32
• **SC2**	3,917,737.00	34%	2.31
• **SC3**	4,025,430.00	34%	2.35
• **SC4**			
Tea	6,484,492.00	38%	1.97
Banana	4,868,591.00	102%	2.49
• **SC5**			
Tea	6,462,918.00	38%	1.97
Banana	4,838,247.00	102%	2.48
• **SC6**			
Tea	6,526,995.00	38%	1.98
Banana	4,945,939.00	102%	2.52

SC1: Business as usual – Revenue is from latex and the sale of the whole tree at the end of 30 years

SC2: Rubber for forest planting – Revenue is from latex and the sale of carbon fixed in the whole tree, in latex and in litter fall

SC3: Commercial planting in new areas – Revenue is from latex, sale of whole tree at the end of 30 years and sale of carbon fixed in timber, in latex and in litter fall

SC4: Rubber with farming systems – Revenue is from latex, sale of whole rubber tree at the end of 30 years and intercropping

SC5: Planting rubber in participatory forestry programmes – Revenue is from latex, intercropping and sale of carbon fixed in whole rubber tree, in latex and in litter fall

SC6: Commercial planting of rubber in new areas with intercropping systems – Revenue is from latex, intercropping, sale of whole rubber tree at the end of 30 years and sale of carbon fixed in timber, in latex and in litter fall

The smallholder survey conducted to determine the present status and distribution of rubber based intercropping systems within the rubber growing areas of the country revealed that the majority (87%) of intercropped lands were below 1 ha. Banana was the most popular companion crop of rubber among farmers (54%). The greatest number of smallholders practicing intercropping was in Kegalle region (36%) covering 44% of the total intercropped land area.

The major socio economic factors governing the profitability of two most widely adopted rubber based intercrops, *i.e.* banana and tea cultivation in smallholdings were identified. Cropping intensity and total land extent of banana owned by the farmer, type of employment and education level of the farmer affect mostly the profitability of banana cultivation in rubber lands (Model 1). Key factors underpinning the profitability of tea intercropping were cropping intensity of tea, availability of labour and total land extent belongs to the farmer (Model 2).

Profitability (banana)	= 13291 + 11.62 x cropping intensity of banana + 3735 x self employed – 11038 x primary education – 11775 x secondary education – 11523 x tertiary education – 3219 x total land extent of banana	**Model 1**
Profitability (tea)	= 14754 + 14.74 x cropping intensity of tea – 24205 x scarcity of labour - 4528 x total land extent	**Model 2**

(E S Munasinghe and V H L Rodrigo in collaboration with the University of Sri Jayewardenepura)

Interplanting of rubber lands with tea

Productivity in rubber/tea systems - Gallewatta/Dartonfield (ARU/TRIC/1990/2)

The study was extended to different sites having rubber/tea intercrop other than Dartonfield/RRISL in order to collect commercial yield data for tea under rubber. Tea yield under both mono- and inter-cropped conditions was collected. Data analysis to develop a yield profile for tea in the rubber /tea system was in progress (S M M Iqbal).

BIOMETRY

Wasana Wijesuriya

SUMMARY

Research support was provided by the Biometry section to other departments on requests such as; experimentation, data analysis, interpretation of results and database management. Staff of the Biometry section was involved in research focusing on biometrical aspects, especially on development and modification of statistical methodologies to suit the needs of the rubber sector. Several new areas were explored to address limitations in handling short non-stationary time series and fitting boundary lines to data. Two applications on GIS were carried out; *viz.* developing land suitability maps and introducing a decision support system for plantation management. Databases were satisfactorily maintained during the year under review on meteorological data collected at the meteorological station at Dartonfield, auction prices of rubber and information on research personnel and projects of RRISL. The study on 'Sustainability of the smallholder rubber sector in the Moneragala district' was completed during the year under review.

DETAILED REVIEW

Staff

Dr (Mrs) Wasana Wijesuriya (Biometrician) and Experimental Officers, Mrs Chintha Munasinghe and Mr Vidura Abeywardene were on duty throughout the year. Mr Keminda Herath completed his MSc in Statistics at Virginia Poly Tec University in USA and commenced his work in the Biometry section on the 12th January.

Research students

- Mr S B Karunaratne of the Postgraduate Institute of Science completed his postgraduate research leading to MSc under the supervision of Dr (Mrs) Wasana Wijesuriya and Dr Jagath Gunathilake. His dissertation was titled "Modeling land suitability for expansion of rubber cultivation in Moneragala district: A GIS approach".
- Mr A C Dissanayake of Faculty of Agriculture, University of Peradeniya completed his undergraduate research work under the supervision of Dr (Mrs) Wasana Wijesuriya and Dr A Nugawela.
- Ms Dinithi Kannangara from the University of Ruhuna and Mr Isuru Senadheera from Wayamba University have completed their undergraduate research components under the guidance of Dr (Mrs) Wasana Wijesuriya and Mr Keminda Herath.

Seminars/Conferences/Meetings/Workshops attended

Officer	Subject	Organization
Wasana Wijesuriya	Research coordination meeting (RCM) of the Coordinated Thematic Research Programme (CTRP)	National Science Foundation (NSF)
	Steering committee of the Senior Scientists' Forum	National Science and Technology Commission (NASTEC)
	National statistical conference	Applied Statistics Association of Sri Lanka
	Workshop on mainstreaming climate change for sustainable development in Sri Lanka	Institute of Policy Studies
	Committee on implementation of SAARC action plan on climate change	Climate change secretariat, Ministry of Environment & Natural Resources
	Stakeholder workshop on SAARC action plan on climate change	Climate change secretariat, Ministry of Environment & Natural Resources
Keminda Herath	AGRES 09 - 9th Agricultural Research Symposium	Wayamba University of Sri Lanka

Seminars/Conferences/Meetings/Workshops addressed

Officer	Subject	Organization
Wasana Wijesuriya	Climate change impacts of plantation crops: Rubber sector	CDM study centre, Faculty of Agriculture, University of Peradeniya
	At the conference on global climate change and its impacts on agriculture, forestry & water in the tropics	
	Yield decline in 2009: Impact of weather conditions at the 24th Scientific Committee Meeting	Rubber Research Institute of Sri Lanka

Services

Statistical analysis and interpretation

Designing of experiments, statistical analyses and interpretation of experimental results were among the key services of the Biometry section rendered to research departments. This service was also extended to undergraduate and postgraduate students of different Universities supervised by scientists of RRISL (W Wijesuriya and K Herath).

Database management

Meteorological

The database with daily meteorological data collected in the meteorological station at Dartonfield was properly maintained. Reports were prepared from this daily database and sent to the Central Meteorological Station. Rainfall records received at the Dartonfield Station were sent to National Building and Research Bureau (NBRO) for issuing warnings on landslides. Rainfall records of substations, *viz.* Kuruwita, Nivitigalakele and Polgahawela were also maintained in a database. These data were made available to researchers and organizations on request. During the year under review a recording type rain-gauge, which transmits rainfall to Central Meteorological Station at hourly intervals was installed at Dartonfield by the Department of Meteorology and Industrial Technology Institute (ITI) (W Wijesuriya, K Herath, C Munasinghe and V Abeywardene).

Auction prices of rubber

The database on auction prices of different grades of rubber was updated for 2009. Some important information derived from this database is given below.

Prices of Ribbed Smoked Sheets (RSS)

The prices of RSS1 in 2009 reached the maximum of Rs.318.60 at the auction on the 22nd December. The minimum was Rs.136.00 in February. Monthly averages showed a steady increase towards the end of 2009 despite of the sharp decline in October 2008 due to the global economic crisis which badly affected the automobile industry, a major consumer of rubber. As can be seen from Fig. 1, the prices have fallen below Rs.150/kg during the early part of 2009, but rose above Rs.300/kg in December.

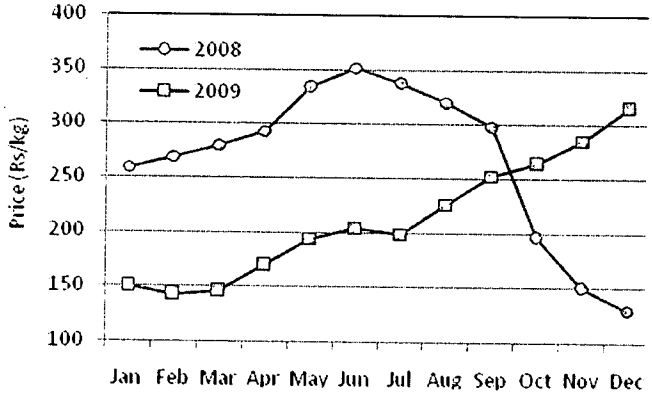


Fig. 1. Monthly variation of auction prices of RSS1 in 2008 and 2009

Prices of Latex Crepe (LC)

The prices of LC1X in 2009 ranged from Rs.127/kg to Rs.345/kg. As observed for RSS1, a steady upward trend was observed for LC1X and reached the peak in November (Fig. 2).

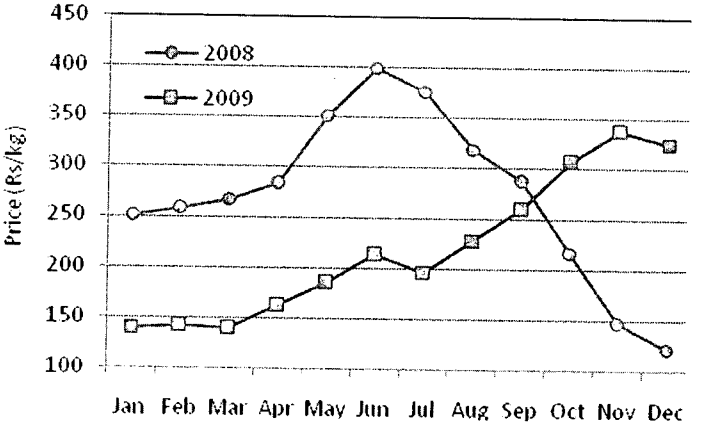


Fig. 2. Monthly variation of auction prices of LC1X in 2008 and 2009

Monthly averages of auction prices for different rubber grades; *viz.* RSS, latex crepe and scrap crepe are given in Table 1.

The changes in monthly average prices for RSS1 and LC1X are presented in Fig. 3. The difference of annual average between LC1X and RSS1 in 2009 was only Rs.3.00/kg. Prices of LC1X were above the RSS1 prices during June and August to December. There was a difference of Rs.51/kg between these two grades in November.

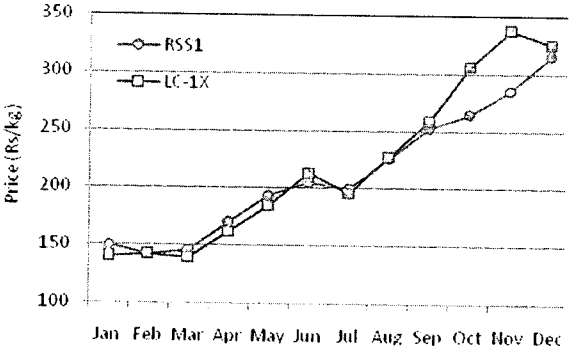


Fig. 3. Changes observed in monthly averages of auction prices for RSS1 and LC1X in 2009

Table 1. *Monthly averages of auction prices for different rubber grades in 2009*

Month	RSS prices (Rs.)					Latex Crepe prices (Rs.)					Scrap Crepe prices (Rs.)			
	RSS1	RSS2	RSS3	RSS4	RSS5	LC1X	LC1	LC2	LC3	LC4	1Xbr	2Xbr	3Xbr	4Xbr
Jan	150	146	141	139	139	140	138	134	132	130	129	130	123	120
Feb	142	140	138	133	129	142	140	135	130	127	124	120	117	115
Mar	145	142	139	137	134	139	136	133	132	123	119	118	118	114
Apr	170	167	164	161	155	162	160	156	155	152	145	139	137	133
May	194	191	189	186	185	185	183	178	175	169	161	158	152	149
Jun	204	203	199	194	188	213	196	189	182	180	178	177	165	163
Jul	199	195	187	184	183	196	189	185	180	172	167	162	156	153
Aug	226	222	219	214	211	228	227	223	221	214	199	179	176	172
Sep	252	246	245	231	225	259	258	253	248	229	218	210	202	198
Oct	264	246	245	231	225	259	258	253	248	229	218	210	202	198
Nov	285	278	272	265	250	337	328	311	306	282	262	254	249	247
Dec	315	297	293	288	278	321	319	313	306	290	284	278	281	279
2009 average	*212*	*206*	*203*	*197*	*192*	*215*	*211*	*205*	*201*	*191*	*184*	*178*	*173*	*170*

RESEARCH

Analysis of project worth: smallholder and estate rubber cultivation

In technical terms the number of years required to recover the investment costs is the "payback period". The present day investment cost of planting rubber ranges from Rs.500,000 to Rs.670,000 and this amount can be recovered after 3 years of tapping (10^{th} year after planting) in the smallholder sector. In the estate sector the initial cost can be recovered after 4 years of tapping (11^{th} year after planting). The average annual profit per ha. after 6 years of planting excluding the sale of old rubber trees in estate and smallholder sectors are Rs.351,517.00 and Rs.454,923.00, respectively. Other indicators of project worth assuming a 10% discount rate in estate and smallholder sectors are given in Table 2. These calculations were based on 2009 values of costs and returns.

The NPV of an investment is the difference between the sum of discounted cash flows, which is expected from the investment and the amount, which is invested. In other words, NPV is an amount that expresses how much value an investment will result in. The positive NPV obtained in this case study suggests planting rubber is a worthwhile investment. IRR is the discount rate that results in a NPV of zero for a series of future cash flows. High Benefit/Cost ratio and the IRR value in both sectors suggest the worthiness of investing on rubber as per present market conditions (Wasana Wijesuriya).

Table 2. *Indicators of project worth (at 10% discount rate) for replanting of rubber in estate and smallholder sectors*

Indicator of project worth	Estate sector	Smallholder sector
Sum of Present Value of Income (PVB)	Rs.3,209,150	Rs.2,920,347
Sum of Present Value of costs (PVC)	Rs.1,346,571	Rs.1,166,461
Net Present Value (NPV) = (PVB-PVC)	Rs.1,862,579	Rs.1,753,886
Benefit/Cost Ratio	2.38	2.50
Internal Rates of Return (IRR)	44.96	46.46

An approach towards sustainable development and economics of the smallholder rubber sector (NSF contract RG/2006/EPSD/01)

This project was funded by NSF under the theme "Environmental protection and sustainable management" of the Coordinated Thematic Research Programme (CTRP). The overall objective of this project was to improve the smallholder rubber sector in the Moneragala and adjacent parts of the Badulla and Ampara districts through sustainable management of environmental, socio-economic, technological and institutional aspects. This is a collaborative project with Ruhuna and Wayamba Universities.

This year the research team was involved in conducting awareness programmes and analysis of questionnaire surveys and participatory studies. Identification and mapping of areas suitable for rubber farming in the Moneragala district were also done during this year.

Questionnaire survey

Questionnaire surveys were done separately for potential rubber farmers and those who own mature and immature rubber lands. In this process, 255 potential rubber farmers and 248 and 143 farmers who own immature and mature rubber lands, respectively were interviewed. Results on socioeconomic characteristics of potential rubber growers were presented in last year's review. Some important findings of surveys done in immature and mature holdings together with 'potential' rubber growers are given below.

There was an indication of the younger generation's preference for rubber cultivation in these areas as the proportion under 50 years of age is more under categories of 'potential' and farmers who own immature holdings compared to farmers who own mature holdings. The education levels of the smallholders were categorized into Primary, Ordinary Level qualified, Advanced Level qualified or higher. More than 50% of the farmers had primary level education (Table 3). This needs to be considered as a constraint in improving the awareness of rubber farmers in the nontraditional rubber growing areas. The higher percentage with a monthly income of less than Rs.10,000 should be regarded as a bottleneck for the adoption of recommended technologies and hence, proper monitoring methodologies need to be adopted in disbursement of subsidies to ensure proper use of funds. The improvement in economic status is evident in the 'mature' category, as a higher proportion of farmers were observed above the income level of Rs.25,000 compared to 'potential' and 'immature' categories (Fig. 4).

Dependency on rubber

The rubber farmers in the non-traditional rubber growing areas, grow different crops (Fig. 5) as a source of income and do not solely depend on rubber. Sixty four percent of the 'potential' rubber farmers and 67% of the farmers who own immature holdings depend on other crops as a source of income. The situation in mature holdings is that, the proportion of farmers solely depend on rubber as the income source is only 13% and 50% of them depend on rubber and other crops.

Table 3. *Household characteristics and educational status*

Characteristic	Categories surveyed		
	'Potential' rubber farmers	Farmers own immature fields	Farmers own mature fields
Size of household	Range: 1-8 Average: 4	Range: 1-10 Average: 5	Range: 1-10 Average: 5
% female smallholders	22	18	13
Age structure (%)			
Under 40 years	34	27	21
40-49 years	35	34	26
50-59 years	26	26	31
60 & above	5	13	22
Level of education (%)			
No schooling	2	0	0
Primary	51	60	54
OL	36	32	34
AL & higher	15	8	12

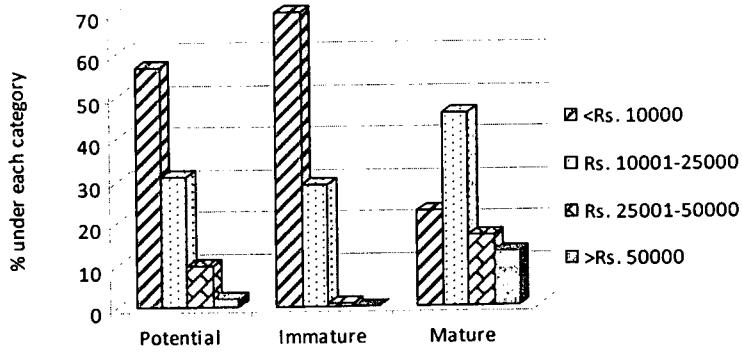


Fig. 4. Income distribution of different categories of rubber farmers

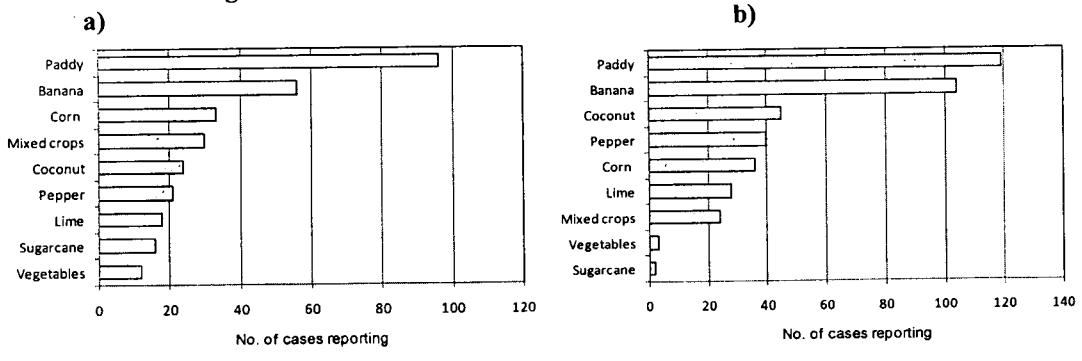


Fig. 5. Different types of crops cultivated by rubber farmers (a) 'potential' rubber farmers (b) rubber farmers

Societal involvements

'*Thurusaviya*' is the farmer organization in operation in the Moneragala area. There is a good indication on societal involvement by 'potential' farmers since 21% of the sample had already taken memberships in this organization even before cultivating rubber. Twenty seven percent of farmers who own immature plantations are members in *Thurusaviya.* Farmers of mature plantations have taken much interest on the societies as 46% hold memberships. However, promotional campaigns on the importance of societal arrangements in different operations of rubber farming, especially marketing need to be arranged to improve the membership.

Awareness on recommendations

Testing awareness on recommendations was done through 'pocket voting'. In this exercise, the farmers read questions one by one and selected the answer and then voted for it by inserting a small card to the relevant envelope. The farmers were categorized into stage of their cultivation (immature or mature) by giving cards of different colours. Finally for each question, the correct answers were counted for each category and awareness on recommendations was calculated as a percentage.

The recommendations were categorized into; a) planting related activities, b) soil fertility management, c) crop upkeep, d) general knowledge on tapping, e) technical knowledge on tapping and f) processing of sheet rubber. To test awareness, the potential rubber growers were sent for questions from (a) to (c) and farmers who own immature holdings were sent from (a) to (e) and farmers who own mature holdings were sent for all the questions.

The awareness scores of different activities in immature stage in the villages are listed in Table 4. The awareness on maintenance of immature fields was found to be the lowest in the selected villages with an average of 19%. Awareness on disease control was also poor indicating an average of 33%. Awareness on other 3 activities; *viz.* planting related activities, intercropping and soil fertility management was moderate, 48%, 44% and 49%, respectively in the selected villages.

Based on the cluster analysis of awareness scores for different activities in selected sites, Gampaha in Haldummaulla divisional secretariat is isolated from all other sites. Hence, a special extension programme is necessary for this area. The rest of the sites can be found in two homogenous groups as depicted in Fig. 6. More emphasis on awareness raising is needed for the sites listed under cluster I; *viz.* Hela Thunkala, Yudaganawa, Batugammana, Pitakumbura, Pallekiruwa, Tenagallanda, Kolladeniya, Rattanadeniya, Siyabalagune, Mantenna, Radaliedda, Badullagammana and Polgahapitiya. However, awareness raising on immature upkeep is a necessity in all the areas.

Table 4. *Awareness on different activities during the immature period of rubber in different villages*

DS Division	Village	% awareness				
		Planting related activities	Maintenance of immature fields	Intercropping	Disorders & Disease control	Soil fertility management
Badalkumbura	Hela Thunkala	44	13	45	12	31
	Lunugala/Kolaniya	46	28	64	38	51
	Kotamuduna	46	43	64	29	50
	Karawila	54	32	63	37	60
	Karandagama	60	41	64	43	65
	Madugahapattiya	66	27	40	57	53
Bibile	Pitakumbura	42	4	27	31	49
	Radaliedda	49	11	51	35	46
	Badullagammana	55	14	43	34	57
Buttala	Yudaganawa	46	14	26	12	43
Madulla	Kolladeniya	32	11	45	42	43
Medagama	Rattanadeniya	47	24	38	36	47
	Polgahapitiya	54	9	43	40	52
Moneragala	Tenagallanda	40	6	38	32	42
	Batugammana	49	21	32	13	54
	Tanwatta	54	37	44	51	58
Wellawaya	Siyabalagune	48	14	39	37	48
Padiyatalawa	Komana	67	24	64	39	59
Haldummmulla	Gampaha	23	5	25	13	27
	Mantenna	44	22	37	29	40
Lunugala	Pallekiruwa	43	2	38	27	53
	Average	*48*	*19*	*44*	*33*	*49*
	Min	*23*	*2*	*25*	*12*	*27*
	Max	*67*	*43*	*64*	*57*	*65*

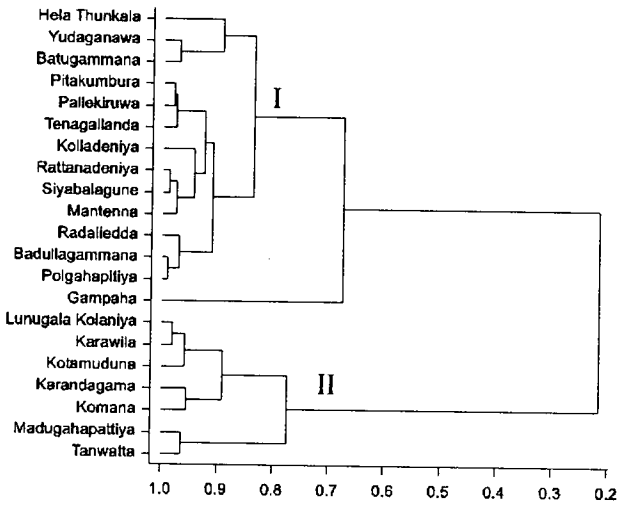


Fig. 6. Dendrogram showing successive fusion of villages based on awareness on activities during the immature phase

Awareness scores of general and technical knowledge on tapping in different villages are listed in Table 5. The awareness on tapping related activities is not adequate in general. More emphasis should be given to the villages clustered under (Cluster I) (Fig. 7) in planning extension activities ([Wasana Wijesuriya, Lalani Samarappuli, Anura Dissanayake, Keminda Herath, D D Dasanayake, A H Kularatne, Kapila Gunaratne, Vidura Abeywardene, P Karunadasa, U Mithrasena, Anoma Thewarapperuma, T Gunathilaka, Susith Rathnayake, R A D Ranawaka, L L A Samarawickreme, R L R U S Bandara, H H Jayasinghe, D R A M G Abeydissanayake, M Dharmadasa, Nihal Gamage, U N Jayasuriya from RRI], Mahinda Wijeratne from University of Ruhuna and Senanai Karunaratne from Wayamba University).

Table 5. *Awareness on general and technical knowledge on tapping*

DS Division	Village	% awareness on tapping	
		General knowledge	Technical knowledge
Badalkumbura	Hela Thunkala	21	19
	Lunugala Kolaniya	40	38
	Kotamuduna	14	2
	Karawila	47	52
	Karandagama	17	15
	Madugahapattiya	56	67
Bibile	Pitakumbura	32	33
	Radaliedda	16	13
	Badullagammana	39	42
Buttala	Yudaganawa	13	9
Madulla	Kolladeniya	NA	NA
Medagama	Rattanadeniya	46	45
	Polgahapitiya	58	65
Moneragala	Tenagallanda	57	50
	Batugammana	59	52
	Tanwatta	63	62
Wellawaya	Siyabalagune	30	36
Padiyatalawa	Komana	45	61
Haldummmulla	Gampaha	13	13
	Mantenna	25	23
Lunugala	Pallekiruwa	28	35
	Average	36	37
	Min	13	2
	Max	63	67

NA- No respondents owning mature fields

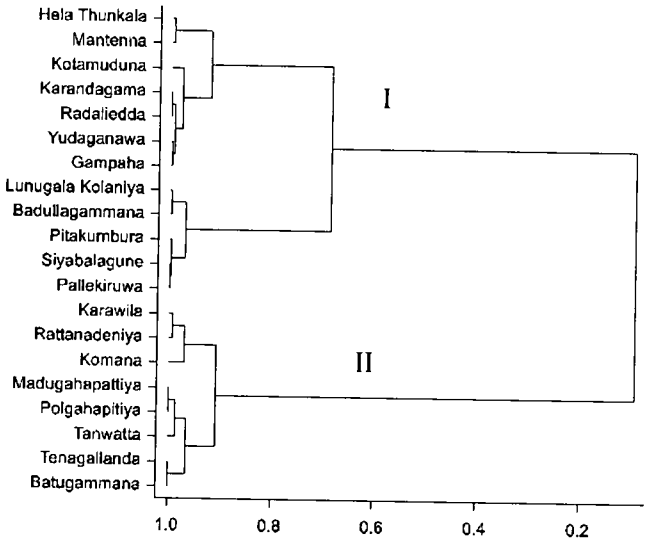


Fig. 7. Dendrogram showing successive fusion of villages based on awareness on tapping related activities

GIS applications in the rubber sector

Identification of suitable lands for rubber cultivation in the Moneragala district

This study was done as a part of the project under the NSF grant RG/2006/EPSD/01. The objectives of this study were; (1) to assess spatial and temporal variation of rainfall and temperature within the Moneragala district, (2) to assess land suitability and (3) to develop land suitability map for rubber cultivation in Moneragala district.

Though rubber can be grown over 1650 mm of annual rainfall it is important to note that growth of the plant is severely affected if the rainfall is less than 500 mm in 6 consecutive months. In order to assess this requirement a spatial analysis was conducted. Results revealed that July to December, August to January, September to February, October to March and November to April recorded more than 500 mm over six consecutive months for the whole district of the Moneragala. The period, January to June of the DS division Kataragama receives less than 500 mm. Also most parts of the DS division, Kataragama and part of the Tanamanwila DS division receive less than 500 mm during February to July. A patch of less than 500 mm is recorded in the Siyabalanduwa DS division too.

A map output generated from ARC GIS 9.2 is depicted in Fig. 8. This software will be used to generate further outputs by overlaying other land use attributes pertaining to rubber cultivation (Wasana Wijesuriya, Keminda Herath, Lalani Samarappuli and Senani Karunaratne [Wayamba University]).

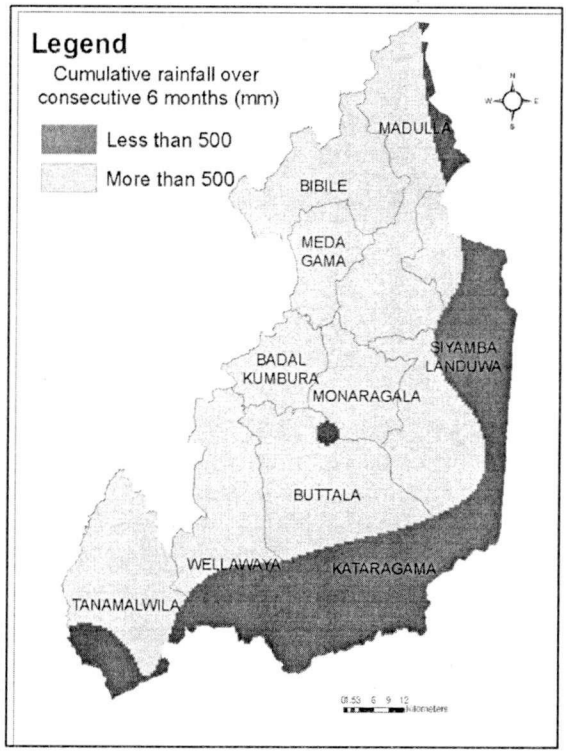


Fig. 8. Analysis of cumulative rainfall over 6 consecutive months (April to September) in Moneragala district

GIS as a tool for efficient decision making in rubber plantations

This study intended to develop a Geographical Information System for effective decision making and strategic development planning for the Dartonfield estate. The geographic information system (GIS) based software, Arc View GIS version 9.2 was used to digitize the existing paper map of Dartonfield group after geo-referencing the map using GPS points to generate digital land use map, at 1:16000 scale. The prepared land use map was intensively field checked to detect any changes of land uses with the time.

A slope map, a rockiness map and a water logging map were developed for the Dartonfield estate and from these, a land suitability map was developed based on the above criteria. Leaf nutrient values (N, P, K and Mg) were also mapped against the fields. A land suitability map was also prepared based on three suitability Parameters (slope, rockiness and water logging condition). Some map outputs of Dartonfield estate for YPH and age are given in Fig. 9. This methodology can be further extended to incorporate all essential indicators of land productivity (Keminda

Herath, Wasana Wijesuriya, Lalani Samarappuli and Vidura Abeywardene from RRI; Senani Karunaratne and Isuru Senadheera from Wayamba University).

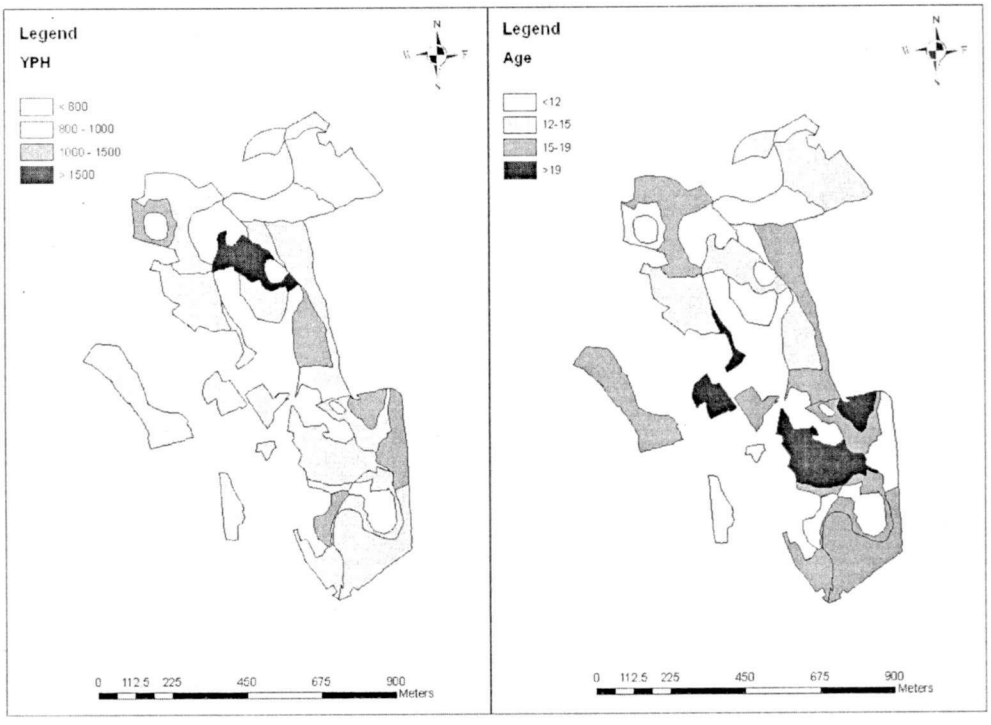


Fig. 9. Spatial distribution of yield per ha (YPH) and age (years) of rubber fields in Daronfield Group

Studies on climate change

A comprehensive literature survey was done on vulnerability and adaptation of the rubber sector to the threat of climate change and a document was prepared on "Climate change impacts of plantation crops : Rubber sector" and presented at the conference on global climate change and its impacts on agriculture, forestry and water in the tropics (Wasana Wijesuriya, Lalani Samarappuli and Keminda Herath).

Application and modification of statistical methods

The following studies are in progress.

Development of an appropriate time series model to forecast economic time series in the rubber sector

This project is in progress with an aim to identify an appropriate time series technique and also to suggest necessary improvements to study and forecast economic time series in the rubber sector. Most of the commonly used time series

techniques such as; ARIMA models require long stationary series, with respect to mean and variance, without missing values. However, most of the data sets found in the rubber sector do not satisfy the above conditions (Fig. 10a). Further, the real nature of the data disappears, once they are transformed into stationary series. Data differencing does not provide a stationary series with respect to both mean and variance (Fig. 10b). Although they were made stationary with log transformation (Fig. 10c), some unusual spikes can appear leading to problems in identifying a proper model.

Further, estimation of parameters of these models is based on heavy assumptions. At the initial stage of this study, bootstrapping which is a nonparametric method will be implemented as a solution. Subsequently, some Bayesian techniques and structural models will be tested and appropriate improvements of the methodology will be suggested (Keminda Herath and Wasana Wijesuriya).

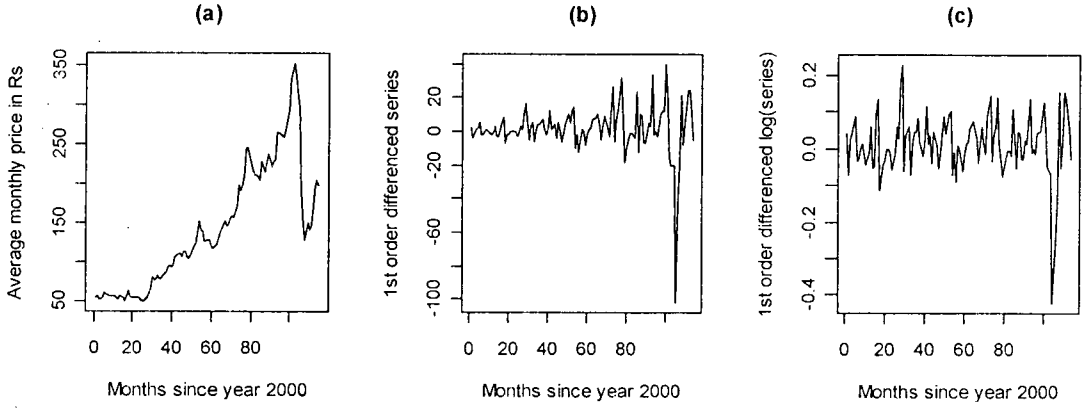


Fig. 10. (a) time series plot of monthly RSS prices since 2000 (b) 1st order differenced monthly RSS price series (c) 1st order differenced series of log transformed monthly RSS price series

Evaluation of existing techniques to analyze boundary line data on various applications in the rubber sector

This study is carried out to identify the draw backs of the commonly used method of fitting boundary lines and to suggest a plausible method, which can address the identified drawbacks in boundary line fitting. The upper boundary and/or the lower boundary are of greater interest in many areas such as biology and economics than fitting a line of best fit through a set of data. It has been identified that the boundary line model is persuasive and of practical interest in many areas of research in the rubber sector. For instance, to determine limiting ranges of leaf nutrient status of foliar analysis and to fit lower and upper boundaries of some key

indicators such as stand per hectare and yield per hectare (YPH) to identify the efficiency of rubber smallholdings. However, methods which have been used to estimate the boundary line model for many applications lacks an underpinning statistical model. It has been identified that a data set with a boundary can be described well by a censored probability distribution. The study is in progress and methods of parameter estimation and inference will be evaluated further (Keminda Herath and Wasana Wijesuriya).

LIBRARY AND PUBLICATION

S U Amarasinghe

SUMMARY

The Library and Publication section continued with its work in collecting and disseminating information on natural rubber and related subject areas and processing and publishing of its regular publications.

To celebrate the centennial of rubber research in Sri Lanka, special publications such as Coffee Table Book, Bibliography on Pathology, RRISL Brochures (Sinhala and English) and 32 Advisory Circulars (Sinhala and English) were released.

The Publication Section got a golden opportunity to exhibit all its publications at the Centennial Rubber Conference Sri Lanka, Hilton, Colombo, May 12th – 13th, 2009 and at five Crop Clinics held in Warakapola, Matugama, Moneragala, Ratnapura and Avissawella. There was a considerable demand for RRISL publications with new research findings of the Institute among the stake holders.

The Agricultural Information Network (AGRINET) continued their service throughout this year as well by helping in resource sharing process of member Libraries.

DETAILED REVIEW

Mr S U Amarasinghe, Librarian and Publication Officer, Mrs R M Amaratunga, Library Assistant and Assistant Publication Officer, Mr P M Prema Jayantha, Clerk/typist and two Library Attendants were on duty throughout the year.

Meetings/Seminars

- The AGM of the Sri Lanka Library Association on 26th June
- Three AGRINET Advisory Committee meetings and three AGRINET Librarian's meetings at CARP Office on 12th May, 7th August and 13th November
- SLISTINET meeting at NSF on 20th March

Resource development activities

Seventy five new books were added to the Library, bringing the total collection to 5579. The Library subscribed to a limited number of journals due to financial constraints. Thirty two journals were received on exchange basis.

Publications

The following publications were published during 2009.

- RRISL Journal, Vol.**88** (2007)
- RRISL Bulletin, Vol.**50** (2009)
- රබර් පුවත් වෙළුම **26** (20009)
- 32 Advisory Circulars (Sinhala & English)
- Bibliography on Pathology
- Rubber Research Institute of Sri Lanka: Driving Force of the Rubber Industry in the Country (Coffee Table book)

ILL service

Twenty one articles were sent to various Agricultural Libraries on their request and *vise versa* seventeen articles were requested for RRISL users. Nearly seven literature surveys on rubber were done using CD-ROM databases available at CARP and PGIA libraries.

Information services

Computerized bibliographic data up to the year 2009 were sent to the National Library of Sri Lanka and CARP Library for compilation of the National Union Catalogue and the National Agricultural Bibliography respectively.

DARTONFIELD GROUP

J Perera

SUMMARY

A total crop of 188,569 kg, has been harvested during this season. The actual crop harvested was 91% of the estimated crop.

The YPH for the year was 977 kg. compared with the same period last season YPH has increased by 66 kg.

The average intake per tapper recorded during the year was 8.80 kg. from a tapping task of 275 trees. Highest intake per tapper of 13.6 kg was recorded from the 1990 clearing with a tapping task of 300 trees tapped on s/2 d/3 tapping system.

The total number of normal, late and no tapping days recorded during the year were 203, 56 and 106 days respectively.

Total rain fall recorded for the year was 3,354.1 mm with 192 wet days. When compared with same period last year it is less by 1890.30 mm and 36 wet days respectively.

The COP and NSA achieved for the year was Rs.155.95 and Rs.228.33 respectively, giving a profit margin of Rs.72.38 per kg. and a total profit of Rs.13.64 million. Profit per hectare recorded for the year was Rs.70,703.61

Latex Crepe No.01X and RSS No.01 manufactured during the year were 81% and 95% respectively.

Fixing of rainguards was not undertaken in season 2009 due to drop of Rubber prices in the early part of the year.

DETAILED REVIEW

Mr Jehan Perera, the Estate Superintendent, Mr K K P Gunawardena, Acting Chief Clerk, Mr D S K Ranaweera, Rubber Facrory Officer, Mrs S I K Pathirage and Mrs O W Namali Udayanthie Junior Clerks, Mr B M Siriwardena, Mr K A Sarath Kumara, Mr Jagath Nakandala, Mr N L D Nihal, Mr Ajith Basil Nakandala and Mr N L D Premechandra Junior Assistant Field Officers were on duty throughout the year.

The group cadre stood as follows at the end of the year.

Senior staff	01
Assistant staff	10
Minor staff	03
Total	**14**

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	38.26	138.46	16.32	193.04
Immature area	0.76	11.36	20.15	32.27
State land take in	0.27	-	-	0.27
Nurseries	7.27	1.00	2.00	10.27
Paddy/Deniya land	0.75	1.22	1.22	3.19
Waste land	0.19	0.18	-	0.37
Earth slipped area	3.01	1.26		4.27
Jungles	0.80	1.50	2.03	4.33
Rocky areas	2.14	5.92	1.26	9.32
Roads	2.92	6.86	0.36	10.14
Building	16.92	5.43	7.79	30.14
Abandoned areas	-	11.16	19.94	31.10
Streams	-	-	2.17	2.17
Play Ground	1.00	-	-	1.00
Grand total	**74.29**	**184.35**	**73.24**	**331.88**

Rainfall

The annual rainfall recorded for the year was 3,354.1 mm with 192 wet days.

Table 2. *Annual rainfall and wet days of the group for last five years*

	2005	2006	2007	2008	2009
Rainfall (mm)	4,129.0	4,260.9	3,997.4	5,244.4	3,354.1
Wet days	222	204	187	228	192

Crop

A total crop for 188,569 kg have been harvested against the estimated crop of 206,520 kg which is a decrease of 17,951 kg (09%).

Table 3. *The crop and YPH (kg) Dartonfield group from 2005 to 2009*

Hect.	**2005**		**2006**		**2007**		**2008**		**2009**	
	196.15		**187.48**		**195.10**		**192.95**		**193.04**	
Division	**Crop**	**YPH**	**Crop**	**YPH**	**Crop**	**YPH**	**Crop**	**YPH**	**Crop**	**YPH**
Dartonfield	33,527	859	40,278	1,032	3,8025	974	27,341	701	29,025	759
Gallewatte	144,169	997	156,863	1,133	16,3228	1,179	132,900	960	138,017	997
N'kele	8,211	656	11,970	1,197	1,1743	1,174	15,581	1,007	21,527	1,319
Group total	1,859	948	209,111	1,115	21,2996	1,136	175,822	911	188,569	977
Group estimate	196,350	1,001	184,900	986	23,0736	1,231	217,954	1,130	206,520	1,070

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 2005 to 2009*

	2005	2006	2007	2008	2009
Dartonfield	6.8	7.1	6.6	7.7	6.6
Gallewatte	9.4	9.9	9.4	9.6	9.5
Nivitigalakele	5.7	6.3	6.3	6.5	8.2
Group average	8.9	8.9	8.5	8.8	8.8

Tapping days

Annual break down of Normal tapping (NT), Late tapping (LT), Double tapping (DT) and No tapping of Dartonfield estate is given in Table 5.

Table 5. *Average number of tapping days of Dartonfield group during last five years*

	2005	2006	2007	2008	2009
Normal tapping	190	199	212	184	203
Late tapping	06	35	22	30	56
Double tapping	(11))	(27)	(44)	(05)	-
No tapping	104	77	76	120	106
Rainguard tapping	65	54	46	31	-

Total number of tapping days have increased over the previous year.

Total profit and profitability per hectare

The total profit and profit per hectare were Rs.13,648,624.22 and Rs.70,703.61 respectively for the year under review.

Table 6. *Comparative statement of the revenue profit per kg. and profit per hectare*

	Years				
	2005	2006	2007	2008	2009
Mature area (ha.)	196.15	187.48	187.48	192.95	193.04
Total profit (Rs.)	10,777,920.74	19,556,061.30	20,268,699.36	14,438,502.64	13,648,624.22
Profit per ha.(Rs.)	54,947.34	104,310.12	108,111.26	74,830.28	70,703.61

Cost of production and productivity

The wages increase of 40% from August 2009 has attributed for the C.O.P. to increase by Rs.5.91 over previous year (Table 7).

Table 7. *Labour rates and break down of cost of production from 2005 to 2009(Rs./kg.)*

	2005	2006	2007	2008	2009
1. Labour wages	216.25	285.50	320.00	320.00	447.75
2. Cost of production	86.84	116.24	128.12	150.04	155.95
2.1 Tapping	29.29	35.35	41.38	47.60	52.27
2.2 Manufacture	16.33	19.20	22.56	21.41	21.02
2.3 General charges	28.35	47.47	50.47	58.78	68.74
2.4 M/area upkeep	12.87	14.22	13.71	22.25	13.92
3. N.S.A.	144.34	209.76	223.28	232.16	228.33
4. Profit per kg	57.50	93.52	95.16	82.12	72.38

Manufacture

Out of the latex crop of 188,569 kg harvested, 109,152 kg has been sent as No.1 which is 81%. Details are given in Table 8.

Table 8. *Summary of grades manufactured during the year*

Grade	Quantity (kg.)	Percentage %
Latex crepe No.1	108,163	81
Latex crepe No.2	1,200	01
Latex crepe No.3	24813	18
Total	**134,176**	**100**
Scrap crepe No. 1	13,789	73
Scrap crepe No.2	4,830	25
Scrap crepe No.3	406	02
Total	**19,025**	**100**
RSS No.1	33,518	95
RSS No.3	1,850	05
Total	**35,368**	**100**
Grand total	**188,569**	

KURUWITA SBU STATION

S A R Samarasekera

SUMMARY

A total crop of 83,551kg have been harvested during the year 2009. When comparing with the estimated crop it records a decline of 16.59%. The actual yield per hectare (YPH) achieved was 1,265.9kg and a yield per hectare of 1,122.5kg was achieved from intercropped rubber area during year. The average intake per tapper (IPT) of the estate was 8.2kg for the year 2009 this is a decrease of 0.2kg when compared with the previous year.

The annual rainfall was 4188.6 mm with 84 wet days as against 4,624.1 mm with 135 wet days during the last year. The average number of normal, late, rain interference, double and no tapping days were 208, 52, 16, 29 and 89 respectively.

The cost of production and the net sale average for the year were Rs.127.90 and 194.16 per kg respectively. The profit per kg was Rs.65.69 and profit made for the year was Rs.5,536,089.26. The total profit made inclusive of sundry income was Rs.8,373,886.88.

DETAILED REVIEW

The visiting superintendent Mr S P Dissanayaka, Deputy General Manager of Agalawatta Plantation over looked the activities of the Sub – Station through out the year.

Staff

Mr S A R Samarasekara, Assistant Estate Manager, Mr D S Jayasinghe, Clerk, Mr J R C Jayalath, Assistant Field Officer and Mr N V U S V Kumara, Junior Assistant Field Officer were on duty through out the year.

Mr V G D N Gunaseela, Junior Assistant Field Officer left the Sub – Station to take up duties in Monaragala Sub – Station with effect from 08th July 2009.

The estate cadre stood as 04 at the end of the year made as follows.

Intermediate staff	- 01
Assistant staff	- 01
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	68.79
Immature area	12.82
Nurseries	2.25
Tea area	3.25
Paddy	1.00
Buildings, Gardens and Road	7.54
Water tank	0.01
Proposed replanting area	3.50
Unsuitable for planting	0.84
Total	**100.00**

Crop

A total crop of 83,551 kg have been harvested against the estimated crop of 100,178kg. This is a decrease of 16,627kg (16.59%) against the estimated crop.

The yield per hectare (YPH) for the past 05 years is given in the Table 2.

Table 2. *Yield per hectare for the last five years*

YPH (kg)	Year				
	2005	2006	2007	2008	2009
Estimated	1,200.00	1,200.00	1,200.00	1,536.70	1,456.29
Actual	1,451.20	1,610.20	1,615.30	1,530.10	1,265.90

The drop in yield per hectare during 2009 is attributed to non-fixing of rainguards.

The yield per hectare recorded (kg) for each month during the year is given in Table 3.

Table 3. *Yield per hectare (kg) recoded for each month during the year 2009*

Month	YPH (kg)
January	156.9
February	125.4
March	93.4
April	77.3
May	73.1
June	50.8
July	111.8
August	75.9
September	71.5
October	138.9
November	134.8
December	156.1

Tapper productivity

The average intake per tapper at the end of the year was 8.2kg. This is a decrease of 0.2kg over the previous year (Table 4).

Table 4. *The average I.P.T (kg) for the last five years*

	Year				
	2005	2006	2007	2008	2009
Intake per tapper	8.7	9.4	8.6	8.4	8.2

Vacant blocks

The number of vacant blocks recorded for the last 05 years in the estate is given in Table 5.

Table 5. *Vacant blocks recoded during the past five years*

Year	No. of vacant blocks	Percentage
2005	477	5.66
2006	195	2.27
2007	308	3.03
2008	393	3.40
2009	143	1.40

The number of vacant blocks have decreased significantly in 2009.

Rainfall

The annual rainfall recorded for the year was 4,188.6 mm with 84 wet days as against 4,624.10 mm with 135 wet days during the last year (Table 6).

Table 6. *Annual rainfall figures and the number of wet days of the estate for the last five years*

	Year				
	2005	**2006**	**2007**	**2008**	**2009**
Rainfall (mm)	3,903	4,100	3,365	4,624.1	4,188.6
Wet days	103	132	130	135	84

Tapping

There were 276 tapping days recorded during the year. A breakdown of the tapping days are given in Table 7.

Table 7. *A breakdown in tapping days for last five years*

	Year				
	2005	**2006**	**2007**	**2008**	**2009**
01.Total tapping	336	335	334	337	276
1.1. Normal	302	306	315	310	208
1.2. Late	18	20	01	16	52
1.3. Rain Interference	16	09	18	11	16
1.4. Rainguard	(88)	(122)	(109)	(106)	-
1.5. Double	(04)	(02)	(03)	(04)	(29)
02. No tapping	(29)	30	31	29	89

Tapping and production cost

The tapping and production cost of the estate has increased by 13% over the last year due to the increase of labour wages (Table 8).

Table 8. *A break down in total tapping cost for last five years*

	Cost/kg. (Rs.) and Year				
Cost item	**2005**	**2006**	**2007**	**2008**	**2009**
Tapping	24.31	26.39	33.28	37.38	41.58
Double tapping	0.17	0.09	0.07	0.20	1.42
Over time on tapping	0.28	0.36	0.27	0.31	0.35
Over Kilos	0.33	0.54	0.60	0.60	1.13
Extra pay to Kangany	0.03	0.02	0.02	0.01	0.02
Scrap pay	0.61	0.88	0.86	1.47	1.59
Incentive pay to field staff	0.22	0.25	0.23	0.12	0.03
Transportation of scrap	-	-	-	0.18	-
Cash tapping	-	-	-	0.31	0.37
Stimulation	-	-	-	-	0.34
Tapping utensils	0.65	0.65	0.73	1.39	0.75
Latex transport	-	-	-	-	0.48
Factory labour	0.57	0.46	1.62	3.52	3.47
Factory sundries	-	-	-	0.01	0.02
Total tapping cost	27.17	29.64	37.68	45.50	51.55

Table 9. *Comparative statement of the mature extent, total profit & profit per hectare for the last five years*

	Year				
	2005	**2006**	**2007**	**2008**	**2009**
Mature extent (ha.)	47.61	48.61	53.31	64.63	68.79
Total profit (Rs.)	4,164,415.92	6,796,618.25	8,973,092.48	10,477,953.44	5,536,089.26
Profit per ha. (Rs.)	69,384.88	139,819.34	162,232.73	162,122.13	80,478.11

Total profit and profit per hectare were Rs.5,536,089.26 and Rs.80,478.11 respectively for the year 2009. This is a decrease of Rs.4,941,864.18 and Rs.81,644.02 respectively when compared with the last year. This will be attributed non-use of rainguards during 2009.

Cost of production and profitability

The cost of production has increased by Rs.13.75 per kg when comparing with the previous year (Table 10).

Table 10. *Labour rate (Rs.) and the break down of the cost of production (Rs./kg.) for the last five years*

	Year				
	2005	**2006**	**2007**	**2008**	**2009**
Labour rate	216.25	285.50	320.00	320.00	405.00
Total C.O.P.	60.31	78.99	95.75	114.27	127.90
Tapping cost/kg	27.17	29.64	37.68	45.50	51.55
General charges/kg	23.52	37.09	45.11	47.59	55.98
Upkeep/kg	9.62	12.26	12.96	21.18	20.37
N.S.A./kg	120.58	165.82	202.41	228.25	194.16
Profit/kg	60.27	86.83	106.66	113.98	66.26

Labour rate per day for the year was Rs.285/= plus an additional incentive of Rs.120/= per day depending on the attendance. Accordingly, labour wages have increased by 27% compared for last year.

Other crops

Tea

A crop 14,078kg of was harvested during the year. The cost of production and net sale average for the year were Rs.44.68 and Rs.54.83 per kg. respectively. The profit per kg was Rs.10.15 and the profit made for the year was Rs.154,626.00.

Cinnamon

443kg of cinnamon was sold during the year from the Rubber/Cinnamon intercrop experimental area.

Rambutan

18,250 fruits were sold during the year from the Rubber/Rambutan intercrop experimental area.

Rubber plants

8,911 young budding plants were issued to the smallholders during the year.

Replanting

The replanting programme for the year was completed.

Fertilizer application

Fertilizer applications for mature and immature rubber fields were carried out as scheduled.

Reward

The selected best tappers were rewarded during the year in order to motivate them.

Meteorological Summary - 2009
Dartonfield Station

H M L K Herath

Comparatively a dry weather experienced during 2009 at Dartonfield. Although, a total of 3540 mm of rainfall was recorded, it was respectively, a 37% and 15% drop from the total rainfall of 2008 and the long term average. Fig. 1 indicates that the distribution of rainfall during this year has followed the usual bimodal pattern. Yet, the peak rainfall months; *viz.* May and October have recorded below average rainfall values. Below average rainfall figures were observed in seven out of twelve months of the year. A minimum rainfall of 45.8 mm and a maximum rainfall of 546.3 mm were observed in January and June of 2009, respectively.

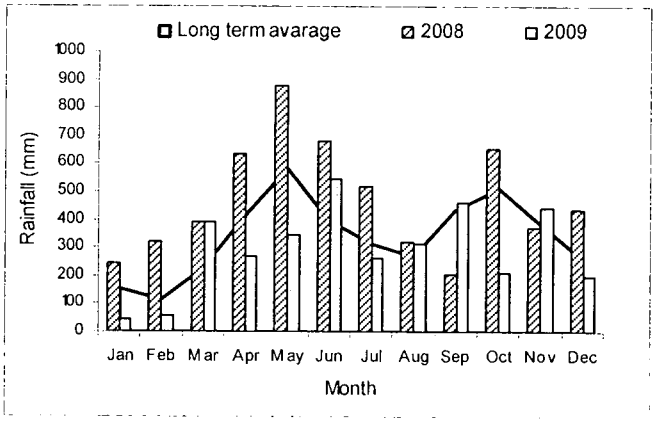


Fig.1. Monthly variation in rainfall

The distribution of weekly rainfall is illustrated in Fig. 2. Eight dry weeks (weeks having a total rainfall less than 10 mm) were observed during this year compared to nine weeks in 2008. The highest weekly rainfall of 229.5 mm was observed in the 38th standard week, which coincided with late October. Further, a rainfall of more than 200 mm was recorded during 11th and 26th standard weeks.

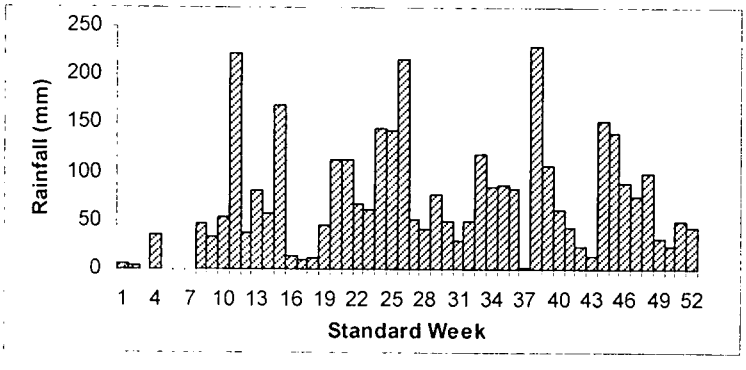


Fig. 2. weekly variation in rainfall

There weren't any rainfall events which 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 216, which is below the long term average of 220 days. A dry spell lasted over a month or more can have adverse impacts on rubber plantations. However, the longest dry spell of 22 days was recorded during the period from 29th January to 19th February. Further, during the first quarter of the year, there was a total of sixty dry days distributed among five dry spells, which were longer than 7 days.

The distribution of rainfall recorded during the first half of this year was very poor. However, rains received during the latter half of the year were well distributed over the time.

Start and end of the first and second spells of rains

The successful start of the rains occurred by 29th March and 08th September in 80% of the years for the first spell and the second spell of rains respectively, when the period from 1964 to 2003 was considered. For the year under review, first spell of rains commenced successfully by 08th of March, which was an early start compared to the 80% expected. However, the onset of second spell of rains in the year was not apparent as per the criteria for detecting start of rainy seasons.

Rains cease generally by 14th August and 05th January for the first rain spell and second rain spell, respectively. For the year under review, the cease of the first rain spell was not apparent as per the criteria for detecting the cease of the rainy seasons. The second rain spell ceased by 17th of February 2010.

Rainfall at RRI substations

There are three substations maintained by RRISL in Kuruwita (WL_{1a}), Narampola (IL_{1a} bordering to WL_{2b}) and Moneragala (IL_{1c}). An annual rainfall of 4209 mm and 2214 mm were recorded respectively, for Kuruwita and Narampola stations during 2009. Another meteorological station is proposed for the sub station at Moneragala. Distributions of monthly rainfall at Kuruwita and Narampola are illustrated respectively, in Fig.3 (a) and Fig.3 (b). The usual bimodal nature of the distribution of rainfall at Kuruwita was not apparent during 2009 while it was clearly visible in the distribution of rainfall recorded in 2008. There weren't any prominent deviations from the bimodal nature of the distributions of rainfall recorded at Narampola during 2008 and 2009.

Table 1. *Monthly variation of rainfall and rainy days in 2009*

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	45.8	(156)	06	(11)	2	4	-	61.6
February	55.9	(114)	07	(09)	3	4	-	74.8
March	390.9	(222)	20	(13)	2	16	2	80.2
April	271.4	(415)	15	(18)	2	12	1	69.7
May	346.6	(584)	22	(24)	2	20	-	62.0
June	546.3	(398)	29	(23)	2	24	3	58.9
July	261.2	(313)	17	(22)	1	16	-	67.9
August	311.0	(268)	27	(20)	7	19	1	94.3
September	461.4	(436)	21	(22)	2	18	1	65.7
October	213.4	(513)	12	(23)	3	8	1	91.7
November	439.4	(387)	23	(20)	3	19	2	58.0
December	196.5	(266)	17	(15)	4	14	4	61.6
Total	3539.8	(4160.0)	216	(220)	32	174	10	846.4

* A rainy day is defined as a day with a rainfall $\geq$ 0.3 mm
** Average values for 1980-2005 are shown in parentheses

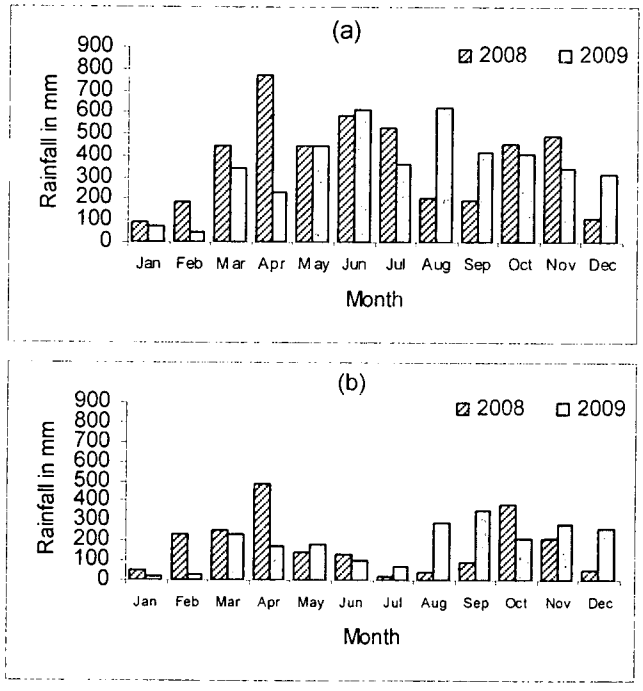


Fig. 3. Distribution of monthly rainfall in (a) Kuruwita and (b) Narampola

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, maximum and average temperatures at Dartonfield are illustrated in Fig.4. During the year under review, the minimum temperature dropped below 20^0C in 6 days in January and 10 days in February, which seemed to be an unusual situation compared to the situation prevailed during the previous years.

According to Fig. 4, the difference between maximum and the minimum temperatures during the first quarter of the year appeared to be high. However, the daily average temperature pattern was rather steady with a mean annual temperature of 27.6^0C and standard deviation of 0.9 which could be a favourable condition for rubber plantations. The lowest mean minimum temperature of 21.6^0C was observed in January while the highest mean maximum temperature of 33.3^0C was observed in December. However, any sign of an adverse conditions with respect to the temperature regime at Dartonfield was not reported during the year.

Table 2. *Variation of observed meteorological factors at Dartonfield – 2009*

(Latitude 6^{0}32'; Longitude 80.09 E; Altitude 65.50mm)

Month	Temperature (^{0}C)					Sun shine hours	Relative humidity (%)			Mean wind speed (Km/hr)
	Mean Max	Mean Min	Mean	No of days Min Temp<20	No of days Max Temp>35		8.30 am	No of days 8.30am>90%	3.30 pm	
January	33.6	21.0	27.3 (26.7)	06	4	6.2	87 (88)	12	70 (68)	1.60
February	33.9	21.0	27.8 (27.1)	10	4	7.4	86 (86)	07	60 (65)	1.80
March	33.5	22.5	28.0 (27.6)	0	0	6.4	89 (85)	19	71 (68)	1.60
April	33.1	23.7	28.4 (27.8)	0	0	5.9	88 (85)	12	72 (75)	1.70
May	31.8	24.6	28.2 (27.6)	0	0	3.9	89 (88)	16	77 (77)	2.10
June	30.7	23.9	27.3 (26.9)	0	0	3.6	93 (89)	29	79 (77)	1.70
July	30.9	23.6	27.3 (26.7)	0	0	4.8	93 (89)	26	74 (75)	1.60
August	30.8	23.9	27.4 (26.6)	0	0	4.8	91 (88)	19	74 (74)	1.70
September	30.8	23.4	27.1 (26.7)	0	0	5.4	89 (88)	13	75 (75)	2.10
October	32.6	23.0	27.8 (26.6)	0	0	6.7	84 (86)	06	86 (77)	1.60
November	27.1	25.3	26.2 (26.6)	0	0	3.4	86 (85)	08	78 (77)	1.20
December	32.6	22.8	27.7 (26.7)	0	0	4.1	86 (85)	08	75 (73)	1.30

** Average values for 1980-2005 are given in parentheses

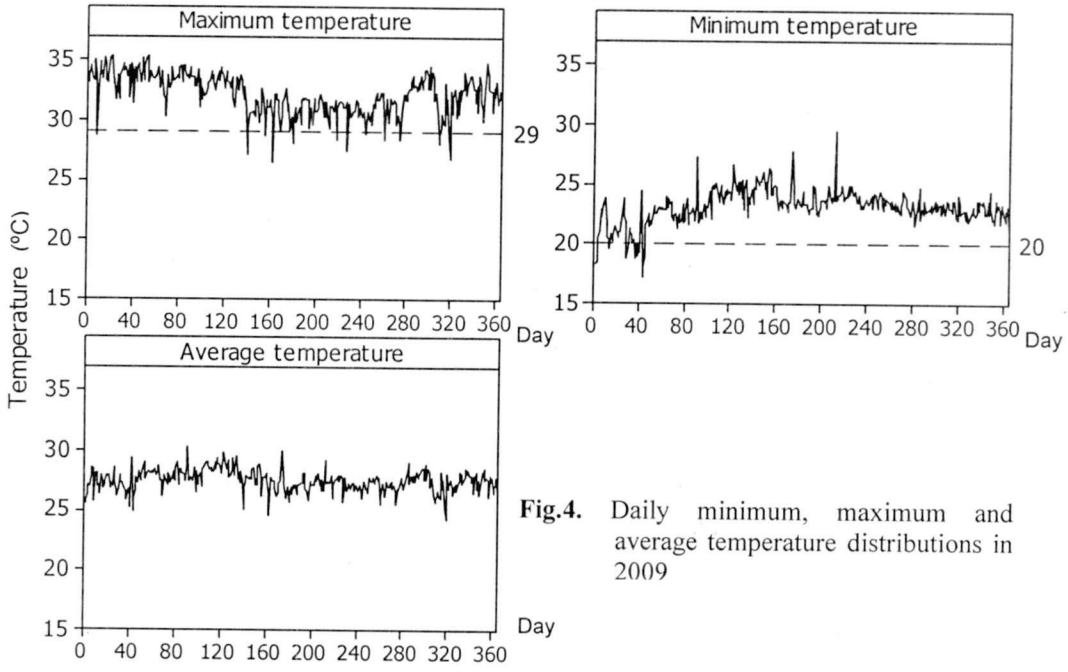


Fig.4. Daily minimum, maximum and average temperature distributions in 2009

The distribution of daily sunshine duration at Dartonfield in 2009 is illustrated in Fig. 5. A total of 1887 sunshine hours was received at an average rate of 5.2 hr/day. Out of this, a total of 766 hours of sunshine was received at an average rate of 6.4 hr/day during the first four months which coincided with the wintering period of rubber. Compared to the optimum requirements for rubber (2000 hours of total sunshine at the rate of six hours per day in all months), the amount and the distribution of sunshine hours were poor during the latter part of this year, where the plantations are expected to be more productive.

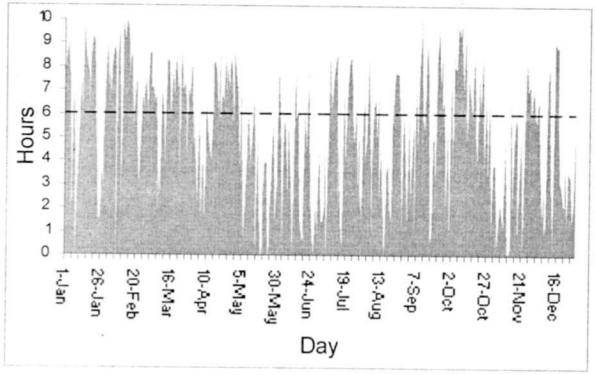


Fig. 5. The distribution of daily sunshine hours during 2009

Daily morning Relative Humidity (RH) at Dartonfield in 2009 was in the range of 59% to 100 %. The mean annual RH recorded during the year was 81% (standard deviation = 7). Monthly averages of morning RH in most of the months were above their long term averages. Monthly values of soil temperatures at 4 different depths are given in Table 3.

Table 3. *Soil temperatures recorded at different depths at Dartonfield - 2009*

Month	08.30 hrs				3.30 hrs			
	5cm	10cm	20cm	30cm	5cm	10cm	20cm	30cm
January	27.8	26.3	27.4	29.0	37.6	33.6	31.2	29.9
February	28.7	26.8	27.9	29.4	38.2	34.4	31.9	30.4
March	28.1	27.2	28.1	29.2	35.7	33.9	31.7	30.2
April	29.0	28.1	28.8	29.6	36.3	34.3	32.3	30.5
May	29.1	28.4	29.1	29.7	33.6	32.4	31.4	30.2
June	27.4	27.2	27.9	28.6	32.0	31.0	29.7	29.1
July	27.0	26.8	27.5	28.4	33.6	32.4	30.8	29.3
August	27.5	27.2	27.9	27.9	32.7	31.7	30.2	29.4
September	27.9	27.3	28.1	28.6	32.4	31.5	30.3	29.4
October	28.4	27.9	28.6	29.2	33.4	32.4	31.1	29.9
November	27.3	26.5	27.0	27.7	31.8	31.0	29.4	28.6
December	27.3	26.8	27.5	28.3	32.0	31.3	30.0	28.9

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