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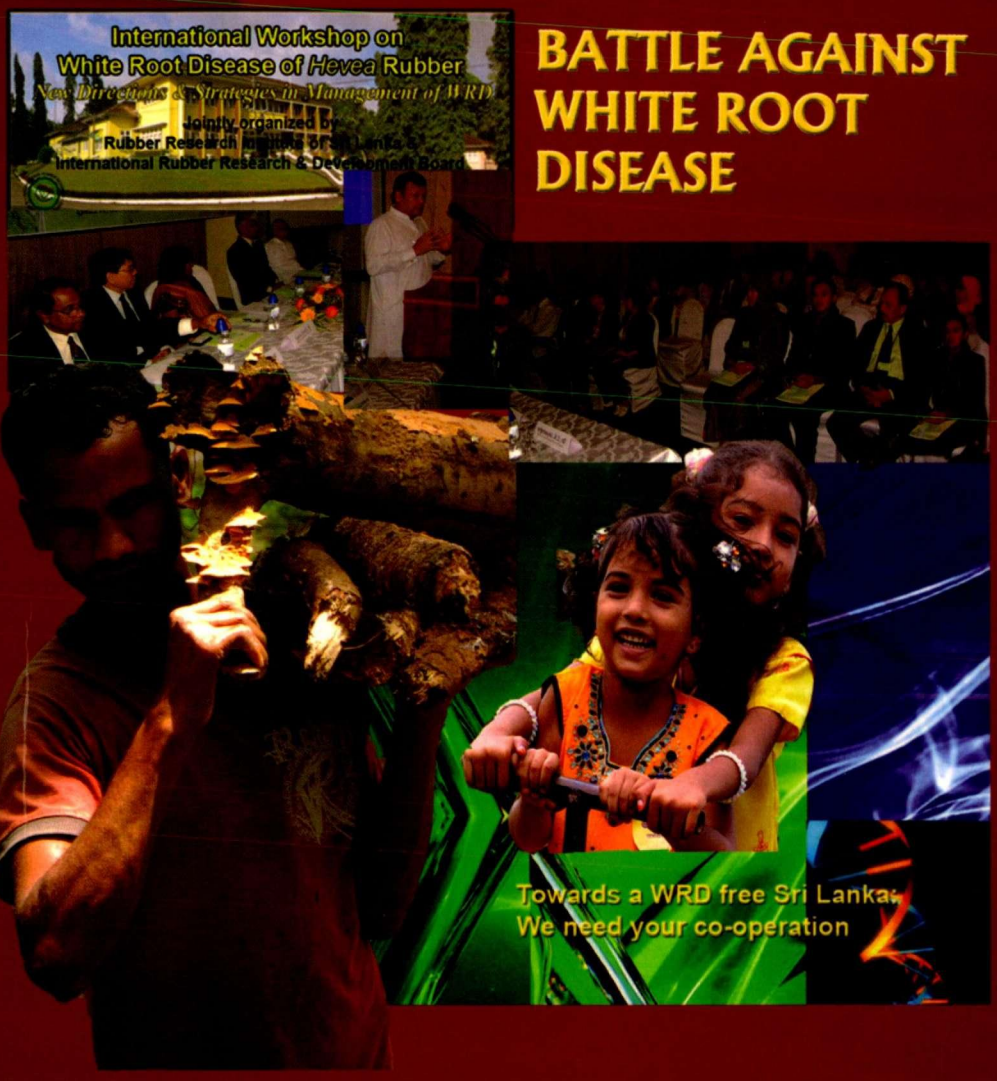
RUBBER RESEARCH INSTITUTE OF SRI LANKA



BATTLE AGAINST WHITE ROOT DISEASE

Annual Review 2010

RUBBER RESEARCH INSTITUTE OF SRI LANKA - ANNUAL REVIEW 2010

Cover Story

Battle against White Root Disease

White Root Disease caused by the fungus *Rigidoporus microporus* is a deadly disease spread in rubber plantations with the beginning of the 20th century.

This silent killer has already destroyed 5-10% of the rubber lands in leading rubber growing countries including Sri Lanka resulting huge bare patches and significant reduction in productivity.

With this background, International Rubber Research & Development Board has come forward to organize an International Workshop in 2010 with the collaboration of the Rubber Research Institute of Sri Lanka to formulate new directions and strategies in management of WRD.

During the sessions it has been clearly shown that in contrast to the South American Leaf Blight, WRD has the advantage of being controllable because of the biology of the pathogen. Research carried out for nearly a century has provided wealth of information and an effective management protocol is available based on these findings. The technology recommended is well enough to prevent and control this devastating disease. **However, with all these technologies still WRD remains as the most threatening root disease of the rubber tree**.

The delegates identified the probable reasons for wide spread of WRD as technology transfer gaps and limitations in implementation of the recommended protocol. Presently Pathologists in rubber growing countries are actively involved in developing a user friendly technology to face the challenges in management of WRD.

To keep WRD away - We need your cooperation

Rubber Research Institute of Sri Lanka

Annual Review – 2010

1st January 2010 to 31st December 2010

Editors
W M G Seneviratne, PhD (Sussex)
C K Jayasinghe, PhD (Sri Lanka)

Head Office & Laboratories
Dartonfield
Agalawatta

Board Office & Laboratories
Telewela Road
Ratmalana

CONTENTS

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Mr H H Jayasinghe, Elected Committee Member
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Deputy Director (Administration)	- Miss W K V de Silva
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Deputy Director – Research (Technology)	W M G Senevirante, BSc (SL), PhD (Sussex)
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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 (up to 06.02.2010)
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	I D M J Sarath Kumara
	L S Kariyawasam
	T M S K Gunasekera
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	Mrs A K Gamage, BSc (SL)
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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)
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	Mrs R K Samarasekera
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	I Kiridena (up to 30.09.2010)
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Experimental Officer	S S Warnapura
Senior Clerk	K K P Gunawardena
Factory Officer	D S K Ranaweera

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Junior Clerk	D S Jayasinghe

* On study leave overseas
** On no pay leave
*** On study leave within the country

Dr A Nugawela

Dr A Nugawela resigned from the post of Director of the Rubber Research Institute on 31st December 2010 after serving the organization for 30 years. Presently, he is the Chair Professor on Plantation Management at the faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka

His thrust areas of research and development were on nursery management, planting practices, harvesting, use of yield stimulants and rainguards. He has more than 130 publications and has addressed in many local and international conferences on natural rubber.

He obtained a BSc Special Degree in Botany from the University of Peradeniya in 1979 and joined the Rubber Research Institute in the capacity of an Assistant Botanist in 1980. In 1985 he was offered a scholarship by the Food and Agricultural Organization of the United Nations to obtain his professional qualifications. He was awarded a PhD from the University of Essex, UK in 1989 recognizing his research contribution to Plant Physiology and Plant Productivity in *Hevea* rubber tree.

In his long carrier at the Rubber Research Institute he has served in the capacities of Botanist, Head of Plant Science Department, Deputy Director Research (Biology) and the Director. He was also consulted among others for the SRRP II Project in Sri Lanka and for the Integrated Rural Development in Ghana in 1998-2000.

During his career at the institute he won the Presidential Research Award 2001, and National Science and Technology Award 2010.

We wish him all success in future endeavors.

National Science and Technology Awards – 2010

Dr A Nugawela, Director, RRISL, Mrs D G Edirisinghe, Acting Head and Mrs M K Mahanama, Experimental Officer of the Rubber Technology and Development Department, Rubber Research Institute of Sri Lanka jointly won the National Science and Technology Awards – 2010 in the category of "Development of eco material/eco friendly process for industry", organized by the National Science Foundation of Sri Lanka in collaboration with the Ministry of Science and Technology.

RUBBER RESEARCH INSTITUTE OF SRI LANKA

DIRECTOR'S REVIEW

W M G Seneviratne

Expansion of rubber cultivation to non traditional areas was given high priority during the last five years with the view of increasing the rubber production in the country. One of the important achievements in this regard was the opening of the Monaragala Substation to fulfill the technological needs of Uwa Wellassa and Eastern Province rubber growers.

The inauguration ceremony was held under the patronage of the Hon. Minister of Plantation Industries, Mr Mahinda Samarasinghe. Harvesting of rubber trees cultivated with the initiation of the expansion programme six years ago in the Eastern Province was also commenced during this year with the participation of the Hon. Minister of Plantation Industries.

Opening of the Monaragala Substation under the auspicious of the Hon. Minister of Plantation Industries, Mr Mahinda Samarasinghe

The Rubber Research Institute of Sri Lanka continued its research and development activities successfully and about 80% of the targets have been reached according to the action plan and corporate plan. Highlights of achievements are summarized below.

Annual hand pollination programme, one of the routine activities was carried out and forty four numbers of new genotypes were produced for evaluation.

Current clonal composition in the country was assessed and it was found that area under RRIC 121 was significantly higher as it covers more than 30% of the replanted area. With this background it was decided to suspend the planting of RRIC 121 gradually.

Tapping quality of the revenue areas managed by the regional planting companies was monitored and reports were submitted to the respective estate management to take necessary steps to correct the situation where ever necessary.

Commencement of harvesting at the Eastern Province

Government, Regional Planting Companies and Private Commercial Nurseries were inspected and 1.8 million plants were certified as quality plants for planting during the year.

Plants of RRIC 100 rejuvenated through successive grafting were multiplied to distribute among the stakeholders. More passages were produced during the year under review. A clearing was established with rejuvenated plants of clones RRIC 100, RRIC 102 and RRIC 121.

In order to ensure quality tapping, special training programmes were conducted to RPCs and 2500 new tapping knives were issued to the stakeholders through Advisory Services Department. Demonstration on sealant preparation greatly assisted the promotion campaign of fixing rainguards launched by the Ministry of Plantation Industries.

White Root Disease of the rubber tree has now become a limiting factor during replanting of old clearings. With this background an International workshop on White Root Disease was conducted with the collaboration of IRRDB to introduce the new strategies in management of this deadly disease.

It was revealed that application of biochar increases important soil fertility parameters such as pH, cation exchange capacity and organic carbon in addition to available nutrients such as K and Mg.

Site specific fertilizer recommendations for 7,430 hectares of mature rubber were issued using newly developed visual basic computer programme. Approximately 150 ha were surveyed for suitability of planting rubber under land selection programme.

Newly developed temperature corrected ready reckoner was able to reduce the error in latex weighing for dry rubber content (%DRC) by *ca.* 50%. Latex density accounted for *ca.* 80% of variation in percentage DRC.

Several important extension and advisory projects were carried out at national and regional levels to increase the land productivity of rubber smallholders in all rubber growing areas of the country.

A simple and a low cost process was developed to convert the rejects and wastes of the natural rubber dipped product industry into highly efficient, user and environmental friendly rubber mats, namely "Power Mat" which had been proven as a commercial product to control weed growth during the immature period of rubber has been awarded the "National Science and Technology Award 2010" for the category "Development of eco material/eco friendly processes for industry".

Use of rejects/wastes from dipped product industry to manufacture mats

Power mats in use to control weed growth at tree bases

Development of user friendly cost effective and quality oriented raw rubber processing technologies and introduction of processing procedures to improve the quality consistency of in all grades of raw rubber is another important piece of work carried out by the Institute.

Two new effluent treatment plants based on the microbiological treatment process developed by the RRI have been satisfactorily installed in a scarp crepe and Crepe rubber factory. Long standing environmental problems created by the discharge of untreated effluents into surroundings by these two factories is completely eradicated after commissioning of these treatment plants.

Cost effective drying methodologies for raw rubber is among another important area of research carried out at present.

Development of cost effective sealants for fixing rain guards, development of NR based adhesives, latex based paints environmentally friendly preservative systems for latex preservation are among important research work carried out by the polymer chemistry department of the RRISL.

Testings of physical properties of raw rubber, rubber compounds, rubber products, raw rubber and latex properties carried out by the technological departments through out the year. Around thirty Workshops on cottage based rubber product

manufacture was conducted in collaboration with Thurusaviya Fund, Rubber Development Department and National Institute of Education.

Development of polymer blends and composite materials, tyre treads for improved abrasion resistance, latex blending of NR with Poly Vinyl Acetate, Foam rubber, Nanofillers in rubber and latex are among important research work conducted by the Technology departments.

Trends in the Sri Lanka rubber industry

Rubber production

The natural rubber production in the country increased up to 150,000 MT during the year 2010. This is 9.5% Increase over the 2009 production which is 137,000 MT.

Rubber extent

As per the latest figures reported on the total rubber extent of the country, 125,000 ha with the total mature extent in the country is 97,720 ha while in the year 2009 the extent was 124,000 ha. A significant increase of the total rubber production increase therefore may not only to be the new bearing commenced tapping but mostly due to higher price of rubber. This would have compelled the rubber growers to extract more latex from the tree by way of somewhat excessive tapping.

Sri Lanka yielded a figure of 1,563kg of rubber per hectare 2010. This is a 3.98% increase over the national productivity level of 1,437kg in the year 2009. Replanting and new planting being carried out steadily in the country and accounts to 6,105 ha of replanting and 2,436 ha of new planting in the year 2009. In 2010, the figures of replanting and new planting increased up to 1493 ha and 1537 ha respectively.

Rubber consumption

Rubber consumption in 2010 in the country reported as 107.9 thousand MT as against 79.5 thousand MT in the year 2009 which is about 35.7% increase. This indicate rubber product manufacturing industry has mostly recovered from the sever set back due to the world economic crisis took place in the latter part of 2008. Gross rubber exports in 2010 were reported to be 51.5 MT.

Rubber manufacturing industry

Export income from rubber products increased from a US$ 286 million in 2004 to US$ 543 million in 2008 which was a remarkable feat. This was a steady and rapid 90 percent increase within a period of 4 years. This trend was reversed in 2009 with a huge 29 percent reduction over the previous year with an income of US$ 386 million. Drop in tyre exports was the main reason which showed a 38 percent decline.

This was due to the prevailing economic downturn and financial crisis that has affected consumer markets since mid 2009. The drop recorded by Malaysia during the same period was only 5.8% (from US$ 3,875 MM to US$ 3,650) which shows the strength of Malaysian rubber industry in comparison to Sri Lanka rubber industry. Malaysian industry's main stay is latex goods while Sri Lankan industry is dominated by solid tyres.

Sri Lanka can boast of international accepted products such as solideal branded industrial tyres manufactured here by Loadstar Ltd. Dipped products are sold all over the world, their household and industrial gloves being marketed under many brand names. Loadstar enjoys more than 20% of the international market. There are multinational companies too in operation in Sri Lanka namely Ansell Lanka Ltd., which manufactures latex based products and Trelleborg Lanka Ltd. produces solid tyres to the global market.

Exports of raw rubber

In 2008, a total of 48,600 MT were exported and sheet rubber exports accounted for 34 percent of income while latex crepe rubber came second with a 31 percent share. Liquid latex exports earned 16 percent of export value and TSR accounted for 10 percent of export incomes. Sole crepe which is a semi finished product gained 8 percent of the export earnings and the balance income came from scrap crepe. The total income was US$ 125 millions but this came down to US$ 98 millions in 2009 due to the global recession although volume exported in 2009 reached 53,700 MT. In 2010, the total imports of natural rubber and synthetic rubber were 12,400 MT and 24,500 MT respectively.

Trends in the global rubber industry

Rubber production

Total world NR production in 2010 was 10.29 Mn MT which is 6.1% growth compared with the previous 2009 production of 9.7 Million MT. This is attributed to the total new planting by rubber producing countries between the period of 2005-2008. Indonesia being highest among the countries gone for replanting amounted for a extent of 51,000 ha between this period. Among the other countries gone for new planting are Thailand (25,000 ha), China (20,000 ha) Myanmar (25,000 ha) major ANRPC member countries account for 92%of the commodity's global output.

This year's annual supply growth in the ANRPC region was observed at a 5.7% growth rate. The supply grew at 17.9%, 2.8% and 12.3% respective rates during the first three quarters. However there was a severe setback observed in the rubber production in ANRPC member countries in the fourth quarter in year 2010 and growth rate fallen to -6.3%. This was mainly because of the unfavourable weather conditions prevailed (heavy rainfall in major rubber producing countries at the latter part of the year 2010) in major rubber producing countries like Thailand (fall -

33.4%), India (-4.6%) and Vietnam (-2.8%) compared to same period in the previous year 2009.

Rubber consumption

The major rubber consuming countries worldwide are China (3.634 million MT), USA (0.908 million MT), India (0.944 million MT) Japan (0.739 million MT), Germany (0.289 million MT), Brazil (0.374 million MT), Thailand (0.42 million MT), Malaysia (0.457 million MT), Indonesia (0.421 million MT).

As such, 48% of the global demand for NR comes from China, India and Malaysia which are three major NR consuming countries within the ANRPC.

Both NR and Synthetic rubber are used for Rubber product manufacture. Price of sysnthetic rubber is generally governed by the price of crude petroleum oil. World rubber consumption of synthetic rubber as at 2010, was 13.48 million tons as against NR 10.19 million tons.

More than 60 percent of natural rubber is used for tyres, which is the major driving force behind changes in natural rubber demand.

The share of natural rubber in the tyre sector was about 50 percent in 2000 and is likely remain around this level in the next decade. Technological requirements are the overwhelming determinant of the share of natural rubber in tyre production and no significant new developments are foreseen that would allow synthetic rubber to replace natural rubber in tyres.

IRSG predicts that overall long term trends for NR is better than that of SR since predicted compounded annual growth rate (CGAR) is 3.4% for NR while 2.5% for SR as per their long term analysis for 2010 - 2020.

OVERSEAS VISITORS

Mr Mark Eaggar, EPI Group Ltd., 7, Bath Street, Cambridge, New Zealand

GENETICS AND PLANT BREEDING

Annual hand pollination programme was carried out at Nivitigalakele substation. Due to severe rainy weather condition that prevailed throughout the year, the final fruit set was very poor and a minimum number of seeds could be secured.

Newly registered RRISL centennial clones, a few selected hand pollination entries and some RRISL 200 and 2000 series clones were established in four different agro climatic regions under ECT/RRI collaborative trials.

Evaluation of yield performance in smallholder/RRI collaborative trials was difficult due to lack of cooperation, interest and recording methods of small holder farmers and non appropriate processing practices adopted by them.

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. Proper and reliable data collection was very difficult even from the trials established at RPC managed estates. Further, poor agro management practices in many estates affected the growth condition of the immature clearings established for further evaluation of new genetic material.

In order to prepare compiled index to identify and differentiate recommended Hevea clones using their distinguishable morphological features, physiological parameters and PCR based Random Amplified Polymorphic DNA (RAPD) marker techniques were used.

A young budding nursery was established at the department premises to produce plants of new genotypes to establish clearings.

GENETICS AND PLANT BREEDING

P Seneviratne

DETAILED REVIEW

Staff

Dr (Mrs) P Seneviratne Acting Head of the department, Assistant Geneticist and Plant Breeder Mr K K Liyanage, Experimental Officers Mr K W Rupatunga, Mr L S Kariyawasam, Mr I D M J Sarath Kumara, Mr T M S K Gunasekera, Mrs A K Gamage, 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 resumed duties on 4th January after spending three years at University of Putra, Malaysia, reading for her PhD degree.

Research Assistant, Mr K B Karunasekera retired after 37 years of long carrier at the RRISL and the department, with effect from 07th February. He was an indispensable person to the department who managed all activities of the department from annual hand pollination up to recommending clones. He dedicated his entire life for the betterment of the department without expecting anything in return. His loyalty is praiseworthy and his services to the department will be remembered throughout. On behalf of the department, I take this opportunity to wish him and his family good health and every success and humbly place on record that RRISL is indebted to him for his excellent commitment.

Seminars/Training Programmes/Workshops/Exhibitions conducted

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

Meetings/Seminars and Workshops attended

Officer	Subject	Organization
KK Liyanage	Works shop on "Plant Genetic Modification" at Genetech, Colombo	Genetech, 54, Kitulwatta Road, Colombo 8.
KK Liyanage SP Withanage	Third Symposium on Plantation Crop Research at Cinnamon Grand Hotel, Colombo	Rubber Research Institute of Sri Lanka
KK Liyanage SP Withanage	International Workshop on White root Disease at Hotel Janaki, Colombo	Rubber Research Institute of Sri Lanka
SP Withanage	5th Asian Biotechnology and Development Conference at Hotel Amaya Hills, Kandy	SLCARP

Research students

- K H Subasinghe, a student from the faculty of Agriculture, University of Peradeniya carried out her final year research project on "verification of genetic identity of twin rubber plants" by RAPD analysis under the guidance of Mr K K Liyanage and Mrs S P Withanage.

Research grants received

A Research grant was received from the National Science Foundation (NSF) to carry out studies on identification of recommended *Hevea* clones grown in Sri Lanka by morphological characteristics and Physiological parameters (RG/2010/AG /01).

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 a few seedling pairs propagated by splitting and rooting cuttings for a root study. Five out of seven twin pairs showed similar banding patterns confirming the authenticity with fifteen RAPD markers.

Two new experiments were started to investigate the impact of gibberellin on *Hevea*, as the preliminary step. The effect on exogenous application of gibberellins was monitored with seedlings. A clear positive impact on internodes elongation of *Hevea* seedling with 10µm gibberellins concentration was seen. Also a signal of feed back regulation on higher concentrations was noticed (Fig. 1).

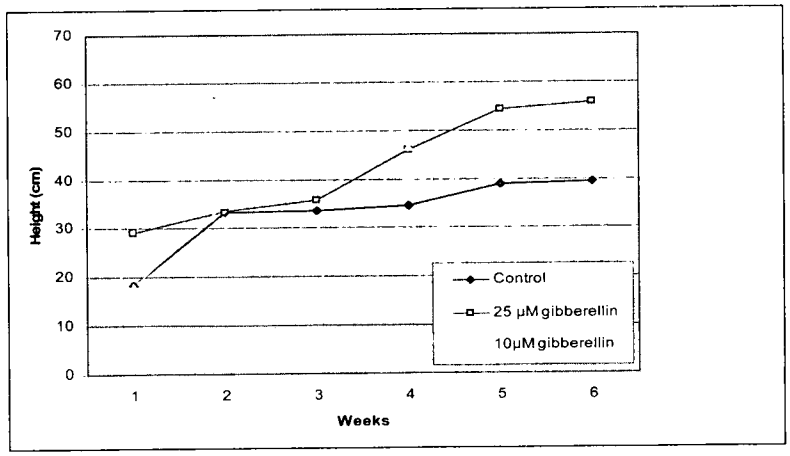


Fig. 1. Positive impact of gibberellin on internode elongation in *Hevea* seedlings

In order to identify *Corynespora* resistant clones by using microsatellite molecular markers, all morphological data on the second selfed progeny of RRIC 103 were recorded. Two distinct groups of plants as complete resistant and susceptible could be identified.

FIELD EXPERIMENTS

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

The annual hand pollination programme was carried out at Nivitigalakele Sub Station. Clones RRISL 2000 and RRISL 211 were used as mother trees and Pollen was collected from RRISL 2001, RRISL 211 and RRII 205. Details on the crosses attempted, the number of pollinations done in each cross, the number of pods harvested and seedlings obtained are given in Table 1. However the success rate was only 0.7%, which was due to heavy rain that prevailed throughout the year which favoured the spread of Phytopthora disease which affected severally on the final fruit set.

Table 1. *Details of 2010 hand pollination Programme at Nivitigalakele Sub Station*

Cross	No. of crosses done	No. of pods harvested	No. of seeds obtained	No. of seedlings raised
RRISL 211 x RRISL 2001	251	01	03	-
RRISL 2001 x RRII 105	2037	14	36	27
RRISL 2001 x RRIC 121	1866	06	18	11
RRISL 2001 x illigemate	Not known	02	06	06
RRISL 2001 x RRISL 211	2019	-	-	-
RRISL 2001 x RRISL 2001	603	-	-	-
Total	6776	23	63	44

(P Seneviratne, S P Withanage, K K Liyanage, K B A Karunasekera, I D M J Sarath Kumara and T M S K Gunasekara)

Evaluation of previous hand pollinated progenies

Small Scale Clone Trials

The details of the small scale clone trials which maintained and monitored during the year under review are given in Table 2.

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

After 17th year girth measurements, it was further confirmed that the girth of HP entry 87-370 (RRISL Centennial clone 3) was significantly higher than the

control clone RRIC 100 (Table 3). But yield data collection was badly affected by high intensity tapping practices adopted by the estate and it was decided to terminate the trial this year.

Table 2. *Details of Small Scale Clone Trials*

HP year	Site	Planting date	Current status
1987	Clyde – Kethhena	May 1993	12th year of tapping
1990	Kuruwita sub station	July 2002	2nd year of tapping
1991	Pallegoda	August 2000	4th year of tapping
	Vogan	November 2000	4th year of tapping
1996	Kuruwita Sub station – I & II	May 1999	5th year of tapping
1997	Clyde – I & II	June 2000	4th year of tapping
1998	N'kele I,II & III	June 2001	3rd year of tapping
	Kuruwita Sub station I,II & III	July 2001	3rd year of tapping
1999	Kuruwita Sub station IV,V & VI	June 2002	1st year of tapping
2000	Arappalakande I-III	May 2003	1st year of tapping
	Delkeith IV & V	June 2003	1st year of tapping
	Elston VIII & IX	July 2003	1st year of tapping
	Nivithigalakele VI & VIII	July 2003	1st year of tapping
2001	Paiyagala I	June 2006	Immature
	Kuruwita Sub station II	July 2006	Immature
2002	Pallegoda I	July 2007	Immature
2002	Eladuwa II	May 2009	Immature
2004	Eladuwa Trial I	July 2009	Immature
2004	Neuchatel Trial II	November 2009	Immature
2007	Kuruwita Sub station (seedlings)	July 2009	Immature

Table 3. *Mean girth of selected HP entries of the 1987 HP progeny planted at Clyde estate in 1993*

Clone	Mean girth (cm)
87-370	85.32^{a}
RRIC100	78.07^{b}
87-364	73.80^{bc}
87-372	71.53^{cd}
87-386	70.30^{cde}

(P Seneviratne, S P Withanage, K K Liyanage, K B A Karunasekera and I D M J Sarath Kumara)

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

The 8th year girth measurements and 2nd year yield data based on eleven test tappings were analyzed (Table 4). The HP entry 90-20 showed the highest girth but lower yield than the control clone RRIC 121 whereas the HP entry 90-21 gave the highest yield though it ranked at 4th place in terms of girth.

Table 4. *Mean girth and yield of top most 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**
90-20	61.5^{a}	90-21	37.20^{a}
90-10	60.31^{ab}	90-1	35.99^{ab}
90-11	58.18^{abc}	90-7	34.64^{ab}
90-21	57.13^{abcd}	90-28	34.29^{abcd}
90-7	55.75^{abcde}	90-10	34.04^{abcde}
90-19	55.69^{abcde}	90-6	31.46^{abcdef}
90-29	55.57^{abcde}	90-27	30.65^{abcdef}
90-4	54.83^{abcde}	90-17	30.64^{abcdef}
RRIC121	54.00^{abcde}	90-4	$28.04^{abcdefgh}$
90-1	53.44^{abcdef}	90-9	$28.04^{abcdefgh}$
90-27	53.37^{abcdef}	90-29	$27.89^{abcdefgh}$
90-23	53.31^{abcdef}	90-8	$27.58^{abcdefgh}$
90-8	$52.81^{abcdefg}$	RRIC121	$26.81^{abcdefgh}$
90-28	52.37^{bcdefg}	90-20	$26.13^{abcdefgh}$

(P Seneviratne, S P Withanage, K B A Karunasekera and H P Pereis)

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

DMRT grouping were done with 10th year girth and 4th year yield for both trials. At Pallegoda (trial 91-01), HP entry 91-21 showed the highest yield but the girth was lower than the first ten clones (Table 5a). Similar pattern was observed at Vogan (trial 91-02) also. There the HP entry 97-62 obtained the highest girth, but the yield was ranked at 10th place (Table 5b).

Table 5a. *Mean girth, yield and the DMRT grouping of top most HP entries of the 1991 HP progeny planted at Pallegoda estate in 200.0*

Mean girth (cm) of 91-01 trial (at Pallegoda estate)		Mean yield (g/t/t) of 91-01trial (at Pallegoda estate)	
Clone	**Girth**	**Clone**	**Yield**
RRISL 205	77.67^{a}	91-21	46.19^{a}
RRIC 121	74.07^{ab}	91-19	41.24^{ab}
91-29	72.10^{abc}	91-2	40.85^{ab}
91-19	70.22^{bcd}	91-1	39.99^{abc}
91-1	68.17^{bcde}	91-4	39.75^{abc}
91-2	67.25^{cdef}	RRIC 121	38.90^{abc}
91-13	67.12^{cdef}	91-8	37.39^{abcd}
91-5	66.00^{cdefg}	91-13	36.15^{abcde}
91-10	65.18^{defg}	91-16	34.373^{abcdef}
91-34	64.75^{defgh}	91-29	$33.04^{abcdefg}$

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

Table 5b. *Mean girth, yield and the DMRT grouping of the best performing HP entries of the 1991 H.P progeny planted at Vogan estate*

Mean girth (cm) of 91-02 trial (at Vogan estate)		Mean yield (g/t/t) of 91-02 trial (at Vogan estate)	
Clone	**Girth**	**Clone**	**Yield**
97-62	82.30^{a}	RRIC 121	73.39^{a}
91-79	76.45^{ab}	91-48	63.88^{ab}
91-79	71.36^{ab}	91-58	60.70^{abc}
RRISL 205	76.07^{abc}	91-79	56.18^{abcd}
RRIC 121	73.46^{bcd}	91-57	54.63^{abcde}
91- 71	68.10^{bcd}	91-86	52.54^{abcde}
91- 63	66.81^{cde}	97-58	52.58^{abcdef}
91-57	66.50^{cde}	91-71	50.46^{abcdef}
97-58	66.06^{cdef}	91-65	50.26^{abcdef}
91.58	64.71^{cdef}	97-62	46.78^{bcdef}

(P Seneviratne, S P Withanage, K K Liyanage, K B A Karunasekera, K W Rupatunga and L S Kariyawasam)

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

In both trials 11^{th} year girth measurements and 5^{th} year yield data based on ten test tappings were grouped using DMRT and first ten superior genotypes were listed accordingly in each trial. In trial 01, highest mean yield was recorded by HP

entry 96-58 though its girth placed on 6th position (Table 6a). HP entry 96-54 achieved the highest yield with 4th highest girth in trial 02 (Table 6b). However, the control clone RRIC 121 still occupied the second highest yield in both trials.

Table 6a. *Mean girth, yield and the DMRT grouping of top most HP entries of the 1996 -01 HP trial planted in 1999*

Mean girth (cm)		Mean yield (g/t/t)	
Clone	**Girth**	**Clone**	**Yield**
96-59	80.53^{a}	96-58	55.76^{a}
96-14	73.18^{ab}	RRIC 121	54.13^{a}
96-15	72.81^{ab}	96-59	44.26^{ab}
96-17	69.14^{abc}	96-14	42.95^{abc}
RRIC 121	69.07^{abc}	96-65	39.80^{abcd}
96-58	64.88^{bcd}	96-15	39.10^{abcd}
96-3	64.45^{bcdef}	96- 3	35.49^{bcde}
RRISL 205	62.40^{bcdef}	96-8	35.15^{bcde}
96-13	62.38^{bcdef}	96-16	33.64^{bcde}
96-31	61.67^{bcdefg}	96-2	33.59^{bcde}
96-2	61.09^{bcdefg}	PB260	33.28^{bcde}

Table 6b. *Mean girth, yield (third year tapping) and the DMRT grouping of the top most HP entries of the 1996-02 HP trial planted in 1999*

Mean girth (cm)		Mean yield (g/t/t)	
Clone	**Girth**	**Clone**	**Yield**
RRIC 121	78.25^{a}	96-54	48.65
96-37	70^{ab}	RRIC 121	42.47
96-45	66.25^{bc}	96 -39	40.86
96-54	65.56^{bcd}	96-20	39.18
96-44	65.23^{bcde}	96-45	37.08
96-47	64.89^{bcde}	96-37	36.00
96-39	64.59^{bcde}	96-33	35.07
RRIC 121	64.32^{bcde}	96-43	35.05
96-26	62.54^{bcdef}	96-47	33.82
96-33	60.40^{bcdefg}	96-26	29.66
96-40	$59.71^{bcdefgh}$	96-44	28.90
RRISL 205	$58.73^{bcdefgh}$	96-40	28.44
96-53	$58.07^{bcdefgh}$	96-53	25.86

(P Seneviratne, S P Withanage, K K Liyanage, K B A Karunasekera, and H P Peries)

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

Table 7 shows the 10th year girth measurements and their DMRT grouping for two trials. However, sufficient number of test tappings could not be done due to heavy rainfall throughout the year. Therefore, mean yields of the 4th year of tapping was not calculated for both trials.

Table 7. *Mean girth of top most HP entries of the 97 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**
97-9	67.96^{a}	RRISL 205	66.92^{a}
97-2	65.73^{ab}	97-67	65.86^{ab}
RRISL 205	64.33^{abc}	97-61	63.78^{abc}
97-10	64.00^{abcd}	97-55	63.39^{abc}
97-19	61.96^{bcde}	97-60	63.15^{abcd}
97-40	61.82^{bcdef}	97-66	62.28^{abcde}
97-23	61.16^{cdefg}	97-64	61.40^{bcdef}
RRIC 121	60.33^{cdefg}	97-79	61.13^{bcdef}
97-26	60.00^{cdefg}	97-56	60.73^{bcdef}

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

Evaluation of 1998 HP entries

Ninth year girth measurements and third year yield were analyzed using Duncan's multiple range test for six trials at two sites separately.

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

The HP entry 98-88 and 98-132 achieved the highest mean girth and yield based on five test tapping in trial 1998-01 (Table 8a) and trial 1998-02 (Table 8b) respectively. Contrary to this in the trial 1998-03, the highest mean girth was recorded for control clone RRISL 205 and highest yield based on ten test tappings was achieved by HP entry 98-133 (Table 8c).

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

Mean yield was based on ten test tappings in all three trials. In trial 1998-04 the HP entry 98-276 recorded significantly a higher girth but not ranked within the first ten entries as far as the yield is concerned. The HP entry 98-105 recorded a significantly higher yield value but the girth was poor (Table 9a). The HP entries 98-80 and HP 98-223 were first in terms of mean yield but obtained the second highest mean girth in trial 1998-05 (Table 9b) and trial 1998-06 (Table 9c) respectively.

Table 8a. *Mean girth, yield and the DMRT grouping of top most HP entries of the 1998-01 HP trial planted at Nivitigalakele Sub station in 2001*

Mean girth (cm)		Mean yield (g/t/t)	
Clone	**Girth**	**Clone**	**yield**
98 – 88	69.25^{a}	98-88	48.91^{a}
98 – 147	64.71^{ab}	98-112	41.46^{ab}
98 – 134	63.73^{abc}	98-99	41.38^{ab}
RRIC 121	62.88^{abcd}	98-137	39.23^{abc}
98-180	62.83^{abcd}	98-108	37.81^{abcd}
RRISL 205	61.73^{bcde}	98-147	36.74^{bcde}
98 -112	61.65^{bcde}	98-134	36.68^{bcde}
RRIC 121	60^{bcdef}	RRIC 121	36.20^{bcdef}
98 – 108	59.43^{bcdefg}	98-100	36.11^{bcdefg}

Table 8b. *Mean girth, yield and the DMRT grouping of top most HP entries of the 1998-02 HP trial planted at Nivitigalakele Sub station in 2001*

Mean girth (cm)		Mean yield (g/t/t)	
Clone	**Girth**	**Clone**	**yield**
98-132	73.82^{a}	98-132	64.64^{a}
98-96	66.38^{a}	98-262	53.39^{b}
98-53	64.53^{bc}	RRIC 121	51.00^{bc}
RRIC 121	64.40^{bc}	98-259	48.46^{bc}
98-129	61.57^{cd}	98-117	44.65^{bcd}
98-159	61.12^{cd}	98-85	43.03^{bcd}
98-85	58.68^{de}	RRIC 130	40.55^{cde}
RRISL 205	57.90^{de}	98-96	37.44^{cde}
98-259	57.71^{de}	98-53	35.24^{defg}
98-117	56.83^{def}	98-159	35.10^{defg}

Table 8c. *Mean girth, yield and the DMRT grouping of top most HP entries of the 1998-03 HP trial planted at Nivitigalakele Sub station in 2001*

Mean girth (cm)		Mean yield (g/t/t)	
Clone	**Girth**	**Clone**	**Girth**
RRISl 205	65.43^{a}	98-133	44.65^{a}
98-280	64.50^{ab}	98-138	43.39^{a}
RRIC 121	64.34^{ab}	RRIC 121	42.92^{a}
98-133	64.30^{ab}	98-228	41.78^{ab}
98-281	61.56^{abc}	98-281	40.55^{ab}
98-151	60.81^{bc}	RRIC 130	39.46^{abc}
98-225	59.93^{cd}	98-269	37.90^{abcd}

Table 8c continued..

Mean girth (cm)		Mean yield (g/t/t)	
Clone	**Girth**	**Clone**	**Girth**
98-269	59.65^{cd}	98-225	34.25^{bcde}
98-197	59.56^{cd}	98-204	31.50^{cdef}
98-260	59.21^{cd}	98-151	31.00^{def}

(P Seneviratne, S P Withanage, K K Liyanage, K B A Karunasekera, I D M J Sarath Kumara, L S Kariyawasam and A K Gamage)

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

Eighth year girth measurements and second year yield data were taken from each trial. Highest girthing HP entries in all three trials (Table 10a) appeared within the first ten entries (Table10 b).

Table 9a. *Mean girth, yield and the DMRT grouping of top most HP entries of the 1998-04 HP trial planted at Kuruwita Sub-station in 2001*

Mean girth (cm)		Mean yield (g/t/t)	
Clone	**Girth**	**Clone**	**Yield**
98-276	69.68^{a}	98-105	53.2^{a}
98-98	63.63^{ab}	98-219	52.56^{a}
RRISL 205	62.40^{bc}	98-230	46.23^{ab}
98-230	61.45^{bcd}	RRIC 121	44.47^{abc}
98-11	60.53^{bcd}	98-124	42.94^{abc}
RRIC 121	60.37^{bcd}	98-237	42.54^{abc}
98-89	60.10^{bcd}	98-89	42.07^{abc}
98-219	59.59^{bcd}	98-143	41.72^{abcd}
98-207	58.55^{bcd}	98-135	38.84^{bcde}
98-83	58.33^{bcd}	98-98	38.35^{bcdef}

Table 9b. *Mean girth, yield and the DMRT grouping of top most HP entries of the 1998-05HP trial planted at Kuruwita Sub-station in 2001*

Mean girth (cm)		Mean yield (g/t/t)	
Clone	**Girth**	**Clone**	**Yield**
98-68	69.27^{a}	98-80	46.59^{a}
98-80	63.17^{b}	98-78	43.44^{ab}
98-50	61.71^{bc}	RRIC 121	41.05^{abc}
98-51	61.64^{bc}	98-70	39.14^{abcd}
98-58	61.40^{bcd}	98-58	38.75^{abcd}
RRISL 205	61.13^{bcde}	98-73	38.47^{abcd}
98-73	58.78^{bcdef}	98-44	35.11^{bcde}
98-54	56.87^{bcdefg}	RRIC 130	34.46^{bcdef}
RRIC 121	56.86^{bcdefg}	98-68	32.81^{bcdef}
98-41	55.50^{cdefg}	98-67	32.68^{bcdef}

Table 9c. *Mean girth, yield and the DMRT grouping of top most HP entries of the 1998-06 HP trial planted at Kuruwita Sub station in 2001*

Mean girth (cm)		Mean yield (g/t/t)	
Clone	**Girth**	**Clone**	**Yield**
RRISL 205	71.09[a]	98-223	43.84[a]
98-223	68.03[ab]	98-278	40.00[ab]
RRIC 121	62.90[bc]	98-19	38.56[abc]
98-154	60.90[cd]	RRIC 121	37.43[abcd]
98-278	57.95[cde]	98-154	36.70[abcde]
98-30	57.69[cde]	98-257	32.62[bcdef]
98-196	57.62[cde]	98-196	29.07[cdefg]
98-19	56.61[cdef]	98-200	29.07[cdefg]
98-23	55.50[defg]	98-18	28.88[cdefg]
98-224	55.40[defg]	RRIC 130	28.62[defgh]

(P Seneviratne, S P Withanage, K K Liyanage, K B A Karunasekera and H P Peries)

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. Seventh year girth measurements and DMRT grouping with the families are given in Table 11. First year yield data were not analyzed due to inadequate number of test tapping carried out.

Table 10a. *Mean girth values of the best performing 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**
99-73	60.75[a]	99-157	69.62[a]	99-189	69.35[a]
99-139	59.81[ab]	99-167	63.85[ab]	99-216	63.87[ab]
99-74	58.92[abc]	99-47	62.31[abc]	99-44	60.62[bc]
99-61	58.00[abcd]	99-159	60.37[abc]	99166	60.31[bcd]
99-67	57.50[abcde]	99-272	58.62[abcd]	99-230	59.43[bcde]
99-55	56.68[abcdef]	99-178	57.18[bcde]	99-64	59.25[bcdef]
99-81	56.37[abcdef]	99-265	56.21[bcdef]	99-63	59.18[bcdefg]
99-43	55.00[abcdefg]	99-242	55.5[bcdefg]	RRIC121	56.35[bcdefg]
99-48	54.62[abcdefgh]	RRISL205	55.00[bcdefgh]	99-156	56.16[bcdefgh]
99-72	54.12[abcdefgh]	99-137	53.35[bcdefghi]	99-78	54.81[bcdefgh]

Table 10b. *Mean yield values of the best performing 1999 HP progeny planted at Kuruwita Sub-station in 2002*

Trial 99-01		Trial 99-02		Trial 99-03	
Clone	**Mean yield based on eleven TTs * (g/t/t)**	**Clone**	**Mean yield based on ten TTs* (g/t/t)**	**Clone**	**Mean yield based on nine TTs* (g/t/t)**
99-55	53.8^{a}	99-272	49.50^{a}	99-166	51.33^{a}
99-67	50.93^{ab}	99-167	48.53^{a}	99-230	49.84^{ab}
99-61	50.08^{abc}	99-157	43.79^{ab}	99-234	40.68^{abc}
99-42	45.31^{abcd}	99-159	43.61^{ab}	99-189	37.27^{bcd}
99-72	43.85^{abcde}	99-161	41.01^{abc}	99-64	34.43^{cde}
99-134	43.00^{abcdef}	RRIC130	40.23^{abcd}	99-216	33.53^{cde}
99-139	42.76^{abcdef}	99-185	39.81^{abcde}	99-93	33.32^{cde}
99-73	$41.82^{abcdefghi}$	99-178	38.50^{abcdef}	RRIC130	33.28^{cde}
99-109	$39.89^{cdefghi}$	99-180	$37.63^{abcdefg}$	99-201	31.76^{cdef}
99-52	$37.09^{cdefghij}$	99-265	$36.72^{abcdefgh}$	99-184	30.19^{cdefg}

*TTs - test tappings

(P Seneviratne, S P Withanage, K K Liyanage, K B A Karunasekera and H P Peries)

Table 11. *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
RRIC 121 × PB 235	56.732^{a}
PB 235 × PB 260	56.36^{a}
PB 235 × RRIC 121	55.41^{ab}
BPM 24 × PB 235	53.08^{abc}
BPM 24 × PB 260	51.71^{bcd}
PB 260 × RRIC 121	51.17^{cd}
RRIC 121 × PB 260	50.48^{cd}
RRIC 121 × GP 36-104	49.44^{cd}
BPM 24 × RRIC 121	48.96^{cd}
BPM 24 × GP 36-104	47.96^{de}
PB 260 × PB 260	44.56^{e}

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

***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. There was no significant difference between family means according to the DMRT grouping derived from seventh year girth

measurements. But mean yield showed difference between families while the family BPM24xPB235 is giving significant higher yield (Table12).

Table 12. *Mean girth and DMRT grouping of families of 2000 HP progeny trail II planted at Arrapalakande estate in 2003*

Family	Mean girth (cm)	Family	Mean yield based on six TTs* (g/t/t)
RRIC 121 × PB 235	54.72[a]	BPM 24 × PB 235	25.19[a]
RRIC 121 × PB 260	54.35[a]	BPM 24 × RRIC 121	23.87[a]
PB 235 × PB 260	54.02[a]	BPM 24 × PB 260	23.51[ab]
BPM 24 × GP 36-104	53.14[a]	BPM 24 × GP 36-104	22.44[ab]
RRIC 121 × GP 36-104	53.10[a]	RRIC 121 × GP 36-104	21.75[ab]
BPM 24 × PB 260	53.00[a]	PB 235 × PB 260	20.92[ab]
BPM 24 × PB 235	52.56[a]	RRIC 121 × PB 235	16.89[ab]
PB 260 × RRIC 121	52.34[a]	PB 260 × RRIC 121	16.47[ab]
BPM 24 × RRIC 121	52.31[a]	RRIC 121 × PB 260	16.01[ab]
PB 235 × RRIC 121	46.25[a]	PB 235 × RRIC 121	11.33[b]

*TTs- test tappings

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

***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. Seventh year girth measurements were taken and top most HP entries and their DMRT rankings are shown in Table 13. However in this trial also first year yield data were not analyzed due to inadequate number of test tappings.

Table 13. *Mean girth of top most 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, S P Withanage, K K Liyanage, K B A Karunasekera and I D M J Sarath Kumara)

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 seventh year girth measurements are given in Table 14. No significant difference was seen between families. Being seedlings high variance was seen even within families. Although the tapping commenced in March, the first year yield data collection was disturbed by the tapping system applied by the Estate which was sorted out towards the end of year.

Table 14. *Mean, minimum, maximum and variance of two families in trial IV at Dalkith estate, planted in 2003*

	Family	
	RRIC 121 × PB 235	**PB 235 × RRIC 121**
Mean (cm)	48.07[a]	50.67[a]
Minimum (cm)	20	21
Maximum (cm)	67.5	78
Variance	106.2	106.00

(P Seneviratne, S P Withanage, K K Liyanage, K B A Karunasekera and A K Gamage)

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

In this trial, 98 genotypes from two families [BPM 24 × PB 260 (53) and RRIC 121 × PB 260 (45)] were planted in a completely randomized design with three single tree plots per clone. Family mean, Variance, Minimum and Maximum values derived from the seventh year girth measurements of two families are given in Table 15.No significant difference in girt was observed between two families. But yield data could not be collected as in the previous trial IV due to the same estate.

Table 15. *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)	45.94[a]	44.11[a]
Minimum (cm)	23.00	20.50
Maximum (cm)	64.00	67.00
Variance	96.5	89.8

(P Seneviratne, S P Withanage, K B A Karunasekera and A K Gamage)

Nivithigalakele substation trial VI and VII - (GPB/BS/HPS/2000/06, GPB/BST/HPS/2000/07)

In trial VI, 46 genotypes from one family with three single tree plots were 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 seventh year girth measurements are given in Table 16.

Table 16. *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)	52.71	56.2
Minimum (cm)	28.5	30.00
Maximum (cm)	72.00	89.5
Variance	106.4	128

(P Seneviratne, S P Withanage, K K Liyanage, K B A Karunasekera and A K Gamage)

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

In trial VIII, 103 genotypes from one family (PB 235 × RRIC 121) with three single tree plots are being tested in a completely randomized design. Mean girth of seventh year shows that they are below the tappable girth (Table 17). In Trial IX, 52 genotypes are derived from 11 families with six single tree plots per genotype in a completely randomized design. Though the trees are seven years old, most of the genotypes have not achieved the trappable girth (Table 18).

Table 17. *Mean, minimum, maximum and variance of trial VIII at Elston estate, planted in 2003*

	Results of the trial VIII PB235XRRIC121
Mean (cm)	48.95
Minimum (cm)	16.00
Maximum (cm)	69.00
Variance	89.9

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 fourth year girth measurements were grouped using the Duncan's multiple range test and the results for each trial and for top most promising HP entries are given in Table19. Although the control clone

RRISL 203 showed poor performance at Payagala estate with compared to Kuruwita estate, overall girthing seems to be better than Kuruwita estate.

Table 18. *Mean and variance of families at Elston estate trials IX planted in 2003*

Parentage (Family)	Mean girth (cm)
BPM 24 × GP 36-104	56.19^{a}
RRIC 121 × GP 36-147	55.11^{ab}
BPM 24 × PB 235	52.98^{ab}
PB 260 × PB 260	52.72^{ab}
RRIC 121 × PB 260	51.6^{ab}
RRIC 121 × PB 235	52.00^{ab}
BPM 24 × PB 260	51.39^{ab}
BPM 24 × RRIC 121	50.50^{ab}
PB 260 × RRIC 121	49.70^{b}
PB 235 × PB 260	49.41^{b}
PB 235 × RRIC 121	49.00^{b}

(P Seneviratne, S P Withanage, K K Liyanage, K B A Karunasekera and H P Peries)

Table 19. *Mean girth of top most HP entries of the 2001 HP progeny planted in 2006*

Payagala estate		Kuruwita sub-station	
Clone	**Girth (cm)**	**Clone**	**Girth (cm)**
2001-110	39.62^{a}	2001-89	35.78^{a}
2001-249	39.33^{ab}	RRISL203	34.76^{ab}
2001-112	38.81^{ab}	2001-185	34.50^{abc}
2001-199	38.75^{ab}	2001-179	34.38^{abc}
2001-257	38.52^{ab}	2001-205	33.92^{abc}
2001-99	38.15^{abc}	2001-207	32.66^{abc}
2001-294	37.68^{abcd}	2001-214	32.50^{abcd}
2001-92	37.45^{abcde}	2001-183	31.83^{abcd}
2001-211	37.39^{abcde}	2001-227	31.41^{abcd}
2001-127	37.28^{abcde}	2001-159	30.97^{bcd}

(P Seneviratne, S P Withanage, K K Liyanage, K B A Karunasekera, T M S K Gunasekera and H P Peries)

Evaluation of 2002 HP clones

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

The third year girth measurements were taken and the mean girth of clones were grouped using the Duncan's Multiple range test and the results are given in Table 20.

Table 20. *Mean girth of top most HP entries of the 2002 HP progeny planted in 2007*

Clone	Mean girth (cm)
2002-17	29.79^{a}
2002-59	28.71^{ab}
2002-24	27.52^{abc}
2002-96	27.45^{abc}
2002-25	27.26^{abc}
2002-26	27.10^{abc}
RRISL 203	27.00^{abc}
2002-69	26.88^{abc}
2002-11	26.80^{abc}
2002-18	26.71^{abc}

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

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

Thirteen genotypes from 2002 hand pollination progeny were planted with two control clones, RRIC 121 and RRISL 203. Randomized block design was used with four replicates per genotype. Replicate size was six. First year girth is shown in Table 21.

Table 21. *Mean girth of top most HP entries of the 2000 HP progeny planted in 2009 at Eladuwa estate*

Clone	Mean girth (cm)
HP 66	12.4^{a}
RRIC 121	11.74^{ab}
HP 138	11.70^{ab}
HP 20	11.58^{ab}
HP 19	10.83^{abc}
HP 9	10.56^{abc}
HP 30	10.46^{abc}
HP 62	10.33^{abcd}
HP 139	10.2^{abcd}
HP 58	9.7^{abcd}

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

Evaluation of 2004 HP clones

Twenty two genotypes from 2004 hand pollination progeny were planted to test

with two control clones *i.e.* RRIC121 and RRISL 203 at two sites. Randomized block design was used with four replicates per genotype. Replicate size was six in both trials.

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

First year girth was taken (Table 22).

Table 22. *Mean girth of top most HP entries of the 2004 HP progeny planted in 2009 at Eladuwa estate*

Clone	Girth (cm)
HP 50	9.3^{a}
RRIC 121	8.5^{ab}
HP 48	7.85^{abc}
HP 228	7.4^{bcd}
HP 320	7.3^{bcd}
HP190	7.2^{bcde}
HP 171	7.17^{bcde}
HP 347	7.15^{bcde}
HP 458	6.98^{bcde}
HP 456	6.97^{bcde}

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

Neuchattle estate trial II (GPB/BST/HPS/2004/01)

First year girth was not taken as the height of most plants was less than 120 cm (P Seneviratne, S P Withanage, K K Liyanage, K B A Karunasekera andl D M J Sarath Kumara).

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

Second year girth data were collected for the seedling progeny and family means are given in Table 23.

Table 23. *Family means of 2007 HP progeny at the Kuruwita Sub-station planted in 2008*

Family	Girth (cm)
RRIC130 × GP 22-137	16.16
RRIC130 × GP 21-163	19.96
RRIC130 × GP 1-2	16.00
RRIC 130 × GP 10-54	15.75
PB 260 × IAN 45/710	14.62
IAN 45/710 × PB 260	14.33

(P Seneviratne, S P Withanage, K K Liyanage, K B A Karunasekera and H P Peries)

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

The tenth year girth measurements were taken during the year (Table 24a). Mean girth for each combination *i.e.* control, monoclonal plots and plots of Bi – and Tri – clones were studied. According to the girth data control Monoclonal plot of RRIC 133 showed the highest growth but it was not significantly different compared to bi clone data of RRIC 121/RRIC 133. Fourth year yield data were also collected during the year and are given in Table 24b. Still RRIC monoclonal 121 gives highest yield and further it shows contribution of RRIC 121 in Bi then Tri clone performances.

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

Tenth year girth measurements were collected from this trial and mean girth values are shown in Table 25a. Girth was measured 150 cm above the graft 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; both showed l higher girth values with respect to their budded stumps. The third year yield data are shown in Table 25b.

Table 24a. *Mean girth of monoclonal, bi-clonal and tri- clonal plots planted at Kuruwita Sub-station in 1999*

Treatment	Mean girth (cm)at 5'
RRIC 133	67.48^{a}
RRIC 121/RRIC 133	66.96^{a}
RRIC 121	66.86^{ab}
RRIC 102/RRIC 121	64.53^{abc}
RRIC 102/ RRIC 133	64.12^{abc}
RRIC 100/RRIC 133	63.98^{abc}
RRIC 100/RRIC 102	63.50^{abc}
RRIC 102/RRIC 121/RRIC 133	62.43^{abc}
RRIC 100/RRIC 133/RRIC 121	62.39^{abc}
RRIC 100/RRIC 102/RRIC 133	61.73^{abc}
RRIC 100/RRIC 102/RRIC 121	61.59^{abc}
RRIC 100/RRIC 121	60.76^{bc}
RRIC 100	60.36^{c}
RRIC 102	59.96^{c}

Table 24b. *Mean yield (g/t/t) of third year tapping of monoclonal, bi-clonal and tri- clonal plots planted at Kuruwita Sub station*

Treatment	Mean yield (g/t/t)
RRIC 121	41.7
RRIC 121/RRIC 133	35.1
RRIC 102/RRIC 121	34.3
RRIC 100/RRIC 121	33.9
RRIC100 x RRIC121 x RRIC133	33.6
RRIC 102/RRIC 121/RRIC 133	30.7
RRIC 100/RRIC 102/RRIC 121	29.7
RRIC 102	25.9
RRIC 102/RRIC 133	25.7
RRIC 133	25.2
RRIC 100/RRIC 133	24.3
RRIC 100	23.9
RRIC 100/RRIC 102/RRIC 133	23.8
RRIC100 x RRIC102	22

(P Seneviratne, S P Withanage, K K Liyanage, K B A Karunasekera and H P Peries)

Table 25a. 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	55.80	PB 86	65.72	PB 86	65.18
RRIC 121	62.97	RRIC 121	62.69	RRIC 121	65.97
PB 28/59	57.71	PB 28/59	62.04	PB 28/59	60.51
RRIC 100	58.17	RRIC 100	67.32	RRIC 100	67.24
PB 260	60.04	PB 260	68.21	PB 260	69.47

Table 25b. *Mean yield for third year tapping (g/t/t) recorded for selected and unselected seedlings and for budded plants*

Budded plants	Yield (g/t/t)	Selected seedlings	Yield (g/t/t)	Unselected seedlings	Yield (g/t/t)
PB 86	27.2	PB 86	27.1	PB 86	26.4
RRIC 121	36.5	RRIC 121	39.8	RRIC 121	28.6
PB 28/59	24.8	PB 28/59	38.1	PB 28/59	28.6
RRIC 100	30	RRIC 100	28.7	RRIC 100	28.2
PB 260	31.8	PB 260	32.7	PB 260	24.8

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

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

Annual girth measurements were taken from all the trials. Table 26a (registered clones) and 25b (unregistered clones) show the girth measurements for the year under review and for the previous two years with the information on planting sites.

Table 26a. *Mean annual girth measurements for registered clones of ECTs (Estate/RRISL collaborative trials)*

Clone	Site	Year of planting	Girth in cm		
			2008	2009	2010
RRISL 201	Tempo	1996	71.65	72.9	74.3
	Kuruwita	1994	72.90	75.5	71.6 (5')
	Salawa	1999	73.15	77.1	76.5 (5')
	Eladuwa	2009	-	-	7.7
RRISL 203	Galewatta	1987	75.0	76.4	
	Monaragala	2009	-	-	6.3
	Eladuwa	2009	-	-	7.4
RRISL 205	Pallegoda	1995	75.0	75.3	745.5
RRISL 206	Pallegoda	1995	69.3	71.4	71.6
	Salawa	1999	61.65	64.5	64.8 (5')
RRISL 207	Dosert division*	2004	34.4	43.0	48.6
RRISL 208	Dartonfield	1994	68.8	69.4	
	Eladuwa	2009	-	-	7.6
RRISL 210	Payagala*	2006	16.25	27.4	38.3
RRISL 211	Dartonfield	1994	66.5	67.0	
RRISL 212	Kuruwita*	2006	13.7	21.0	32.9
RRISL 214	Dosert division*	2004	33.5	42.3	44.9
	Kuruwita*	2006	11.3	17.6	28.3
RRISL 216	Dartonfield	1994	65.85	67.5	
RRISL 217	Kuruwita	1995	60.05	61.4	58.9 (5')
RRISL 219	Dartonfield	1994	69.1	70.2	
	Kuruwita	2008		6.0	13.73
RRISL 223	Galewatte	1994	66.2	67.6	
RRISL 225	Nivitigalakele	2002	53.5	62.1	
RRISL 2000	Pallegoda	1998	70.0	69.2	71.0
	Nivitagalakele	2001	60.10	62.5	64.5
	Dosert division*	2004	38.00	46.2	52.5
	Kuruwita	2005	19.7	30.5	43.4
RRISL 2001	Pallegoda	1995	66.3	66.0	67.0
	Nivitigalakele	2001	56.65	59.2	64.4
	Dosert division*	2004	34.4	42.4	48.7
RRISL 2002	Dosert division*	2004	34.3	41.7	48.3
	Nivitigalakele	2001	57.4	60.6	63.7

Clone	Site	Year of planting	Girth in cm		
			2008	2009	2010
RRISL 2003	Dosert division*	2004	33.4	41.1	47.8
RRISL 2004	Dosert division*	2004	34.3	42.5	47.7
RRISL 2005	Dosert division*	2004	40.23	48.2	51.9
RRISL 2006	Dosert division*	2004	35.5	45.6	51.2
	Monaragala*	2009	-	-	7.9
	Eladuwa*	2009	-	-	9.4
RRII 105	Pallegoda*	1998	55.6	56.4	60.0

* Immature fields

Table 26b. *Mean annual girth measurements of un-registered HP entries selected to ECTs (Estate/ RRISL collaborative trials)*

Clone	Site	Year of planting	Girth in cm		
			2008	2009	2010
78-140	Eladuwa*	2006	15.0	25.6	37.5
78-150	Nivitigalakele*	2006	18.9	33.7	46.3
78-158	Eladuwa*	2006	13.9	24.3	37.7
78-260	Eladuwa*	2006	12.7	21.5	30.7
78-278	Kuruwita*	2006	13.4	22.0	35.1
78-334	Eladuwa*	2006	17.8	32.5	44.5
78-341	Eladuwa*	2006	16.2	30.0	42.3
78-510	Kuruwita*	2006	13.8	23.3	36.9
78-534	Kuruwita*	2006	13.6	22.0	33.9
78-689	Eladuwa*	2006	15.1	27.3	37.8
78-759	Kuruwita*	2006	14.5	23.7	35.8
78-770	Kuruwita*	2006	12.2	20.9	35.6
78-873	Kuruwita*	2006	10.1	17.5	30.5
86-10	Kuruwita*	2009	-	-	6.0
86-87	Kuruwita*	2009	-	-	6.2
87-139	Eladuwa*	2009	-	-	7.3
87-182	Kuruwita*	2008	-	6.0	-
87-235	Kuruwita*	2008	-	4.6	9.4
87-290	Kuruwita*	2008	-	5.2	-
87-370	Kuruwita*	2008	-	6.4	-
	Kuruwita*	2009	-	-	5.7
	Monaragala*	2009	-	-	6.0
	Eladuwa*	2009	-	-	7.2
92-124	Pallegoda*	2007	7.5	13.3	
	Kuruwita*	2007	7.1	12.4	17.3
	Eladuwa*	2009	-	-	7.2
	Monaragala*	2009	-	-	7.9
92-129	Pallegoda*	2007	7.8	13.5	
	Kuruwita*	2007	6.6	11.5	15.6
92-250	Pallegoda*	2007	6.6	12.9	

Clone	Site	Year of planting	Girth in cm		
			2008	2009	2010
92-279	Pallegoda*	2007	7.8	14.0	
92-132	Pallegoda*	2007	6.6	11.6	
	Kuruwita*	2007	7.4	12.0	16.9
	Eladuwa*	2009	-	-	6.9
92-358	Payagala*	2006	17.6	29.9	40.8
	Monaragala*	2009	-	-	7.8
95-33	Kuruwita*	2002	-	-	58.2
95-55	Kuruwita*	2002	-	-	51.5
GP 12-93	Kuruwita*	2006	11.9	19.0	30.8
GP 22-137	Payagala*	2006	13.6	22.4	32.5
GP 44-24	Payagala*	2006	16.0	26.8	37.2
RRIC 100 seedlings	Kuruwita s.s.	2005	20.8	32.7	44.7

* Immature fields

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 27.

Table 27. *Clone, year of tapping, number of tapping days, average yield (g/t/t) and yield/tree/year of ECT trials*

Clone/Selected HP entry	Year of tapping	No. of tapping days	Average g/t/t	Yield/tree/year (Kg)
RRISL 201	09	106	40.3	4.2
RRISL 203	16	131	42.31	7.3
RRISL 205	10	71	37.9	2.7
RRISL 206	10	95	46.1	4.3
RRISL 208	08	131	53.46	5.54
RRISL 211	08	D2*-130	D2- 43.4	(D2)_4.3
RRISL 211	08	D3*-44	D3-48.4	(D3)- 3.78
RRISL 216	08	132	32.8	1.5
RRISL 217	09			
RRISL 219	08	118	27.6	2.4
RRISL 2000	07	91	43.6	3.9
RRISL 2001	10	95	36.5	3.4
RRII 105	07	86	49.2	4.2
95-55	02	85	35.2	2.9
95-33	02	81	23.2	1.8

D2*/D3*- Tapping system

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

Ninth year girth measurements were taken from these trials. Table 28 shows the girth measurements for the year under review and for past two consecutive years. All three clones planted in this trial showed vigorous growth.

Table 28. *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		
		7	8	9
RRISL 201	Kegalle (SRT/01/01)	63.4	67.0	72.1
	Homagama (SRT/01/03)	62.5	66.2	67.9
RRISL 203	Kegalle (SRT/01/01)	58.6	60.6	61.8
	Homagama (SRT/01/03)	54.6	57.8	58.3
RRISL 205	Kegalle (SRT/01/01)	52.8	55.5	58.1
	Homagama (SRT/01/02)	64.8	64.8	67.5

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

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

Eighth year mean girth of the four clones obtained from three sites planted in year 2002 and seventh year girth of clones planted in year 2003 are given in Table 29. Girth measurements of the year under review and those for the previous two years are also given. Collection of yield data was not done properly due to lack of support given by most of small holders and also due to their uncontrollable processing practices.

Table 29. *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.	Girth (cm)			Yield(g/t/t)
		Year			
		6	7	8	8
RRIC 201	Kalutara (SRT/02/02)	55.4	60.7	-	-
	Kalutara (SRT/02/03)	49.8	56.0	-	-
	Kamburupitiya (SRT/03/01)	63.1		64.1	35.1
	Radawela (SRT/03/02)	56.3	-	57.3	-
RRIC 205	Kalutara (SRT/02/02)	56.4	60.4	-	-
	Kalutara (SRT/02/03)	46.9	51.8		-
	Kamburupitiya (SRT/03/01)	58.1	-	59.00	31.6
	Radawela (SRT/03/02)	59.3		62.9	-
RRIC 206	Kalutara (SRT/02/02)	56.5	59.9	-	-
	Kalutara (SRT/02/03)	50.6	55.4		-
	Kamburupitiya (SRT/03/01)	52.4		52.6	34.2
	Radawela (SRT/03/02)	57.0		57.9	-
RRIC 121	Kalutara (SRT/02/02)	43.2	49.9		-
	Kalutara (SRT/02/03)	43.6	48.7		-
	Kamburupitiya (SRT/03/01)	56.4		58.1	42.8
	Radawela (SRT/03/02)	57.3		61.6	-

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

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

Extensive cleaning was done but other maintenance was kept to minimum possible due to lack of funds. Especially the application of fertilizer could not done though planned and also required by the trees. It was confirmed by the JEDB that only 13.75 ha is owned by the Institute.

New plantings

Estate/RRI Collaborative clone trials

Seven estate/RRI collaborative clone trials were established as per the details given in Table 30. It is expected to monitor the performances of newly registered centennial clones/selected HP entries along with few promising clones in RRISL 200 and 2000 series further, at commercial scale. Due to termination of Genetic environment (GXE) trial since 2007, measures were taken to cover up different agro climatic regions by ECT/RRI collaborative trials to carry out further studies on environmental effect on clones and their adaptation ability in that particular environments.

Table 30. *Details of the Estate/RRI collaborative clone trials established during this year*

Estate/Sub station	District	Clone	Agro Climatic Region
We Oya – Yatiyantota	Kegalle	RRISL Centennial 3	Mid county Wet (WM)
Moralioya - Ruwanwella	Kegalle	RRISL 2006 RRISL 208	Mid county Wet (WM)
Edalla – Polgahawela	Kurunegala	RRISL Centennial 3 RRISL Centennial 5	Low country Intermediate (IL)
Katandola –Elpitiya	Galle	RRISL 203 RRISL 2001	Low country Wet (WL)
Damaria B – Passara	Badulla	RRISL 201, RRISL 203, RRISL 208 RRISL 2001 RRISL 2006	Up country Intermediate (IU)
Kuruwita SS	Ratnapura	RRISL Centennial 3 RRISL Centennial 5	Low country Wet (WL)
Muwankanda - Kurungala	Kurunegala	RRISL 203, RRISL 2001	Low country Intermediate (IL)

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

PLANT SCIENCE

Data gathered so far confirmed of high and reliable seed production of clone RRIC 100 in dry areas of the country. A recommendation was made to re-introduce RRIC 100 up to 10% of the total hectarage. Arrangements were made to gradually suspend further planting of clone RRIC 121 which covers more than 30% already.

Trials with different container types and potting mixtures to reduce the top soil requirement were continued. Young buddings of RRIC 121 have performed better than bare roots of the same clone. Trials were continued on the irrigation systems for rubber nurseries and also for plantations in the intermediate zone. A young budding nursery was established at the Moneragala sub station. All rubber nurseries were visited for plant certification. Bud grafting training programmes were conducted for nurseries of RDD, private and RPCs. Farmers in non-traditional areas were trained on field establishment. Budwood of all new clones were issued to stake holders to establish bud wood nurseries.

Only girth data were collected from all crown budding trials. Tree girth, bark thickness and individual tree yield (g/t/t) decreased significantly with the increase in planting density. Comparatively higher YPH values were continued in higher densities.

Different chemical formulae and harvesting methods were tested for TPD affected trees with no promising results. Different frequencies and the lengths of the tapping cut were tested for sustainable high yields and for longer tapping cycles. Effective use of ehephone was investigated. The reasons for low DRC levels reported in some RRIC 102 clearings on different estates were investigated. Tapping quality of the clearings managed by the RPC s was monitored and reports were submitted. About 5000 ha area was covered under this programme. Training programmes were conducted to improve productivity of rubber estates by upgrading the tapping quality through regular monitoring and educating the harvesters. About 2500 new tapping knives were issued to the stake holders. Demonstrations on sealant preparation and fixing rain guards were done. Polythene and poly bag samples were tested for quality assurance. Estimation of the crop in damaged and over exploited areas were undertaken.

Satisfactory crop was harvested from tea, cinnamon and rambutan inter-cropped with rubber. Introducing economically important tree species for the fence of clearings was commenced. Comparative eco-physiological performance of rubber and oil palm were studied. Maintenance of all experimental sites including numbering, weeding and manuring etc .were attended.

PLANT SCIENCE

P Seneviratne

DETAILED REVIEW

Staff

Dr (Mrs) P Seneviratne, Head of the Department, Dr A M W K Seneviratne Botanist, Mrs S A Nakandala, Mr K A G B Amaratunga and Mr T U K Silva Assistant Botanists, 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, R Handapangoda, Technical Officer, Mrs D E Jayawardena and Mrs P D A H M A de Almeida, Clerk Typists were on duty throughout the year.

Mr N M C Nayanakantha continued his postgraduate training in India. Dr A Wickramarathna resigned from the Institute with effect from 02.06.2010.

Research students

- W H R A Dayaratne of Rajarata University of Sri Lanka conducted her final year project on "The reasons for the gap between potential and commercial yields of some rubber clones" under the supervision of Dr (Mrs) P Seneviratne.

- B W A N Baddewithana of Ruhuna University of Sri Lanka conducted his final year project on "The Possible reasons for yield variation in RRIC 102 clearings of *Hevea brasiliensis* Muell. Arg", under the supervision of Dr (Mrs) P Seneviratne.

- H I C Jayasekera of Ruhuna University of Sri Lanka conducted her final year project on "The effect of clone and position of bud on the grafting success and the scion growth of *Hevea brasiliensis* Muell. Arg", under the supervision of Dr (Mrs) P Seneviratne.

Seminars/Training Programmes/Workshops/Exhibitions conducted

Subject/Theme	Number of programmes	Beneficiary/Client	Officers involved
Tapper training programmes	55	RPCs, NIPM Asst. Managers, Factory Officers, Workers, REO's	KAGB Amaratunga RP Karunasena W Karunathilaka

Subject/Theme	Number of programmes	Beneficiary/Client	Officers involved
Bud grafting	10	Smallholders, Estate workers, Farmers and Nursery workers	W Seneviratne, MN de Alwis, LN de Zoysa, R Handapangoda
Rain guards	05	RPCs	RP Karunasena
Immature upkeep and field establishment	03	RPCs	MN de Alwis LN de Zoysa
Immature clone identification	01	RDD and private nursery workers & Smallholders	MN de Alwis, LN de Zoysa R Handapangoda
Nursery management	04	RPCs, University Students, Field Officers of Elston Estate	MN de Alwis, LN de Zoysa R Handapangoda
Rubber harvesting	03	University (Rajarata, Uvawellassa, Sabaragamuwa Wayamba and Kelaniya) and RPCs, Kahawatta, Lalan, Pussella and Kelanivalley	W Senevirathna, KAGB Amaratunga, RP Karunasena, W Karunathilaka
Use of Stimulants	04	Managers, Asst. Managers, Field Officers and Tappers	KAGB Amaratunga
Demonstration of Rubber x Tea intercropping	02	Managers, Kelanivalley Plantation	TUK Silva
Trainer- training programmes on harvesting	12	Managers, Asst. Managers, Field Officers and REOs	KAGB Amaratunga, TUK Silva, RP Karunasena, LS Kariyawasam, RK Samarasekera, MKP Perera, D Pathirana, W Karunathilaka
Rubber Planting	10	Rubber farmers of Moneragala District, organized by SPEnDP	MN de Alwis, LN de Zoysa, R Handapangoda

Seminars/Conferences/Meetings attended

Officer	Subject	Organization
P Seneviratne W Senevirathna	Scientific Committee Meetings	Rubber Research Institute of Sri Lanka
P Seneviratne	Committee Meetings on Agricultural Biotechnology and Plant Breeding	Sri Lanka Council for Agricultural Research Policy
W Senevirathna	Technology Foresight	National Science Foundation
P Seneviratne	Seminar on Biotechnology	National Science Foundation
W Senevirathna	Meeting on SPEnDP Project	IFARD Project
W Senevirathna	Workshop on Adaptation of Best Asian Innovation Practices in the Sri Lankan Context	NASTEC, Ministry of Technology and Research
A Wickramarathna	Workshop on "protein structure and homology modelling"	University of Colombo
SA Nakandala	First Symposium of Land Degradation	SLCARP and Ministry of Environment
P Seneviratne W Senevirathne SA Nakandala KAGB Amaratunga TUK Silva	3rd Plantation Crop Research Symposium	CRI,RRI, TRI & SRI

Visits

Advisory	-	10
Experimental	-	102
Nursery inspection	-	310
Inspection on tapping quality	-	55
Total	-	*477*

LABORATORY INVESTIGATIONS

Tissue culture

***Propagation of clonal* Hevea**

Nodal cuttings were cultured in order to maintain the tissue culture activities. New experiments were not started during the year as the officer-in-charge was reading for his PhD abroad (N M C Nayanakantha, P Seneviratne and G A S Wijesekera).

FIELD EXPERIMENTS

Rubber seed production

Data on flowering and seed production could not be collected as planned during the year under review due to lack of staff and transport facilities.

Re-introduction of clone RRIC 100

Based on the data collected over the years on rubber seed production, a recommendation was made to Regional Plantation Companies and to the Rubber Development Department to make arrangements to include the withdrawn clone RRIC 100 in the budwood nurseries and in clearings up to 10% of the total extent, by planting 33% of the annual replanting hectorage with the clone RRIC 100, for a period of 10 years from the year 2012 (N M C Nayanakantha, P Seneviratne and P D Pathirana).

Clonal propagation

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

Field planted rooted cuttings of clones RRIC 100, RRIC 121 and RRIC 130 have reached an average girth of 56.5 cm at 5' after 8 years of planting. Tapping of these trees was commenced in 2010. Trees of RRIC 121 and RRIC 130 have reached average girth of 59.7 cm and 55.95 cm respectively while the girth of RRIC 100 was only 50 cm at 5' (P Seneviratne and G A S Wijesekera).

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

Several attempts were made to produce plants from the elite tree of clone PB 28/59 through rooted cuttings but so far plants could not be raised (P Seneviratne and G A S Wijesekera).

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

Trees planted in consecutive years from 1991 to 2005 were cut back at 1' and all shoots were removed after collecting data, leaving one shoot for further growth (P Seneviratne and G A S Wijesekera).

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

Girth measurements of trees with different root systems i.e. tap root and fibrous roots, but with same genetic make up are given below. Seedlings with tap roots have given mean girth of 56.4 cm (±5.55), while their corresponding cuttings have given mean girth of 55.4 cm (±6.68) at 5' height (Table 1).

Table 1. *Girth measurements of the trees of the same genetic make up but with different root systems*

Pair No.	Girth of seedling (cm)	Mean girth of the corresponding cutting (cm)
1	68.5	93
2	62.5	75
3	56	40.5
4	65.5	62
5	21	36
6	20	22.5
7	61.3	37
8	54	61.5
9	80	94.5
10	43	20
11	54	72
12	91	52.3
13	57	54.3
Mean	56.45 (±5.55)	55.4 (±6.68)

A RAPD analysis was done to confirm the authenticity of the twin rubber plants, and morphological characteristics were also observed to compare the results of RAPD analysis. According to the results, five pairs gave positive results.

(RAPD analysis was done by Ms K H Subasinghe a final year project student of University of Peradeniya who did her final year project at the Genetics and Plant Breeding Dept) (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 three years of field planting are given in Table 2. A decreasing trend in the girth is seen with increasing time taken for germination. But, as the germination time of all treatments are longer than the expected seven days for normal good quality seeds, the differences among different treatments is minimum. Therefore, it was decided to terminate the data collection (P Seneviratne and G A S Wijesekera).

Budgrafting

Successive grafting - BG/1999/1 - Dartonfield

Another passage was generated during the year. Accordingly 12 successive bud grafting passages have been completed. Arrangements have been made to root the cuttings of different passages to check the rooting ability (P Seneviratne and G A S Wijesekera).

Table 2. *Mean girth of the trees after three years of field planting*

Number of days taken for germination	Mean girth at 4' (cm)	
	RRIC 100	RRIC 102
12/13	23.75	22.9
14/15	21.6	22.25
17	22.1	-
18	22.03	21.2
19	21.3	20.6
20/21	20.7	20.3
22	22.8	21.3
23	23.75	20.4
24	19.4	-
25	-	21.75
26	21.75	-
27	-	17.25
32/49	-	21.6

(P Seneviratne and G A S Wijesekera)

Rejuvenation of budwood plants - Egaloya Rubber Nursery

Two more generations were produced during the year. Altogether 13 successive bud grafting passages have been completed and 10 plants from each clone belong to generations 10,11 and 12 were planted in the budwood nursery at Egaloya. Plants of 13th generation were brought to Dartonfield in order to continue the experiment at Dartonfield (P Seneviratne and G A S Wijesekera).

A new experiment was started to assess the rejuvenation capacity of the first 10 successive grafting passages. 50 seedlings were budgrafted with the budwood of 1-10 generations of all three clones. Sprouting of the scion, scion length, diameter, length of the 1st whorl and the angle between the stock and the scion were measured (Tables 3-6).

Finally all the plants of rejuvenation assessment were field planted in Ablete Estate at Eladuwa.

Table 3. *Sprouting percentage after 10 days of cut back*

Clone	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8	G_9	G_{10}
RRIC 100	75	40	91.7	74.1	73.7	92.5	44	22	20	34.5
RRIC 102	60.6	60.8	76.2	19	78.9	44.5	70.8	72.3	52.8	56.7
RRIC 121	57.1	42.6	78.3	72.7	35.7	61.8	67.4	80.9	86	50

Results indicate that the mean sprouting percentage vary to a greater extent among generations and also among clones. The size of the stock plant decreases with the increase of the generation and this affects the time of sprouting.

Table 4. *Mean scion length after 5 weeks of cut back (cm)*

Clone	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8	G_9	G_{10}
RRIC 100	23.9	23.8	23	27.9	24.1	27.7	21.5	25.8	30.6	30
RRIC 102	32.5	30.8	30.4	32	29.4	26.9	30.3	26.6	28.5	25.1
RRIC 121	24.2	28.1	28.8	26	25	31.3	25.7	29.5	28.2	27.9

Increase in the length of the shoots is seen with the advancement of the generation though it is not as prominent as last year. This increase is not seen in clone RRIC 102 perhaps due to other factors such as bigger size of the mother trees in early generations (Table 4).

Table 5. *Mean diameter of the scion after 05 months of cut back (mm)*

Clone	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8	G_9	G_{10}
RRIC 100	8.09	8	8.53	9.37	8.61	9.4	7.9	-	-	-
RRIC 102	9.48	8.88	9.52	9.85	10.03	9.4	8.85	9	9.89	9.77
RRIC 121	9.57	9.1	10.2	9.36	8.77	10.07	10	10.31	10.18	10.2

The diameter of the shoot increases with the generation for all three clones indicating better growth (Table 5). Among the clones, RRIC 121 has given the highest diameters after 5 months and RRIC 100 has given the lowest.

Table 6. *Angle between the stock and the scion after 5 weeks*

Clone	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8	G_9	G_{10}
RRIC 100	12.5	13.4	12.5	14.6	16.1	12.2	14.4	18.4	21.3	16.9
RRIC 102	22.4	25	27	18.6	26.5	20.2	26.9	26.3	24.1	18.8
RRIC 121	28.1	24	28.4	28.2	23.4	27.7	24.9	21.7	31.9	15.3

A clear decreasing trend in the angle between the stock and the scion is observed in the two clones RRIC 102 and RRIC 121 (Table 6). Angle too is a good indication for rejuvenation.

Root trainers

Details of this experiment were given in the Annual Review for 2007. Mean girth measured at 4' after two years of field planting are given in Table 7 (P Seneviratne and G A S Wijesekera).

Table 7. *Mean girth (cm) measured at 4' after 02 years of field planting*

Container Type		Potting mixture							
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Black polythene	N	6	5	8	8	5	3	7	-
cone shape	mean	13.5	10.4	13.35	13.7	13.3	13.3	15.9	-
(32 cm × 13 cm)	SEM	1.1	1.02	1.07	0.76	0.86	2.4	0.29	-
Black polythene	N	10	6	6	10	3	7	8	4
cone shape	mean	14.1	13.6	12.3	16.04	12.1	13.4	13.6	14.5
(40 cm × 15 cm)	SEM	0.71	0.88	0.93	0.51	0.31	0.97	1.28	1.55
Plastic root trainer	N	2	-	2	4	-	2	-	3
Cone shape	mean	12.5	-	13.5	14.2	-	14.05	-	14.3
(30 cm x 9 cm)	SEM	1.5	-	1.5	0.81	-	1.25	-	2.33
Normal Y/B bag	N	6	7	2	4	17	5	10	-
	mean	13.8	14	14	13.8	13.7	13	12	-
	SEM	0.8	0.89	0.5	0.92	0.68	0.8	0.38	-

Mean girth of the plants show no significant differences as it may be expected after two years. This indicates that either the container type or potting mixture has no effect on plant growth after 02 years of field planting (P Seneviratne and G A S Wijesekera).

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

Details of the experiment were given in the Annual Review for 2009. Plants were bud grafted with the budwood of clone RRISL 210 and the scion growth after 05 months of cut back are given in Table 8.

Table 8. *Growth of the budded plants after 5 months of cut back*

Treatment	% of soil saved (by weight)	Growth of the plants	
		Height (cm)	Diameter (mm)
T_1 Top soil + coconut husks cut into pieces	26	46 (±5.54)	8.6 (±0.35)
T_2 Top soil + two full coconut husks	22	33.3 (±5.84)	9 (±0.39)
T_3 To soil + two coconut husks cut into halves	22	54.1 (±3.65)	9.3 (±0.38)
T_4 Top soil + hole at the base + perforation	-	44.5 (±3.37)	8.8 (±0.39)
T_5 Top soil + hole at the base	-	49.9 (±3.11)	9.1 (±0.31)
T_6 Top soil + perforation (control)	-	43.3 (±3)	8.7 (±0.341)

According to the results top soil per bag can be reduced upto about 25% by weight with coconut husks inserted in the bag. T_1 ,T_2 & T_3 show better growth with compared to control treatment T_6. Coconut husks may improve the condition within the bag on top of its expected benefit of reduction of the amount of soil (Table 8).

As far as the container type is concerned, a bag with a hole at the base of the bag but without perforation has performed better than the control in this study. Bud grafted plants were field planted in Frocester estate for further monitoring (P Seneviratne and G A S Wijesekera).

Effect of the central hole on the coiling of tap root

Bags with ½" and ¾" hole at the bottom were used with normal young budding bags with perforation but no central hole. Average diameter and height of the seedling after 10 weeks of planting are shown in Table 9.

Table 9. *Average diameter and height of the seedlings after 10 weeks of planting*

Treatment	Diameter (mm)	Height (cm)
½ hole at the bottom	6.82 ± 0.09	58.63 ± 1.58
¾ hole at the bottom	6.96 ± 0.1	57.06 ± 1.38
Normal – Young budding	7.24 ± 0.1	61 ± 1.13

Both the girth and the height are slightly higher with normal bag in this experiment. The objective of this is to prevent coiling of the tap root at the base of the bag prior to penetrating to the ground (P Seneviratne and G A S Wijesekera).

Stock - Scion interaction in budded plants

Seedlings of clones RRIC 100, RRIC 121, PB 260 and mixed clones were used as stock plants, while RRIC 102, 100, 121, RRISL 203, 2001, 201 and PB 260 were used as scion clones. Height measurements of the scion shoots are given in Table 10. Plants were field planted at Frocester estate for further monitoring. The diameter values are given in the Table 11.

Table 10. *Mean height of scion shoots after 3 months of cut back (cm)*

Stock	RRIC 102	RRISL 203	RRISL 2001	RRIC 100	RRIC 121	PB 260	RRISL 201
RRIC 100	40.7	29.5	39.8	35.33	-	-	-
RRIC 121	43.6	38.6	40.7	-	33.25	-	-
PB 260	39.2	30.5	39	-	-	31.8	-
Mixed	37.3	37.7	37.2	-	-	-	28.9

Satisfactory growth of scion shoots of clones RRIC 102 and RRISL 2001 is seen among all clones. It is too early to make comments on the interaction.

Table 11. *Mean diameter of scion shoots after 03 months of cut back (mm)*

Stock	RRIC 102	RRISL 203	RRISL 2001	RRIC 100	RRIC 121	PB 260	RRISL 201
RRIC 100	6.92	7.25	7	7.83	-	-	-
RRIC 121	7.6	6.88	6.83	-	6.62	-	-
PB 260	7.4	7.15	7.31	-	-	7.5	-
Mixed	7.55	7.67	7.92	-	-	-	7.32

No significant difference is noticed among the clones of stock and scion for the period under observation (P Seneviratne and G A S Wijesekera).

Irrigation systems for rubber nurseries

Performance tests for sprinkler irrigation systems (Technical & Non-technical)

Trial was carried out at the Kumbukkana government rubber nursery. Wetting pattern and uniformity co-efficient of each sprinkler irrigation system (*i.e.*, technical and non-technical irrigation systems) were calculated. Average wind speed, average temperature and relative humidity were 1.4 m/s, 34.6^{0}C, 48% pattern efficiencies respectively.

Water distribution patterns *i.e.* of technical and non-technical sprinkler irrigation systems varied at different heights (Table 12).

Table 12. *The percentage pattern efficiencies of technical and non-technical sprinkler irrigation systems*

Riser height	Bare land		With plants (Avg. height 109.85 cm, diameter 1.04 cm)- bud grafted stage	
	Technical sprinkler	Non-technical sprinkler	Technical sprinkler	Non-technical sprinkler
1 m	84.4	79.28	-	-
1.5 m	79.79	84.5	72.56	83.1
2 m	79.36	79.1	81.13	78.74

Uniformity co-efficient varied in the range of 79-84% (Table 13) according to the design of the sprinkler nozzle and riser height.

Table 13. *The percentage uniformity co-efficient of technical and non-technical sprinkler irrigation systems*

	Bare land	
Riser height (m)	Technical sprinkler	Non-technical sprinkler
1m	79.90	68.96
1.5m	69.26	76.29
2m	75.25	66.61

Determination of Permanent Wilting Point (PWP)

Pre test for determination of PWP was conducted in the protected house. Young budding plants were taken at two stages (*i.e.* before bud grafting and after bud grafting). The experimental design was Complete Randomized Design (CRD). Half of the plants in the design was irrigated every other day and the other half of plants was not watered until wilting signs appeared.

Both morphological and physiological parameters with respect to the soil moisture were assessed until the plants reached PWP.

Available soil water content at the wilting point of the plant was about 4% and the leaf water potential of the stressed plants at the wilting point decreased with the stress limit range from 20 to 40 bars.

The effect of applying Salicylic acid (SA) on withstanding stress

A pre test was designed with four levels of SA concentrations which were applied as soil drench and foliar spray to the rubber seedlings aged four months. SA concentrations were 0.05, 0.1, 0.5, 1.0 mM and 100ml of the solution was added to each plant. Plants were irrigated for one week and they were kept in the protected house under control environmental conditions. Height of the plants, stem diameter and number of leaves in the upper leaf whirl were recorded. After one week of irrigation, plants were not watered for two weeks except for the control plants. On the 15^{th} day all plants were watered until saturation. All treatments were assessed after reaching field capacity and survival was determined by the ability of plants to regain turgidity and resume normal growth after the stress treatment. Damage was recorded as irreversible wilting.

Two weeks after withholding the watering, the plants not treated with SA as well as those treated with 0.05 mM or 1.0 mM SA lost turgor and turned yellow early in the dry period. But plants subjected to soil drench or foliar spray with 0.1 mM or 0.5 mM SA retained a relatively high degree of turgidity. Plants treated with 0.1 mM and 0.05 mM SA as foliar spray performed well than the soil drenched plants.

However further research is necessary to understand the physiological and biochemical mechanisms by which SA induces tolerance to a variety of environmental stresses (S A Nakandala, P Seneviratne and P D Pathirana).

Agro-management practices for immature rubber under suboptimal conditions in Sri Lanka

An area was selected in Moneragala Sub station, Intermediate zone of Sri Lanka and about 820 plants of RRISL 2000, 2001 and 2004 clones were planted according to the design with the on set of Northeast monsoon. Treatments are porous tube, pitcher/pot irrigation, mulching with rice straw or sugar cane lopping and the control. Plants will be treated according to the design of when the plants are well established in the field, for about 3-4 months.

Pre test was conducted to see the wetting patterns of each treatment *i.e.* porous unit and the pitcher in the 3' height glass tanks filled with soil. Pitchers and porous units were filled with measured amount of water and let to seepage through the dry soil. Wetting patterns of the each system were clearly seen through the glass (S A Nakandala, P Seneviratne and P D Pathirana).

Crown budding

RRIC 110 (1993 and 1995 replantings) - CB/1998/1 - Padukka estate

Girth measurements, numbering and colour banding were done during the year in both Menerigama and Main divisions.

Table 14. *Mean girth and the TPD percentage of RRIC 110 trees crown budded with different clones*

Clearing	Crown	No. of trees	Average girth (cm)	% of brown bast trees
1995-	RRIC 100	96	69.3 ± 1.01	47
RRIC 110	RRIC 102	50	71.11 ± 1.33	57
Menerigama	RRIC 117	57	70.83 ± 1.31	56
Division	RRIC 121	15	82.22 ± 2.11	61
	RRIC 130	35	69.6 ± 1.62	45
	H. spruciana	24	57.9 ± 1.42	78
1993-	RRIC 100	79	60.79 ± 1.09	34
RRIC 110	RRIC 102	52	59.6 ± 1.4	21
Main division	RRIC 117	63	62.12 ± 1.0	20
	RRIC 110 (control)	35	70.42 ± 2.5	30
	H. spruciana	7	63.74 ± 4.22	46

In Menerigama Division, highest girth has been recorded for RRIC 121 whilst *Hevea spruciana* recorded the lowest. In the Main Division highest girth was for RRIC 110 whilst the lowest was for RRIC 102. Higher rate of brown bast was mainly due to the reason of excessive double tapping done by the estate. Yield records could not be taken due to unfavourable weather conditions (P Seneviratne and R K Samarasekera).

RRISL 224 trunk with different crowns (1992 replanting of G&P B Department) - CB/1999/1 - Gallewatta

Girth measurements, colour banding, numbering and yield records were done during the year.

Mean girth and yield of trees with different crowns are given in Table 15.

Table 15. *Mean girth and yield of different crown clones on RRISL 224 as the truck*

Crown	Number of trees	Mean girth (cm) (SEM)	Average yield (g/t/t)
RRIC 100	41	77.18 (± 2.13)	39.5
RRIC 121	39	83.9 (± 2.14)	59.91
H. pauciflora	7	55.37 (± 4.05)	22.5
RRIC 100 + RRIC 121	5	87.78 (± 3.88)	50.8
RRIC 100 + 121 + 102	1	100.9 (±)	48.0

Trees crown budded with RRIC 100 + RRIC 121 + RRIC 102 showed the highest girth whilst *Hevea pauciflora* showed the lowest. Highest yield has been recorded from RRIC 121. The lowest girth and yield have been given from *Hevea pauciflora*. As far as yield is concerned, RRIC 121 shows the best yield (P Seneviratne and R K Samarasekera).

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

Girth measurements, numbering and colour banding were done during the year. Data are shown in Table 16.

Table 16. *Mean girth of different truck* x *crown clone combinations*

Treatment	Trunk clone	Crown clone	No. of trees	Mean girth (cm)	SEM
1	PR 305	Control	26	54.24	± 1.22
	PR 305	RRIM 717	14	49.26	± 1.45
	PR 305	Pollarded	14	51.98	± 1.48
2	RRIM 717	Control	27	55.38	± 1.42
	RRIM 717	PR 305	19	46.27	± 1.80
	RRIM 717	Pollarded	09	55.52	± 2.67
3	BPM 24	Control	09	49.64	± 1.17
	BPM 24	PB 260	01	57.0	-
	BPM 24	Pollarded	08	47.68	± 1.28
4	PB 260	Control	06	63.31	± 2.25
	PB 260	BPM 24	06	52.8	± 3.10
	PB 260	Pollarded	01	57.3	-
5	RRIC 121	Control	11	69.64	± 2.88
	RRIC 121	RRISL 217	07	53.65	± 2.09
	RRIC 121	Pollarded	04	68.17	± 1.75

Treatment	Trunk clone	Crown clone	No. of trees	Mean girth (cm)	SEM
6	RRISL 217	Control	09	61.41	± 2.91
	RRISL 217	RRIC 121	05	53.48	± 2.58
	RRISL 217	Pollarded	09	55.17	± 1.5
7	RRIC 121	Control	15	63.13	± 1.67
	RRIC 121	RRIC 130	02	55.9	± 0.1
	RRIC 121	Pollarded	10	68.48	± 2.95
8	RRIC 130	Control	17	58.32	± 1.52
	RRIC 130	RRIC 121	03	49.8	± 11.05
	RRIC 130	Pollarded	16	57.43	± 1.58

The clone RRIC 121 showed the highest girth whilst the lowest girth was recorded for BPM 24. As far as trunk and crown combinations are concerned, PB 260 crown on BPM 24 trunk showed the highest girth (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, colour banding and numbering were done during the year. Girth measurements and TPD rates are given in Table 17.

Table 17. *Girth of RRIC 130 trees crown budded with RRIC 133, BPM 24, RRII 105 and RRIC 102 control trees*

Clearing	Crown	No. of trees	Mean girth (cm) (SEM)	% TPD trees
1999	RRIC 133	16	66.2 ± 3.02	-
	BPM 24	34	54.7 ± 2.06	-
	RRII 105	36	59.0 ± 2.07	5
	Control(RRIC 102)	21	70.49 ± 4.13	9

Mean girth was highest in control RRIC 102 trees due to continuous growth and lowest was recorded for BPM 24. Yield measurements were not taken due to unfavourable weather conditions (P Seneviratne and R K Samrasekera).

Budwood nurseries

The effect of clone on the amount of budwood

Budwood plants belong to different clones were pollarded and manuared. Data on number of shoots per plant and number of buds per shoot are to be collected (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 of the budwood nurseries at Olikanda, Dartonfield and Dolahena were pollarded and budwood were supplied to stakeholders as given in the Table 18.

Table 18. *Budwood harvested from Dartonfield, Olikanda and Dolahena nurseries*

Clone	Quantity (m)	Stake holder
RRISL 201	10	Opatha Estate
RRISL 203	10	
RRISL 217	10	
RRISL 2001	10	
RRISL 2005	10	
RRISL 2006	10	
RRISL 2001	60	Rubber Development Department for Egaloya Nursery
RRISL 201	30	Plant Science Department for Moneragala
RRISL 203	80	
RRISL 215	30	
RRISL 218	30	
RRISL 2000	25	
RRISL 2001	75	
RRISL 2004	50	
RRISL 2005	55	
RRISL 2006	75	
RRIC 121	35	Soils and Plant Nutrition Department
RRISL 2002	30	Plant Breeding Department
RRISL 2004	60	
RRISL 2005	20	
RRISL 2006	40	
RRISL 203	30	
RRISL 2002	10	Sunnycroft Estate
RRISL 2003	10	
RRISL 2004	10	
RRISL 2005	10	
PB 260	10	
RRISL 203	05	Plant Science Department
RRISL 210	60	
RRISL 2001	05	
RRIC 100	30	Plant Science Department for North planting
RRISL 2001	30	Private Nurseries
RRISL 203	60	

(P Seneviratne and M K P Perera)

Moneragala Substation

Young budding nursery

Preliminary work was completed to expand the young budding nursery to produce 50,000 plants. Half of this quantity is to be established in January next year with seeds collected from Moneragala. About 300 kg of seeds were collected from Kurunagala and 26,000 plants were transplanted into the bags. Manuaring and other agro management practices were done and plants will be grafted in early next year.

Budwood nursery

About 250 plants of clones RRISL 2006, RRISL 2005 and RRISL 201 were added to the budwood nurseries at the substation and about 300 plants of RRIC 100 were successfully bud grafted and ready for field planting in the same budwood nursery (P Seneviratne, S A Nakandala and P D Pathirana).

Monitoring and certification of rubber plants

Nursery inspection and plant certification activities were done throughout the year. Details of the nurseries belong to Regional Plantation Companies (RPC's), government, private sector are given in Tables 19 to 21.

Table 19. *Details of RPC Nurseries established in 2009 Aug., 2010 January & 2010 Aug.*

Regional Plantation Company	Number of estates	Number of nurseries	No. of plants established 2010	Plants certification YB		
				2009Aug.	2010Jan.	Total
Agalawatte	6	6	85000	6000	-	6000
Balangoda	8	18	152500	31600	27850	59450
Lalan	1	3	221000	134000	14000	148000
Elpitiya	3	8	61000	23800	-	23800
Hapugastenna	4	9	187000	52000	23000	75000
Horana	5	14	150275	19300	-	19300
Kahawatte	3	6	145000	25000	33000	58000
Kegalle	13	37	114450	84300	-	84300
Kelani Valley	11	21	278400	81050	-	81050
Kotagala	9	11	119700	15200	-	15200
MalwatteValley	3	10	63000	28700	-	28700
Maturata	2	3	5519	750	-	750
Namunukula	1	1	20000	-	-	-

Regional Plantation Company	Number of estates	Number of nurseries	No. of plants established 2010	Plants certification YB		
				2009Aug.	2010Jan.	Total
Pussellawa	4	10	93475	31400	-	31400
Udapussellawa	1	1	-	4500	-	4500
RRI	3	4	74454	4500	-	4500
Modolsima	1	2	21500	-	6000	6000
JEDB	1	2	21000	-	12200	12200
Total	**79**	**166**	**2000569**	**542100**	**116050**	**658150**

Table 20. *Detail of Government nurseries established in 2009 August, 2010 January and 2010 August*

Name of the nursery	Season	No. of plants established	No. of plants certified
Egaloya	2009 Aug. YB	222563	94183
	2010 Jan. YB	211800	75000
	2010 Aug. YB	225000	-
Gurugoda	2009 Aug. YB	300200	96000
	2010 Jan. YB	211800	65000
	2010 Aug. YB	250000	-
Karapincha	2009 Aug. YB	187000	60000
	2010 Jan. YB	200000	55000
	2010 Aug. YB	222000	-
Meerigama	2009 Aug. YB	200000	122000
	2010 Jan. YB	250000	88000
	2010 Aug. YB	250000	-
Welikadamulla	2009 Aug. YB	300600	160000
	2010 Jan. YB	400000	225000
	2010 Aug. YB	325000	-
Middeiya	2009 Aug. YB	74000	30000
	2010 Jan. YB	120000	30950
	2010 Aug. YB	80000	-
Moneragala	2009 Aug. YB	250000	110000
	2010 Jan. YB	353990	154265
	2010 Aug. YB	317797	-
Grand total		**4105443**	**1365398**

Plant certification could not be done according to the schedule as none of the nurseries produced plants according to the action plan to supply plants for the planting season. Plant establishment is done without a proper plan in government

nurseries. Nursery condition is satisfactory in nurseries under RPC management. Government nurseries showed the lowest productivity. Establishing an unnecessarily a large quantity of plants and poor agro management practices are the main reasons for the low productivity and relatively poor plant quality in government nurseries.

Table 21. *Detail of private nurseries established in 2009 August, 2010 January and 2010 August*

Region	Season & number of nurseries	No. of plants established	Number of plants certified
Kegalle	2009 Aug. YB (39)	468160	254880
	2010 Jan. YB (17)	625000	260000
	2010 Aug. YB (35)	688200	6000
Ratnapura	2009 Aug. YB (13)	174000	88100
	2010 Jan. YB (5)	151000	90500
	2010 Aug. YB (14)	304700	-
Kalutara	2009 Aug. YB (7)	57100	31400
	2010 Jan. YB (1)	22500	13500
	2010 Aug. YB (5)	63000	-
Galle	2009 Aug. YB (4)	14000	1650
	2010 Jan. YB (3)	5000	3000
	2010 Aug. YB (3)	10200	-
Moneragala	2009 Aug. YB (9)	215000	63500
	2010 Jan. YB (18)	857000	139700
	2010 Aug. YB (7)	218000	-
Total		**3872860**	**952230**

(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

Data collection was not done as it was decided to terminate the experiment. Planting with the bag is accepted and practised with many advantages. Further, the effect of the method of planting has more effect on the field establishment of plants and initial growth (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 22.

Table 22. *Mean girth of trees grown under three different soil conditions (SEM values are given in brackets)*

Soil condition of the planting hole	Tapped		Untapped	
	Girth (cm)	Girth increment (cm)	Girth (cm)	Girth increment (cm)
Bad	59.28 (± 0.885)	3.45 (± 0.276)	58.47 (± 0.0.917)	3.268 (± 0.197)
Moderate	60.98 (± 1.287)	3.645 (± 0.308)	60.74 (± 1.322)	3.508 (± 0.224)
Good	59.64 (± 0.566)	2.88 (± 0.137)	58.78 (± 0.824)	3.124 (± 0.183)

Girth increment has been comparable in both tapped and untapped trees. Though the moderate soil types show a little higher girth in both tapped and untapped trees results are not significantly different. Correlation among the initial girth of the trees and the present girth are given in Table 23. Correlations exist though the values are low in the moderate type soils.

Table 23. *Correlation among the current girth and the initial girth*

	Tapped			Untapped		
	Bad	**Moderate**	**Good**	**Bad**	**Moderate**	**Good**
Correlation coefficient (r)	0.443	0.538	0.285	0.315	0.342	0.293
P value	0.0021	0.0026	0.0011	0.006	0.0381	0.0032
Sample size (n)	46	29	128	73	37	99
STDEV	6.003	6.932	6.433	7.823	8.043	8.204

(P Seneviratne and L Zoysa)

Comparison of planting material-PT/Galewatta/2007

The experimental details were given in the Annual Review for 2007. Fertilizer application was done four times during the year and mulching was done at a rate of one Kg of paddy straw/plant.

The girth of the young budding plants and that of the bare root are shown in Figure 1. A significant difference is seen between the young buddings and bare roots of RRIC 121. PB 260 being a vigorous clone show satisfactory growth of bare roots of PB 260. However the casualty rate was very high with bare roots of PB 260 and casualties were supplied throughout the early months of the first year.

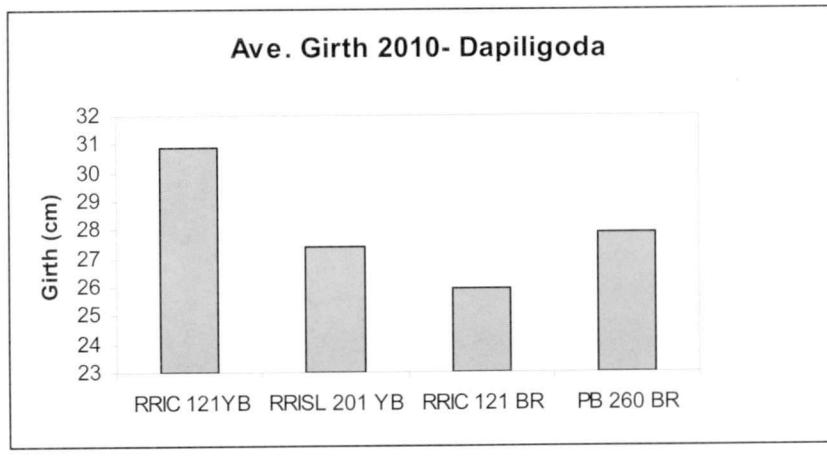


Fig. 1. Girth of the different planting materials (cm) (P Seneviratne and M K P Perera)

Northern Province planting

Plants were grafted at the Welikadamulla RDD nursery and the details of the clearings are as shown in Table 24. Planting commenced from 8.11.2010 to 12.11.2010 under the supervision of the department staff. Details of the farmers are given in the Table 24 and the locations are marked (✡) in the Figure 2 (P Seneviratne, P D Pathirana, M N de Alwis and L Zoysa).

Table 24. *Details of the rubber planting in the North region*

Owner of the land	Number of plants	Clones
Chamith Bandara, Vavunia South, Madukanda	273	RRIC 121, RISL 203, RRISL 2001
Ruwan Jayawardana, Vavunia South, Madukanda	364	RRIC 100, RRIC 121, RISL 203, RRISL 2001
K Kandewalu, Vavunia North, Nadunkani	94	RRIC 100, RRIC 121, RISL 203, RRISL 2001
M Muthukumaran, Vavunia North, Nadunkani	84	RRIC 121, RISL 203, RRISL 2001
Kumaraswami, Oddisudan	113	RRIC 100, RRIC 121, RISL 203, RRISL 2001

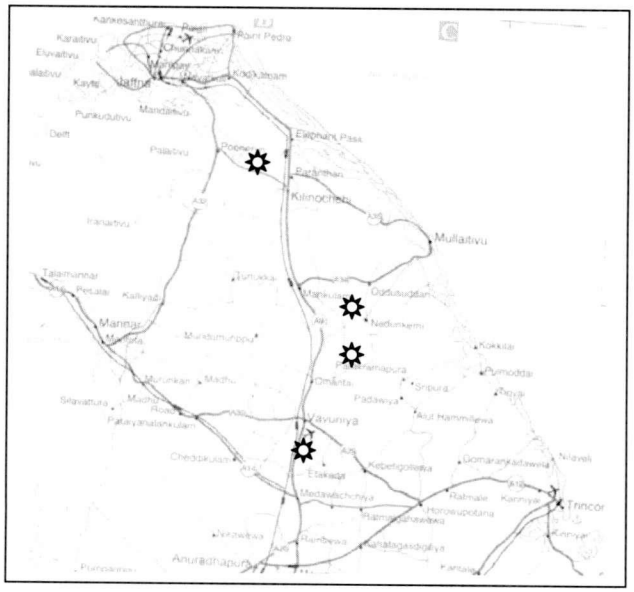


Fig. 2. Approximate locations of planting in the Northern region

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 and yield data collected during the year for clone RRIC 121 and for the mixed clonal area are given in the Table 25.

Table 25. *Mean girth (cm) and mean yield (g/t/t) for clone RRIC 121 and mean girth of 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	28	82.6 (±1.93)	47.3 (±2.55)	11	68.9 (±3.37)
T_2 - Leaves cut	27	81 (±1.71)	53.5 (±2.25)	18	64.3 (±2.38)
T_3 - 3" long apex removed	25	83.6 (±1.74)	46.4 (±1.72)	19	64.3 (±2.47)
T_4 - Control	29	81.3 (±1.39)	46.6 (±2.59)	11	60.7 (±2.38)

As the clearing is 11 years old differences among the treatments seems to have narrowed down. The effect of branching on the tree girth is more apparent and also required during the immature period of the clearing. However, the girth of

control treatments seems to maintain at low levels (P Seneviratne, G A S Wijsesekera and L Zoysa).

Clonal composition in rubber plantations

Clonal composition cannot be updated every year as it is very difficult to collect data on uprooting and replanting. Therefore, the details of the latest clonal composition is what is reported in the Annual review for the year 2009 (P Seneviratne, L Zoysa and G A S Wijsesekera).

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 26 (a). Tree girth and bark thickness have decreased significantly with the increase in planting density. Also, a similar decrease was shown in the individual tree yield (g/t/t). This can be attributed to significantly poor girth and bark thickness in higher planting densities. Although not significant among four planting densities, comparatively higher YPH values were recorded in higher densities due to the higher number of trees per hectare.

Table 26. *Effect of planting density on growth and yield parameters of rubber. In (a) plant girth (cm), bark thickness (mm) at 150cm height and trees in tapping, (b) tree yield (g/t/t) and estimated YPH (kg/ha/year)*

(a)

Density	RRIC 100				RRIC 121			
	Girth (cm)	BT (mm)	% Trees in tapping	Tappable trees/ha	Girth (cm)	BT (mm)	% Trees in tapping	Tappable trees/ha
500	68.69	8.01	70.68	353	78.20	7.61	70.01	350
600	67.15	7.86	68.91	413	74.38	7.21	68.01	408
700	62.07	7.63	68.08	477	71.27	6.98	70.84	496
800	62.05	7.24	74.08	593	69.22	6.87	76.60	613

(b)

Density (tree/ha)	RRIC 100		RRIC 121	
	Yield (g/t/t)	Yield (kg/ha/yr)	Yield (g/t/t)	Yield (kg/ha/yr)
500	18.43	1104	34.82	2002
600	21.24	1451	33.13	2201
700	16.83	1365	29.32	2486
800	14.47	1455	24.36	2496

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

Planting at low density (PT/1996/Gallewatta & 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 (A Nugawela, P Seneviratne and K A G B Amaratunga).

Low DRC in clone RRIC 102

The reason for conducting this study was the low yields reported from some clearings of RRIC 102. One tapping block from 1993 clearing at Dartonfield estate of clone RRIC 102 which is tapped on panel 'B' was selected for data collection. RRIC 100 trees were taken as the control. Metrolac readings were compared with lab DRC and the data are given in Table 27.

Table 27. *Average yield (g/t/t) of RRIC 102 and RRIC 100 trees*

Clone	Vol. (ml)	met	Lab DRC	No. of trees	g/t/t
RRIC 102	4993	70	29.0	50	23.9
RRIC 100	3053	90	33.6	30	28.4

With the collaboration of Soils and Plant Nutrition Department the treatments in the experiment were changed to add kieserite to the normal amount of fertilizer as one treatment. Accordingly three treatments and the details are given below.

T1- RRIC 102 - ½ S d2 + 150 g kieserite + 200g MOP + 200g Urea + 100g Rock Phosphate
T2- RRIC 102 - ½ S d2 + 200 g MOP + 200g Urea + 100g Rock Phosphate
T3- RRIC 100 - ½ S d2 + Normal rubber fertilizer

The results of the pre and post application of fertilizer are given in Table 28. Results should be analysed after the next application of fertilizer.

Table 28. *Volume, metrolac reading, lab DRC and yield of RRIC 102 and control clone RRIC 100*

Clone			Preliminary measurements				After application of fertilizer			
	Treat-ment	No. of trees	Vol (ml)	Met	Lab DRC	g/t/t	Vol (ml)	Met	Lab DRC	g/t/t
RRIC 102	T1	16	767	80	29.2	12.4	1316	100	32.6	24.6
RRIC 102	T2	19	647	80	35.2	9.0	1182	110	34.5	19.9
RRIC 100	T3	30	2055	100	34.0	21.18	2824	120	36.4	32.0

(P Senevirtne, R P Karunasena and R K Samarasekera)

Exploitation

Girth at opening

Objective of this experiment was to enhance return on the investment through opening the trees at a higher girth. Three tapping blocks from 2004 clearing at Pitiakanda estate with clone RRIC 121 were selected for the experiment. Each tapping block was divided into 2 sections and the following treatments were introduced.

Treatments

T1 - Open at 50 cm girth
T2 - Open at 55 cm girth
T3 - Open at 60 cm girth
T4 - T1 together with intensity correction
T5 - T2 together with intensity correction
T6 - T3 together with intensity correction

Trees will be tapped using the system mentioned in Table 29. Stimulant will be applied on the panel and along the taping cut on a width of 2.5 cm band. Latex volume, scrap and DRC will be recorded separately for each treatment. Girth measurements will be made once every six months (A Nugawela, P Senevirtne, R P Karunasena and R K Samarasekera).

Table 29. *Details of the stimulation and tapping system of the experiment*

Tapping system	Actual tapping intensity	Strength of stimulant (%)
½ S d3 + E	63-57	3.75
	56-50	4.25
	49 & below	5.00

Longer tapping cycle through shorter tapping cuts – Pitiyakanda estate

Numbering, colour banding, girth, yield and bark consumption rate measurements were done during the year. Mean girth, bark consumption and yield for the period of January – November 2010 are given in Table 30.

Though g/t/t is high, T3 could not be continued due to uncontrollable poor quality of tapping. There was no significant difference between T1 & T2 treatments. T1 seems better as tapping cycle could be maintained properly. Special attention should be taken on the concentration and the number of stimulation rounds as it affects the period of tapping (P Seneviratne, R P Karunasena and R K Samarasekera).

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

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

Table 30. *Mean girth, bark consumption and yield of the trees of different treatments*

Treatment	No. of trees	Mean girth (cm)	Bark consumption (cm)	No. of tapping days	Average g/t/t
T1- S/4 d3 + 5%E 12/y	46	59.4	28.7	103	25.5
T2- S/3 S d3 + 2.5%E 12/y	52	59	27.6	103	24.1
T3- S/4 d3 (BUT)+5% E 12/y	46	57.3	43.4	103	32.9
T4- S/2 d2 + 2.5% E (5/y)	50	57.9	27.1	103	28.9

Table 31. *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 treatment	Mean for clone	Un tapped
RRIC 102	S/2 d2	0.63	0.84	0.51	0.63		
	S/2 d3	0.64	0.55	0.77	0.65	0.62	1.86
	S/2 d3 + Eth.	0.74	0.49	0.44	0.57		
RRIC 121	S/2 d2	0.83	1.36	0.69	0.96		
	S/2 d3	1.11	0.89	0.46	0.82	0.85	1.74
	S/2 d3 + Eth.	0.51	0.71	1.12	0.78		

The girth of the trees tapped and untapped for the two clones are given in Table 32. However, the girth difference between the tapped and untapped trees of clone RRIC 121 is continued to be low.

Table 32. *Mean girth (cm) of the tapped and untapped trees for the two clones*

Clone	Tapping system	Mean girth increment (cm)					
		G 40	G 45	G 50	Mean for treatment	Mean for clone	Un tapped
RRIC 102	S/2 d2	63.54	62.9	65.56	62.99		
	S/2 d3	62.09	81.37	70.8	71.69	67.09	88.91
	S/2 d3 + Eth.	63.33	61.53*	63.4	66.59		
RRIC 121	S/2 d2	71.34	71.88	68.51	69.81		
	S/2 d3	72.9	73.99	71.82	71.90	70.98	86.16
	S2 d3 + Eth.	65.2	69.84	73.38	71.24		

* RRIC 102 – S/2 d2 + E – G45 – Girth is lower than last year due to losing some treatment trees (P Seneviratne and R P Karunasena)

Shorter replanting cycles – SRP/2007 – Dartonfield

Numbering, colour banding and rain guarding were done during the year. Ethrel application was done in every 3 months during the year. Data for a period of ten months are given in Table 33.

Table 33. *Average yield (g/t/t) for different treatments*

Treatment	No. of tapping days	No. of trees	Av. g/t/t	Crop per year (kg)
T1 - S/4 d1 + 2.5%E + RG	27	20	8.1	2.6
T2 - S/2 d3 + 2.5%E + RG	09	20	14.2	1.5
T3 - S/4 d2 E + RG	13	20	6.6	1.0
T4 – S/4 d1 + E - RG	12	19	6.6	1.0

The clone RRIC 121 which is used in the experiment is normally tapped under 100% intensity. In T2 trees are tapped under 67% intensity with ethrel to get the same yield as 100% intensity. T1 is tapped at 100% but with ethrel it should be 133% and therefore crop must be increased at least by 30%. But the estimated g/t/t could not be harvested. There is no significant difference between the treatments T3 and T4 (P Seneviratne and R K Samarasekera).

Shorter replanting cycles - Sapumalkanda estate

Numbering, colour banding, girth, yield and bark consumption measurements were done during the year. Data collected are given in Table 34.

Table 34. *Mean girth, yield and bark consumption for a period of 11 months*

Clone & clearing	Treatments	No. of trees	Pre treatment g/t/t	Girth at 5 ft. (cm)	Av.No. of tapping days	g/t/t	Crop/year (kg)	Bark consumption %	BB%
RRISL 201	T_1 - S/2 d2	22	18.4	74.8	13	25.0	3.9	38.1	12
& 2001	T_2 - S/2 d1	16	23.5	70.8	24	20.11	5.7	42.2	33
	T_3 – S/2 d3	12	-	66.7	9	38.6	4.1	24.5	7

As far as T_1, T_2 and T_3 are concerned T_2 has given the highest crop, higher incidence of TPD and bark consumption. T_1 & T_3 have given the same crop for the year. When comparing T_1 & T_3, lower BB% and bark consumption rates have been indicated by T_3. The same crop can be harvested from T_3 while maintaining longer tapping cycle and reduced tapping cost (P Seneviratne, R P Karunasena and R K Samaraekara).

Tapping Panel Dryness

Continuous monitoring of TPD (TPD/2002/03)

Data were not taken during the year due to lack of staff (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. Data collected are given in Table 35.

According to the data gathered so far, ¼ S upward cut every other day on the opposite higher panel (T_2) and continuous tapping on the same panel at ½S D/2 (T_1) gave comparable yield which is about one third the yield of healthy trees. However, the cut length of T_2 is about half of that of T_1. Continuous tapping at ¼S D/2 ↓ on the dried panel (T_5) gave no yield throughout (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)

Details of the experiment were given in the Annual Review for 2009.

A summary on average DRC and yield per tree per tapping (g/t/t) in healthy and TPD trees, after 41 and 67 rounds of chemical applications, respectively in healthy and TPD trees, during 13 months of the experimental period is given in the Table 36.

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

Trt.	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Ave.
T_1	15.3	14.9	13.6	11.9	13.9	13.9	10.3	12.3	8.7	7.3	7.5	9.3	10.5	10.8	***11.4***
T_2	13.3	17.2	14.2	10.9	10.9	10.7	8.6	9.5	7.6	6.9	7.5	10.9	10.6	11.0	***10.7***
T_3	4.9	5.2	4.2	2.4	2.9	5.2	3.1	5.5	2.4	2.2	2.0	11.0	6.5	5.2	***4.5***
T_4	5.4	4.5	3.6	3.3	3.2	5.2	2.3	4.7	2.0	1.7	1.8	2.0	1.9	1.8	***3.1***
T_5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	***0.0***
T_6	34.5	40.8	37.3	31.8	40.8	36.6	24.4	28.2	28.9	31.6	30.7	32.4	37.6	39.5	***33.9***

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

Table 36. *A summary on average DRC and yield per tree per tapping (g/t/t) in healthy and TPD trees*

Treatment	Healthy trees			TPD trees		
	DRC	g/t/t	% incr.	DRC	g/t/t	% incr.
T_0	39.6	37.8	0.0	41	1.4	0
T_1	37.1	36.8	-2.6	46	3.6	166
T_2	38.4	42.3	11.9	46	4.9	264
T_3	38.6	38.8	2.6	44	3.0	120

T_0=Control T_1=Vitex T_2=Ethephon T_3=Mortex
(only for first 3½ months)

On healthy trees: During the first two quarters, from April to September 2009, yield of Vitex treated trees has been increased by 22.8% and 27.9% respectively. The magnitude of the yield increase was 4.8 and 8.2 grams per tree per tapping for the two quarters respectively. However, during the third and fourth quarters, yield of Vitex treated trees reduced by 0.5 g (-1.1%) and 12.3 g (-25.8%) respectively. Therefore, the overall yield increase was negligible (0.7g higher in the control) making the two treatments comparable after 13 months of results. Ethephon treated trees showed 12% yield increase over the control trees whilst Mortex (treated only for first 3½ months) showed 2.6% yield increase Table 36.

On TPD trees: Although the yield of TPD trees was low ranging from 0.2 to 8.7 grams per tree per tapping in either treatment, Ethephon Vitex and Mortex treated trees gave comparatively slight increase in yield but was uneconomical (Table 36, 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

The experiment was maintained after submitting the final report of the project. See the publication Senevirathna *et al.* (2010) for the highlight of results (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, annual girth increment and bark thickness measurements taken at the end of the reporting year is given in the Table 37.

Table 37. *Mean girth, annual girth increment and bark thickness of different clones measured at 120 cm height*

Clone	No. of trees	Girth at 120 cm (cm)	Annual girth increment (cm)	Bark thickness at 120 cm (cm)
RRISL 2000	17	34.4 ± 1.75	11.8 ± 0.58	0.46 ± 0.02
RRISL 2001	17	29.9 ± 1.64	9.3 ± 0.59	0.42 ± 0.03
RRISL 2002	15	30.4 ± 1.21	12.1 ± 0.69	0.44 ± 0.02
RRISL 2003	16	29.2 ± 1.59	9.1 ± 0.52	0.38 ± 0.02
RRISL 2004	16	29.0 ± 1.21	9.7 ± 0.48	0.41 ± 0.02
RRISL 2005	18	32.9 ± 1.28	10.2 ± 0.41	0.44 ± 0.02

Annual girth increment was highest in both RRISL 2000 and 2002 clones compared to other clones. However RRISL 2005 also showed a satisfactory girth subsequent to RRISL 2000. Bark thickness showed little difference among the clones (A M W K Senevirathna and W Karunathilake).

New ethrel trial

Details of this experiment were reported in the Annual Review for 2009. The brush size was reduced from ¾" x ½" to ½" x ½" this year. Two treatments with coconut oil maintain high level of brown bast while there is no significant effect for the crop (Table 38).

Table 38. *Yield (g/t/t) and % brown bast (BB) in different treatments before and after stimulation*

Treatment	Before stimulation g/t/t	BB% before stimulation	After stimulation g/t/t	BB% after stimulation	Crop measurements %
T1	34.39	10	55.48	10	61
T2	31.64	3	50.12	3	58
T3	35.12	13	48.42	14	38
T4	26.01	15	37.21	17	43

(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 were given in the annual review for 2002. Growth of rubber with respect to the girth measured at 150 cm height was monitored (Table 39) and that was higher in wider within row systems, *i.e.* T3 and T4. Thickness of virgin bark of rubber behaved similarly among

treatments (Table 40). Trees were rain guarded and tapped with half spiral cut on every three days with five stimulation rounds of Ethephon (S/2 d3 ET2.5%). Daily latex yields and % dry rubber content (%DRC) were monitored. Wider within row systems, *i.e.*, T3 and T4 recorded higher g/t/t values than the other two systems, *i.e.*, T1 and T2 (Table 42). In general, T3 recorded higher YPH values due to the higher g/t/t and higher number of trees in tapping (Table 41 & 42). Basal girth and yield per bush of tea were higher in the wider inter row systems, *i.e.* T2 and T4. These two systems recorded higher tea yield per hectare per year due to the higher yield per bush and the higher stand per hectare (Table 43). Growth and the establishment rates of rambutan and jak were satisfactory and better than that of bud grafted (bg) and seedling (s) durian (Table 44).

Table 39. *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	61.51	60.63	60.81	59.59	64.16
T2 (3m×3m)-18m	64.34	60.83	58.15	57.90	60.00
T3 (3.5m×3.5m)-15m	66.76	64.78	64.07	62.41	61.40
T4 (3.5m×3.5m)-18m	67.58	64.06	62.96	62.93	65.94

Table 40. *Summary of the bark thickness of rubber (mm). Measurements were made at 150 cm height*

Main trts.	Sub treatments				
	Tea	Cinnamon	Durian	Rambutan	Sole rubber
T_1	6.40	6.20	5.87	6.14	6.61
T_2	6.36	6.32	6.35	6.37	6.50
T_3	6.49	6.81	6.43	6.69	6.56
T_4	6.81	6.66	6.71	6.47	6.71

Growing economically important crops along the rubber fence(IC/F/2010)

The objective of this trial was to utilize the fencing space around rubber plantation in a useful manner to generate additional income. The sites have already been selected at Hapugastenna estate, Ratnapura (wet zone) and in the Sub-station of RRI, Moneragala (intermediate zone). In Hapugastenna estate, five hectare land with the clone RRIC 121 planted in September 2010 was selected and five species, *i.e.* cinnamon, areca, rattan, dracaena and cane palm were established in October-November. Establishment of the plants in the site of intermediate zone was postponed to the year 2011 (T U K Silva).

Table 41. *Mean percentage trees in tapping (%TIT) and trees in tapping per hectare (TIT_{ha}) of rubber under different planting systems*

Trt	Tea		Cinnamon		Durian		Rambutan		Sole rubber		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 42. *Mean yield per tree per tapping (g/t/t) and yield per hectare (YPH) of rubber under different planting systems*

Trt	Tea		Cinnamon		Durian		Rambutan		Sole rubber		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	81.93	2622	72.75	2433	71.08	2266	79.63	2314	67.41	2219	74.56	2371
T2	87.15	2469	87.43	2221	87.78	2346	96.97	2553	66.31	1532	85.13	2224
T3	82.52	2421	111.66	3279	99.97	3057	116.20	3282	123.83	3762	106.83	3160
T4	107.00	2442	86.47	2233	120.34	3093	92.13	1949	94.46	1743	100.08	2292

Table 43. *Summary of the growth and yield performance of rehabilitated & unrehabilitated Tea under different planting arrangements of rubber*

Main treatment	Tea growth		Tea yield (green fresh leaves)			
	Basal girth (cm)		Tea (unrehab.)		Tea (rehab.)	
	Tea (unrehab.)	Tea (rehab.)	g/bush/ year	Kg/ha/ year	g/bush/ year	Kg/ha/ year
T1	17.32	15.85	373	3108	450	3750
T2	17.71	16.19	465	4429	550	5238
T3	17.85	15.88	396	3210	502	4070
T4	19.30	17.53	494	4595	561	5218

Table 44. *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	52.86	36.80	11.97	5.20*
T2	54.91	53.00	32.87	16.22
T3	50.71	37.50	22.20	9.59
T4	54.15	36.70	4.95*	18.18

* Plants were re-established in 2007 due to the damage by rabbits
(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 satisfactory. Monitoring of the growth was difficult due to the height of sprawling of canes and inaccessibility. Harvesting of the canes is to be done in due course (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 (Table 45).

The highest g/t/t is also shown by the same spacing treatment (13.2 meters) as shown in Table 46.

Table 45. *The growth of rubber measured as girth in the 12th year*

	Inter row spacing treatment (m)										
Rubber spacing	7.2S	8.4S	9.6S	10.8S	12.0S	13.2S	13.2P	14.4P	15.6P	16.8P	18.0P
Rubber girth (cm)	64.4	66.5	63	69.1	72.3	76.1	68.1	68.4	67.1	67.9	68.0

Table 46. *Rubber yield in grams/tree/tapping under different inter row spacing*

	Inter row spacing treatment (m)										
Rubber spacing	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	49.0	48.3	45.8	53.8	56.5	66.3	44.3	45.3	47.0	44.8	45.8

Bark yield is highest in single row system (spacing 13.2 m). However, there is no clear pattern for the bark yield increment from the lowest to the highest row distance. Among double row two, clear pattern is not seen and highest yield is reported for 15.6 m paired row system (Table 47).

Table 47. *Cinnamon bark yield (Kg/ha) under different inter row spacing (Kuruwita Sub Station)*

	Inter row spacing treatments (m)										
Rubber Spacing	7.2S	8.4S	9.6S	10.8S	12.0S	13.2S	13.2P	14.4P	15.6P	16.8P	18.0P
Bark yield	728.2	780.3	590.6	719.2	689.4	924.2	878.1	796.9	903.7	571.4	642.4

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

(P Seneviratne and M K P Perera).

PLANT PATHOLOGY AND MICROBIOLOGY

Rigidoporus microporus was proven to be pathogenic on the cover crop, Mucuna bractiata. Subsequent studies showed that cross infection rate of R. microporus from Mucuna to rubber and vice versa is very high and this creeper is responsible for spreading white root disease in rubber plantations. Complains were frequently received from growers regarding the mammalian pest attacks and TMTD based repellant was distributed among the growers. The incidence of common canopy diseases were mild throughout the year. White root disease was continued to be a threat to rubber plantations. International workshop on White root disease was conducted with the collaboration of International Rubber Research and Development Board. Island-wide survey of Corynespora leaf fall disease revealed that most of the recommended clones are resistant to the disease. The clone RRISL 201 showed a mild to moderate CLFD level. Several complaints were received for unusual yellowing and buckling of leaves of rubber plants during the wintering.

PLANT PATHOLOGY AND MICROBIOLOGY

W P K Silva

DETAILED REVIEW

Dr C K Jayasinghe, Acting Head of the Department was on duty until September 2010. Dr (Ms) W P K Silva, Head of the Department assumed duties on 1st November 2010 after no-pay leave. Ms T H P S Fernando, Assistant Plant Pathologist and Audio Visual Production Officer, Mr W Amarathunga were on duty throughout the year. Experimental Officers Mr E B Fernando, Mrs B I Thennakoon, Mrs D Siriwardane, Mr C Wijerathna, Mr P Pieris and Mr N Nishantha continued to work in the department.

Seminars/Training Programmes

Dr C K Jayasinghe, Dr W P K Silva 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 Wijeratne 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.

Officers	Subject	Organization
C K Jayasinghe, W P K Silva & T H P S Fernando	WRD Workshop	RRISL & IRRDB
C K Jayasinghe & T H P S Fernando	3rd Symposium on Plantation Crop Research	RRI/ TRI/ CRI/ SRI

Visits

Department staff made following visits during the year.

Experimental	- 198
Advisory	- 37
Other	- 143
Total	**378**

GENERAL

All canopy diseases were mild throughout the year and no new clones were reported to be affected with Corynespora leaf fall disease (CLFD). However, RRISL

201 showed mild to moderate CLF disease severity levels. International workshop on white root disease was conducted with the collaboration of IRRDB. Operations on management of white root disease was continued throughout the year. *Rigidoporus microporus* was proven to be pathogenic on the cover crop, *Mucuna bractiata*. The mammalian pest attacks became a grave threat and research on control of the problem is in progress. Chemical repellant was distributed among the affected farmers.

LABORATORY AND FIELD INVESTIGATIONS

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

Management of Corynespora leaf fall disease under nursery conditions

Previous experiments have shown the efficiency of overhead light shading in the management of CLFD and their effect on other nursery diseases. Testing of different shading levels together with recommended chemical control methods were temporary terminated due to transport problems (T H P S Fernando, C K Jayasinghe, R L C Wijesundera and D Siriwardene).

Management of the bark cracking disorder

Frequent complaints were received from growers regarding the disorder and arrangements were made to advice on detection and chemical control. Routine observations were also made at the experimental sites to monitor the progress in chemical treatments (W P K Silva, C K Jayasinghe and N Nishantha).

Biology of pests (BP/90/1)

***Studies on the epidemiology of* Corynespora cassiicola**

The incidence and severity of CLFD, the effect of other common foliar diseases and weather factors on CLFD was monitored throughout the year using the spore trap and the leaf count methods. As the spore trap was under repairs, data could not be taken continuously (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

Several visits were made to the above nurseries and pollarding and general maintenance was done (W P K Silva, T H P S Fernando, N Nishantha and C Wijeratne).

Screening of the clones against CLFD under field conditions

Screening of clones against CLFD was completed. The clone RRISL 201 showed a mild-moderate disease level (Table 1) (W P K Silva, T H P S Fernando and N Nishantha).

Table 1. *Survey on Corynespora leaf fall disease - 2010*

Clone	ADSI
RRIC 121	0
RRIC 102	0
RRIC 130	0
RRISL 203	0
PB 260	0
RRIC 133	0.67
RRISL 201	1.05
RRISL 205	0
RRISL206	0
RRISL210	NA
RRISL211	0
RRISL215	0
RRISL216	0
RRISL217	0.5
RRISL219	0
RRISL2001	0
RRISL2003	NA
PB 235	0
BPM 24	0
PB 217	0
RRISL 208	1.0
RRISL 220	0
RRISL221	0
RRISL222	0
RRISL223	1.25
RRISL226	0
RRISL2000	0
RRISL2002	NA
RRISL2004	NA
RRISL2005	NA
RRISL2006	NA
GPS 1	0
PB 255	0
PR 255	0
PR 305	0
RRII 105	0.67
RRIM 712	NA
RRISL 200	3.0
RRISL 202	2.67

ADSI - Average Disease Severity Index

N.A. - Not Available: ADSI; 0-free from the disease; 0.01-1.0, slight infections; 1.01-2.0, moderate infections; 2.01-3.0, severe infections

Determination of the reasons for the disparity between* in vitro *and* in vivo *screening tests

Based on the previous studies, it was reported that the clones like RRIC 121 which are presently free from CLFD, succumb to the disease under favourable conditions upon artificial inoculations. Experiments are in progress to find out the host, pathogen and environmental factors affecting the disease establishment under field conditions (T H P S Fernando, C K Jayasinghe, R L C Wijesundara and D Siriwardene).

***Factors affecting the establishment of Corynespora leaf fall disease* – in vitro**

Studies on factors affecting spore production, germination and viability is in progress. The optimum temperature for the production of lesions on detached leaves was 30°C. Lesion production started at 20°C and below 15°C no lesions were observed. A significant reduction in the lesion size was observed at 35°C and no lesions were observed at 40°C (Table 2).

Table 2. *Effect of different temperatures on the production of* Corynespora cassiicola *lesions*

Temperature (^{0}C)	Lesion size
10	No lesions
15	Pin – point size lesions
20	Pin – head size lesions
25	Extended lesions within 2nd or 3rd veins
30	Well extended lesions within 2nd or 3rd veins with profusely grown mycelia
35	Pin head size lesions
40	No lesions

The relative humidity played a major role in the production of lesions of CLFD. At 100% RH, well extended lesions were observed and with the decrease in RH, the sizes of lesions also reduced. No lesion development was observed at or below 88% RH (Table 3) (T H P S Fernando, C K Jayasinghe, R L C Wijesundara and D Siriwardene).

Table 3. *Effect of relative humidity on the production of* C. cassiicola *lesions*

Relative humidity (%)	Lesion size
100%	Well extended lesions with profusely grown mycelium
98%	Well extended lesions
95%	Lesions developed with slight mycelial growth
92%	Lesion sizes reduced restricted lesions (pin head size)
88%	No lesions
75%	No lesions

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

***First report of* Rigidoporus microporus *on* Mucuna bractiata**

Rigidoporus microporus was reported on the creeping cover crop, *Mucuna bractiata* from Sri Lanka for the first time. Isolates were obtained and Koch's postulates have been proven. With the report of the disease, interim circulars were sent to all estate managing companies, Advisory Services Department and Rubber Development Department stating the importance of preliminary practices in the management of WRD (T H P S Fernando, C K Jayasinghe, W P K Silva and C Wijeratne).

***Studies on white root disease with special reference to* Mucuna bractiata**

A survey is in progress to establish WRD infections on the cover crop, Mucuna in the three main rubber growing districts. The study was concentrated on finding out the current disease distribution and the knowledge on the detection of the disease (W P K Silva, T H P S Fernando and C Wijerathna).

***Pathogencity of* R. microporus *on the cover crop,* Mucuna**

The pathogen was isolated from two rubber growing areas, Deraniyagala and Kalutara. Pure cultures were maintained on Malt extract agar. *Mucuna bractiata* seedlings on pots were artificially inoculated using infected rubber root pieces. The Mucuna plants showed the infection one month after inoculation and spread rapidly on the roots. Inspection of the inoculated roots after two months period showed dead roots. No foliar symptoms were visible. It was understood that even though the WRD fungus can be pathogenic on Mucuna, due to the fast growing nature of the creeper foliar symptoms are not visible on the foliage (T H P S Fernando, C K Jayasinghe, W P K Silva and C Wijerathne).

Testing of tree injection method to control WRD

Use of chem.-jet injectors in the chemical treatments against WRD is being tested. The preliminary work has been completed to study the depth of insertation of the injector and time duration taken for the absorption. The experiment is in progress to test the efficiency of the new application technology (C K Jayasinghe, W P K Silva, T H P S Fernando and C Wijerathna).

Rehabilitation of White root diseased field at Deraniyagala region through chemical controlling and timing of bio-control

The fumigation work on the affected cover crop was completed. Affected rubber plants were identified and chemically treated. The adjoining healthy plants were also chemically protected. Sulphur applications were done to enhance the antagonistic micro-organisms. Gliricidia poles have also been established to detect

any remaining inoculums (T H P S Fernando, W P K Silva, C K Jayasinghe and C Wijerathna).

Studies on unusual yellowing and buckling of rubber leaves

Observations were made on frequent complaints received from growers. It was found that the clone RRIC 102, RRISL 203 and RRIC 121 are prone to this disorder during the wintering season (W P K Silva, C K Jayasinghe and N Nishantha).

New alternative hosts for *Corynespora cassiicola*

Ricinus Sp. was identified as an alternative host for *C. cassiicola* (T H P S Fernando, C K Jayasinghe, R L C Wijesundara and D Siriwardene).

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

Repellant was distributed among small holders. All the experimental sites were monitored for their efficiency (C K Jayasinghe, E B Fernando and B I Thennakoon).

Biological control of *Hevea* diseases (BC/89/1)

Development of a successful biological control system to manage cockchafer grubs

A draft project proposal was submitted to TRI with the aim of testing entomopathogenic fungus *Beauveria* Sp. (C K Jayasinghe and N Nishantha).

MISCELLANEOUS

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

Two multiclonal clearings established with resistant to CLFD and susceptible clones to CLFD at Kuruwita substation, Ratnapura are being monitored for average disease severity index (T H P S Fernando, C K Jayasinghe, R L C Wijesundara and D Siriwardene).

Genetic variation in present population of *C. cassiicola* by RAPD's

DNA isolation from the 15 *C. cassiicola* isolates was completed. The reaction conditions for PCR were optimized. Screening of the primers against the different isolates is in progress (T H P S Fernando, C K Jayasinghe, R L C Wijesundara, K Liyanage and D Siriwardene).

SOILS AND PLANT NUTRITION

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.

Field studies and laboratory P fixation studies have indicated that application of HERP is adequate for the growth of young budding plants established in Agalawatta series soils from planting to cut-back stage. Di-ammonium phosphate could be included in the liquid formulation after the cut back stage. It was found that biochar produced from rubber wood could be applied upto 2% (by weight) into young budding polybags with only N and Mg fertilizers. Application of biochar has significantly increased important soil fertility parameters such as pH, cation exchange capacity and organic carbon in addition to available nutrients such as K and Mg. Four emperical models were developed to estimate the N, P, K and Mg uptake of rubber plants during the first four years of immature period using girth of the plant as the independent variable.

Using newly developed Visual Basic computer programme site specific fertilizer recommendations for 7430 hectares of mature rubber were issued. Approximately 150 ha were surveyed for suitability of planting rubber under land selection programme. The Department analyzed approximately 6000 samples (24,000 parameters) for outside organizations including more than 450 fertilizer samples for rubber growers to assure application of good quality fertilizers to their rubber lands.

SOILS AND PLANT NUTRITION

Lalani Samarappuli

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, T Gunatilleke and J A S Chandrasiri and the English Stenographer Mrs L Rupasinghe were on duty throughout the year.

Research students

- K A C Rasanjali from the University of Ruhuna completed her final year project on "Comparison of two *Mucuna* species on their performance as a cover crop for rubber: Contribution to soil fertility" under the supervision of Dr Lalani Samarappuli.

- B J P Baruhupala completed her final year research project of B.Sc. (Agriculture) degree program, University of Ruhuna, Sri Lanka on "Effect of biochar application on some chemical and physical properties of a major rubber growing soil" under the supervision of Dr R S Dharmakeerthi.

- Gayantha Vithanage from the Rajarata University of Sri Lanka completed 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	How best the immature period could be reduced	Scientific Committee Meeting, RRISL
L Samarappuli	Present status of land degradation and its control in rubber plantations	Ministry of Environment

Officer	Subject	Organization
L Samarappuli	Good agricultural practices for soil fertility improvement	Regional Scientific Committee Meeting, RRISL
L Samarappuli	Rubber plantations in Sri Lanka: A sustainable solution for environmental challenges	Soil Science Society of Sri Lanka
L Samarappuli	CDM development in Sri Lanka	Ministry of Environment
RS Dharmakeerthi	Use of biochar as a soil amendment in rubber (*Hevea brasiliensis*) plantations: Effectiveness in young budding polybagged plants	3rd Symposium on Plantation Crop Research. Colombo Sri Lanka, Rubber Research Institute of Sri Lanka
RS Dharmakeerthi	Biochar: An alternative and sustainable technology to improve soil fertility	Fertilizer Day Program on Organic materials as an alternative to chemical fertilizers. Organized by Soil Science Society of Sri Lanka

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, 2010	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 2010	Soil Science Society of Sri Lanka
L Samarappuli and RS Dharmakeerthi	Integrated financing strategy (IFS) for sustainable land management in Sri Lanka	Ministry of Environment
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	4
Rubber Development/Extension Officers	2
University students	5
Diploma students	1

Advisory visits

Client	No. of visits
Plantations	06
Smallholdings	09

LABORATORY AND FIELD INVESTIGATIONS

Soil fertility management

Ground cover management

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 (L Samarappuli, U Mitrasena, A Thewarapperuma and T Gunathilake).

Another experiment was started to study the effectiveness of different maturity stages of *Mucuna* cuttings in producing roots at nodes in order to use as a planting technique. (L Samarappuli, U Mitrasena, A Thewarapperuma and T Gunathilake).

A field experiment is in progress at Payagala estate, Kalutara to compare growth performance of *Mucuna* raised by seeds and cuttings (L Samarappuli, U Mitrasena, A Thewarapperuma and T Gunathilake).

With the objective of distributing *Mucuna* plants among small holders, a programme was initiated with RDD to produce *Mucuna* plants in selected RDD nurseries. Two mother nurseries were established in Attanagalla and Mirigama RDD nurseries. In Ratnapura well established *Mucuna* field was identified as mother nursery (Lalani Samarappuli, P Karunadasa, U Mitrasena, T Gunathilake and T Dissanayake).

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).

Experiment started to study the establishment and growth of *Mucuna* under mature rubber (3 years before uprooting) was terminated. Data are being analysed (Lalani Samarappuli, U Mitrasena and T Gunathillake).

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. The same study was started in different soil series and in different climatic conditions in collaboration with plantation companies (Lalani Samarappuli, P Karunadasa, U Mitrasena and T Gunathilake).

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 1 (Lalani Samarappuli, P Karunadasa, U Mitrasena and T Gunathilake).

Table 1. *Effect of different treatments on growth of rubber plants*

Treatments	Nottinghill 5½ years girth (cm)	Dammeria 5 years girth (cm)	Nalanda 5 years girth (cm)
Control	46.1[a]	39.2[a]	30.3[a]
Gliricidia 450 sticks/ha (single row)	47.4[a]	38.7[a]	32.2[a]
Gliricidia 900 sticks /ha (Double row)	47.3[a]	38.7[a]	33.9[a]

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

Weeds and weed control

Circle weeding

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 (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 was terminated. Data are being analysed (Lalani Samarappuli, T Gunatilleke, A Thevarapperuma and U Mitrasena).

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

Mulching

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. These experiments were terminated. Data are being analysed (Lalani Samarappuli, P Karunadasa and U Mitrasena).

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 2 (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 2. *Effect of different treatments on growth of rubber plants*

Treatments	Nottinghill 5½ years girth (cm)	Dammeria 5 years girth (cm)	Nalanda 5 years girth (cm)
Pueraria	46.1[a]	39.2[a]	30.3[a]
Mucuna	47.7[a]	43.3[a]	34.1[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. This experiment was terminated. Data are being analysed (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Soil moisture stress management in Moneragala

To establish demonstration plots at Moneragala Sub-station, selection of sites was in progress (Lalani Samarappuli, P Karunadasa, U Mitrasena and T Gunathilake).

Planting rubber in Northern part of Sri Lanka with best practices

The portion of rainfall, which reaches the ground, could be lost to the rubber trees depending on the adopted management practices. This would seriously impede the storage of water in the soil and consequently availability of soil moisture during stress periods. Adopting a combination of agronomic practices would, therefore, help to maintain better performance of rubber plants during early establishment period. Organic manure application to planting hole as well as to field plants, mulching, planting tree legumes in between rubber planting rows to create a favourable micro climate and application of sulphate of ammonia based fertilizer are identified and adopted as some of the best practices in rubber plantings in Northern part of Sri Lanka (L Samarappuli, S Dharmakeerthi, P Karunadasa and S N Silva).

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 and was continued (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Fertilizer use and plant nutrition

Fertilizers to nursery plants

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

Biochar (BC) application is believed to improve fertility of degraded tropical soils. The experiment conducted using commercially available timber mill waste charcoal and young budding nursery established at Dartonfield Estate, Agalawatta also confirmed that the pH, CEC and OC content of the soil has increased after 8 months compared to the initial soil (Table 3).

Table 3. *Effect of charcoal addition on some key soil fertility parameters*

	pH		CEC		OC	
	Initial	**8 months**	**Initial**	**8 months**	**Initial**	**8 months**
Without BC	4.87	4.76	5.36	4.66	1.45	1.50
With BC	6.27	5.42	5.22	7.91	1.95	2.60

However, application of 1% charcoal gave no additional benefit to the growth of the seedling or scion compared to the no fertilizer control in all growth parameters measured. Charcoal when applied with 50% of the current fertilizer recommendation significantly improved the growth parameters. However, this treatment also did not record a growth improvement compared to the plants in the corresponding 50% current fertilizer recommendation (Table 4). Growth retardation of the seedling plants could possibly be due to Mn deficiency induced by the increase in soil pH or N

deficiency induced by high C/N ratio or both. However, plant P and K nutrient status was improved due to BC addition (Table 4). The results of this experiment suggested that in future experiments, application of N and Mg fertilizers together with biochar to maintain optimum K/Mg ratio, methods to control pH induces micronutrient deficiencies, effectiveness of different biochar materials and rates should be evaluated.

A second experiment was conducted using biochar produced from rubber wood (BC) using young budding nursery plants at Dartonfield estate, Agalawatta. Different rates of BC (0, 0.5, 1 and 2% by weight) were applied into polybags with and without current fertilizer recommendation or N and Mg fertilizer. Growth paramaters measured indicated that BC when applied with only N and Mg fertilizers gave a similar growth to the plants with current fertilizer recommendation (Fig. 1) (R S Dharmakeerthi, J A S Chandrasiri and V Edirimanne).

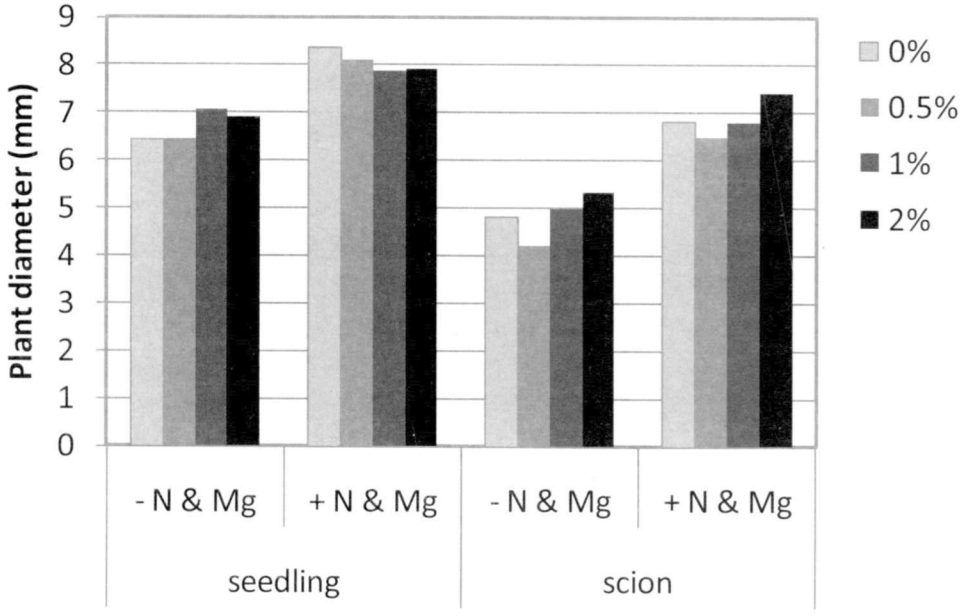


Fig. 1. Effect of the application of different rates of rubber wood biochar on growth of young budding plants with and without N and Mg fertilizers

Investigations on P fertilizer use in young budding nurseries

This experiment further evaluate the usefulness of DAP in liquid formulation when 50g of HERP is applied as a basal dressing 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.

Table 4. *Effect of charcoal addition on growth of young budding plants and leaf nutrient contents*

Treatment		Seedling 3 months		Scion 3 months		Seedling leaves at cut back					
		DIA	LA	DIA	LA	N	P	K	Mg	Mn	Zn
Fertilizer	Charcoal	mm	cm^2	mm	cm^2	%				ppm	
–	–	6.7^{c}	523^{b}	5.8^{a}	285^{b}	1.96^{b}	0.15^{b}	0.70^{c}	0.17^{a}	112^{ab}	59^{a}
100%	–	7.9^{a}	1071^{a}	7.0^{a}	649^{a}	2.98^{a}	0.25^{a}	1.07^{b}	0.15^{a}	171^{a}	62^{a}
–	+	6.8^{c}	630^{b}	6.3^{a}	249^{b}	2.32^{ab}	0.24^{a}	1.31^{a}	0.13^{a}	36^{c}	42^{a}
50%	+	7.5^{b}	1030^{a}	6.9^{a}	729^{a}	2.48^{ab}	0.24^{a}	1.33^{a}	0.17^{a}	101^{b}	29^{a}
50%	–	7.8^{ab}	1150^{a}	6.9^{a}	783^{a}	2.78^{a}	0.19^{ab}	1.04^{b}	0.17^{a}	119^{ab}	50^{a}

DIA – diameter, LA – leaf area per plant,
Values with same superscript in a column is not significantly different at $p<0.05$

Mean diameter of seedlings after the 14th week is shown in Table 5. Application of different phosphorous fertilizers showed a significant effect ($P<0.05$) on seedlings diameter at the 14th week after planting. Application of HERP as phosphorous fertilizer has significantly increased the seedling diameter. The response of seedling diameter to HERP only treatment was greater compared to other phosphorous levels. There were no significant difference in shoot and root growth between HERP only and HERP+DAP applied plants.

Table 5. *Effect of HERP and DAP on mean height and diameter of the seedlings and the scion in young budding plants established on Agalawatta series soils*

Treatment	Seedling (at 14th week)				Scion (at 8th week)	
	Height (cm)	Diameter (mm)	Root DM g/plant	Shoot DM g/plant	Height (cm)	Diameter (mm)
No P fertilizer	59^{a}	6.8^{c}	7.7^{a}	13.4^{b}	14^{a}	4.1^{b}
50g HERP as a basal dressing	63^{a}	7.7^{a}	9.2^{a}	18.5^{a}	14^{a}	4.7^{ab}
50g HERP + DAP (current fertilizer recommendation)	56^{a}	7.4^{ab}	7.5^{a}	16.0^{ab}	14^{a}	5.5^{a}
DAP in liquid mixture	60^{a}	7.2^{bc}	8.3^{a}	13.5^{b}	13^{a}	5.0^{a}

Phosporous fixation capacity was measured by adding different quantities of P (0, 20, 40, 80, 160, and 320 ppm) and then measuring available P contents after incubating 3-5 days. A very high variation among rubber growing soils was observed (Fig. 2). These data indicated that application of 10 to 180 ppm of P in readily available form could increase the available P content beyond 50ppm. Past studies revealed that application of 50g of HERP could increase the available P content in the young budding polybags over 600 ppm soon after application and even though they get fixed rapidly in wet zone rubber growing soils when the available P contents were measured even after 2 months, it was still more than 100 ppm. These results support the poor response of young budding plants to HERP+DAP treatment prior to cut back stage (R S Dharmakeerthi, C K Maheepala, J A S Chandrasiri and V Edirimanne).

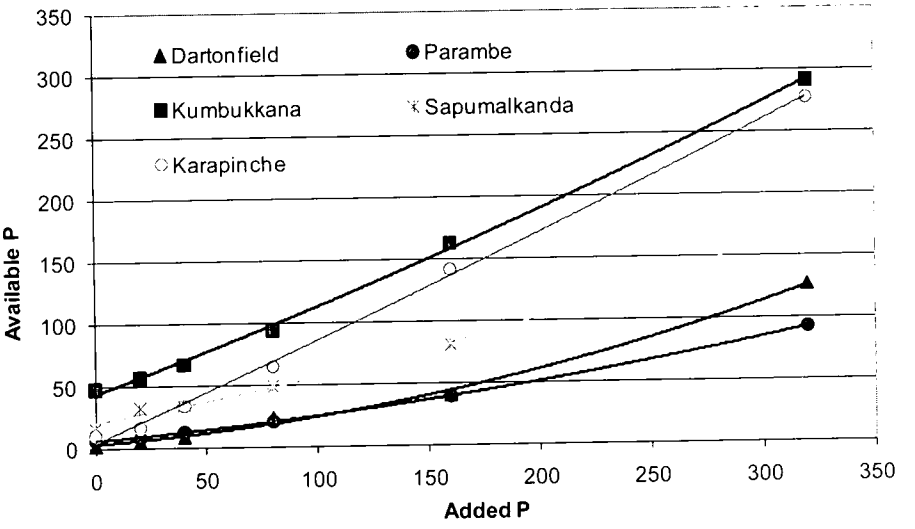


Fig 2. Phosphorus fixation curves developed for different five soils collected from rubber growing areas

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 4½ years after planting are presented in Table 6 for Nottinghill estate. Leaf N, P, K and Mg for Clyde estate are presented in Table 7 (Lalani Samarappuli, P Karunadasa, U Mitrasena and T Gunathilake).

Table 6. *Girth of rubber plants (cm)*

Treatments	Girth (cm)
Control	40.2^{b}
4 applications/yr & 2 ft. away	43.1^{ab}
4 applications/yr & 2½ ft. away	44.5^{a}
2 applications/yr & 2 ft. away	41.4^{b}
2 applications/yr & 2½ ft. away	42.8^{ab}

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

Table 7. *Leaf N, P, K and Mg of rubber plants*

Treatments	N (%)	P (%)	K (%)	Mg (%)
Control	3.1[a]	0.252[ab]	0.655[a]	0.172[a]
4 applications/yr & 2 ft. away	2.9[a]	0.247[b]	0.677[a]	0.177[a]
4 applications/yr & 2½ ft. away	3.3[a]	0.257[ab]	0.702[a]	0.175[a]
2 applications/yr & 2 ft. away	3.2[a]	0.252[ab]	0.660[a]	0.187[a]
2 applications/yr & 2½ ft. away	2.9[a]	0.267[a]	0.730[a]	0.187[a]

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

K and Mg requirement of RRIC 102 clone

The clone RRIC 102 appears to be very sensitive to Mg deficient conditions. Several experiments were carried out to determine effect of K and Mg on gwoth and yield of RRIC 102 clone established at the Sapumalkanda Estate and Illukatenna estates of the Lalan Rubbers (Pvt.) Ltd. and Regina Estate Dodangoda. Experiment carried out at the Sapumalkanda Estate with 2006 replanting indicated that increasing K levels beyond the currently recommended levels has a positive impact both on the growth and leaf K contents when Mg levels are at currently recommended level (Table 8). Application of Mg more than the currently recommended level appears to have a positive response on the growth of RRIC 102 clone during the immature phase.

Table 8. *Effect of K and Mg levels on the girth increment and leaf K and Mg levels during the 3rd and 4th year after planting (i.e 1st and 2nd year after the treatment initiation)*

Treatment level		Girth increment (cm)			Leaf 4th year	
K	Mg	3rd year	4th year	Total	K (%)	Mg (%)
1	1	11.6	10.5	22.1	0.89	0.20
1	2	12.4	11.1	23.5	0.84	0.19
2	1	11.3	12.8	24.1	1.03	0.19
2	2	11.9	10.6	22.6	0.83	0.16

Experiments conducted using mature RRIC 102 replantings established in Illukatenna estate and Regina Estates indicated that application of K or Mg at higher levels did not influence the g/t/t of the plant (Table 9) (R S Dharmakeerthi, S N Silva and C K Maheepala).

Table 9. *Effect of K and Mg levels on average g/t/t of RRIC 102 measured during 2008, 2009 and 2010*

Treatment level		2008	2009	2010
K	Mg			
		Illuktenna Estate 1997		
1	1	21.8	16.0	14.6
1	2	21.4	14.6	13.1
2	1	21.4	15.7	14.8
2	2	25.7	15.8	14.1
		Regina Estate 1996		
-	0	-	-	25.9
-	1	-	-	27.4

Fertilizers to mature rubber

Leaf NPKMg status of mature rubber

Variation in leaf nutrient status of mature rubber is being studied using the soil and foliar survey data base (L Samarappuli and T Dissanayake).

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 sufficiency or deficiency under different soil groups (R P Hettiarachchi, L Samarappuli, U Mitrasena and T Gunathilake).

Fertilizer requirement of new clones

Trials conducted in Monaragala

The experiment to evaluate the fertilizer requirement of two *Hevea* clones grown in Monaragala region was continued for the sixth year at the Kumarawatta Estate. Growth measurements made at the end of 6th year indicated significant differences among fertilizer levels and clones (Table 10). Data suggests that application at currently practiced level is adequate for 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 10. *Effect of fertilizer mixture, fertilizer level and clone on the growth of* Hevea *after 6 years of planting in Monaragala*

Fertilizer mixture	Girth (cm)	Fertilizer level	Girth (cm)	Clone	Girth (cm)
R/U/12:14:14+Mg	41.3	No fertilizer	37.5	RRISL 203	40.5
R/U/15:15:7+Mg	40.9	100% current recommendation	43.0	RRIC 121	41.4
R/U/12:14:14	41.2	200% current recommendation	42.7		
R/U/15:15:7	41.4				

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

Since there is no system for site-specific fertilizer recommendation for immature rubber, this study attempted to develop a protocol based on simple parameters. Eleven fertilizer experiments were conducted from the year 2006 to 2009 in two agroecological regions (Wet Zone and Intermediate Zone) with two clones (RRIC 121 and RRISL 203). Plants at different ages were fertilized with different levels of the currently recommended fertilizer mixture (0, 0.5, 1, 1.5 and 2 times the currently recommended levels). Sites were characterized for fertility parameters and initial leaf nutrient status was also measured. Girth responses of the plants were then monitored for two or three years. Total N, P, K and Mg uptake by 2 and 4 year old rubber plants were also estimated.

Girth response to fertilizer ranged from 0-2 cm/year. There were significant clonal and site variations in rate of girthing and total nutrient uptake. Girth after one or two year period was very strongly related to initial girth and the girth response to fertilizer did not vary with the initial girth of the plant. Models were developed to estimate the nutrient uptake pattern by the rubber plant during the immature period using the girth of the plant (Fig. 3). Fertilizer uptake efficiency were very low and ranged from 8-60%, 1-12%, 6-26% and 5-33% for N, P, K and Mg, respectively in situations where there was a significant girth response to fertilizer (R S Dharmakeerthi, V H L Rodrigo, S N Silva, C K Maheepala, V Edirimanne and J A S Chandrasiri).

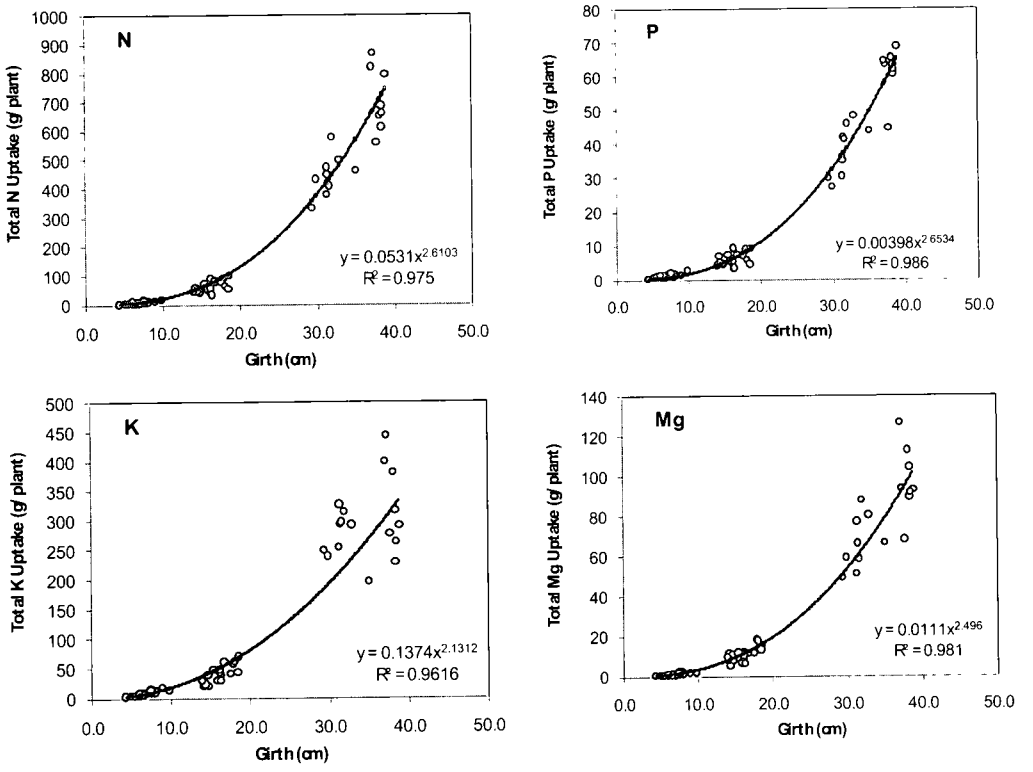


Fig. 3. Relationship between girth of the plant to total N, P, K and Mg uptake. Solid line indicates the developed regression model

Organic fertilizers

Immature stage

Two 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 at 7½ years after planting in experiment at Pitiyakanda estate and girth at 6 years after planting in experiment at Bibile estate are presented in Tables 11 and 12, respectively (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 11. *Effect of different treatments on growth of rubber plants*

Treatment	Girth (cm)
Nil (control)	57.8[a]
EM treated paddy straw	61.5[a]
Burned paddy husk	59.6[a]
Coconut husk	61.5[a]

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

Table 12. *Effect of different treatments on growth of rubber plants*

Treatment	Girth (cm)
Nil (control)	37.3[b]
Burned paddy husk	39.0[ab]
Paddy straw	40.6[a]
Green manure	41.6[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 13 (Lalani Samarappuli, P Karunadasa and T Dissanayake).

Table 13. *Effect of different treatments on yield of rubber*

Treatment	2006 (g/t/t)	2007 (g/t/t)
Chemical fertilizer only	27.3	34.2
Organic fertilizer only	27.0	28.1

Biofertilizer

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 were evaluated in this experiment. The effect of biofertilizers on shoot growth of YB plants were determined in this study. Growth of the seedlings (Table 14) indicates that the commercially available biofertilizers have not improved the growth of young budding

seedlings. When compared with either no fertilizer control or the current or the 50% of the current fertilizer recommendation (R P Hettiarachchi, R S Dharmakeerthi and V Edirimanna).

Table 14. *Effect of commercially available biofertilizers on growth measurements of young budding plants*

Treatments	Seedling growth measurements			
	Height/cm		Diameter/mm	
	08 weeks	12 weeks	08 weeks	12 weeks
1 S+C	40.45	58.9[a]	4.53	5.49
2 S+C+H	43.40	62[a]	4.45	5.61
3 S+C+H+F	43.60	73.90[a]	4.53	5.78
4 S+C+H+F (without DAP + additional SA) + BP	40.55	69.40[a]	4.44	5.85
5 S+C+H+F (without SA) + BG	38.65	63.25[a]	4.36	5.62
6 S+C+H+F+BG+BP	41.45	70.55[b]	4.51	5.90
7 S+C+H+BG+BP	39.25	59.75[b]	4.41	5.09
8 S+C+H+1/2F +BG+BP	39.10	66.10[b]	4.21	5.36
9 S+C+H+F (without DAP + SA) +BG+BP	39.70	59.25[b]	4.44	5.39
10 S+C+H+F (without DAP + SA) +BG	40.60	60.80[b]	4.34	5.22

S = Soil C = Compost (50g/bag) H = HERP(50g/bag)
F = Current fertilizer recommendation (SA, DAP, SOP, ES)
BG = (Bio-Gold) a N-fixing biofertilizer
BP = (Bio-Phos) Phosphorus solubilizing 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. Some biofilms have found to be very efficient P solubilizars of phosphate rock sources and N fixers. Studies are being conducted inorder to produce that could be used to increase the fertilizer use efficiency in rubber plantations. This project was carried out in collaboration with the Institute of Fundamental Studies, Hantana, Kandy and the Plant Pathology and Microbiology Dept. of RRISL.

Isolation of potential microbes

Bacteria and fungi associated with rubber roots collected from a rubber plantation in Moneragala were isolated. Initially, root samples were collected and the isolation of pure cultures of bacteria and fungi were separately sub cultured on NA (nutrient agar) and PDA (potato dextrose agar) plates. The isolated microbes

consisted of 20 bacteria and 03 fungi. Bacterial cultures were screened by Gram staining, acetylene reduction assay, pH and turbidity development of the growth medium in order to identify possible biofilm forming bacteria. This isolated 10 potential bacteria. Most of the isolated bacteria are Gram negative and they show the ability to perform low pH values in the growth medium. Considering these factors, pure isolates of bacteria and fungi were co-cultured. One effective biofilm was detected and the effectiveness of formulated biofilm will be monitored in future studies (Table 15) (R P Hettiarachchi, G Seneviratne and R S Dharmakeerthi).

Table 15. *Results of gram staining, pH and turbidity of some selected bacterial mono cultures isolated from roots*

Bacteria	Gram staining (+/-)	Ph	Turbidity
B1	Positive	6.3	LESS
B2	Positive	5.9	LESS
B3	Negative	4.09	HIFH
B4	Negative	4.26	HIGH
B5	Negative	6.35	NO
B6	Negative	3.94	NO
B7	Negative	4.05	NO
B8	Positive	6.42	NO
B9	Negative	3.46	LESS
B10	Negative	5.57	NO

Site-specific fertilizer recommendation by soil and foliar survey program

Under this programme about 7430 hectares of mature rubber fields were surveyed and fertilizer recommendations were given for the next three years (L Samarappuli, A Thewarapperuma and all the staff of the department).

Land selection and suitability for rubber cultivation

Under the routine land selection programme 150 hectares of land were surveyed for the suitability of rubber cultivation (L Samarappuli, R 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. According to the land suitability survey there is no limitation with respect to rockiness in the selected sites of Moneragala and Badulla districts and soil depth of the selected

sites is found in the desirable range. Drainage is also reported to be satisfactory in the selected sites, (Table 16) (L Samarappuli, P Karunadasa, U Mithrasena, Anoma Thewarapperuma and T Gunathilake).

Table 16. *Status of rockiness, soil depth, water table and drainage in some selected sites*

District	DS Division		Site	Rockiness %	Soil depth (cm)	Water table (cm)	Drainage status
Moneragala	Badal-kumbura	1	Lunugala Kolaniya	< 50	> 150	> 130	Satisfactory
		2	Karawila	< 50	> 150	> 150	Satisfactory
		3	Ankada/ Gamewela	< 50	> 150	> 150	Satisfactory
	Bibile	4	Radaliedda	< 50	> 150	> 150	Satisfactory
		5	Bokagonna	< 50	> 110	> 110	Satisfactory
		6	Badulla-gammana	< 50	> 110	> 110	Satisfactory
		7	Yalkumbura	< 50	> 110	> 110	Satisfactory
	Wellawaya	8	Siyambalagune	< 50	> 150	> 150	Satisfactory
	Madulla	9	Dambagalla	< 50	> 150	> 100	Satisfactory
	Siyambalan-duwa	10	Pallegama/ Helamulla	< 50	> 200	> 150	Satisfactory
	Moneragala	11	Tenagallanda	< 50	> 100	> 150	Satisfactory
	Medagama	12	Ittegala	< 50	> 100	> 150	Satisfactory
Badulla	Haldummulla	1	Nikapotha	< 50	> 120	> 150	Satisfactory
	Haliela	2	Unugalle estate	< 50	> 150	> 150	Satisfactory
	Lunugala	3	Peesagama	< 50	> 100	> 100	Satisfactory

Analytical services

The Department analyzed approximately 6000 samples (24,000 parameters) for outside organizations including more than 450 fertilizer samples for rubber growers to assure application of good quality fertilizers to their rubber lands (L Samarappuli, R Hettiarachchi and all the staff of the department).

BIOCHEMISTRY AND PHYSIOLOGY

Newly developed temperature corrected ready reckoner was able to reduce the error in latex weighing of dry rubber content (%DRC) by ca. 50%. Latex density accounted for ca. 80% of variation in %DRC. A protocol for gaseous stimulation was developed for Sri Lankan conditions. Stimulation protocol of S/2 d4 tapping system was revised and this together with low intensity harvesting system of S/4 d3 was selected for wide scale testing in commercial plantations. Further, investigations were geared to develop weekend harvesting systems for the rubber smallholders who are mainly engaged in off-farm occupations. Characterization of unfractioned unbleached crepe of different clones was completed. Further, investigations on the clonal variation in the properties of fractioned bleached latex crepe began.

BIOCHEMISTRY AND PHYSIOLOGY

V H L Rodrigo

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 and Technical Officer, Mr R P S Randunu were on duty throughout the year.

Research students

- D S Hewamanage worked as a temporary Research Assistant of a research project on low frequency harvesting systems funded by the National Science Foundation Grant No: RG/2006/AG/07 until 30th September, 2010.

- W R A C Prasanna, an undergraduate from University of Wayamba carried out his final year research project on "Identification of suitable Ethephon concentrations for the emerging low intensity harvesting systems under varying climatic conditions in Sri Lanka" for BSc in Plantation Management under supervision of Dr V H L Rodrigo.

- S S Jayanetthi, a student from Aquinas College conducted the practical component for Diploma in agriculture under supervision of Dr V H L Rodrigo.

Seminars/Conferences/Workshops/Exhibitions attended

Officer/s	Subject/Theme	Organization
VHL Rodrigo KVVS Kudaligama	Scientific Committee Meetings	RRISL
VHL Rodrigo	Symposium in Climate Change	Centre for Environmental Justice
VHL Rodrigo	AGM of section B	SLAAS
VHL Rodrigo KVVS Kudaligama	International Workshop on White Root Disease	RRISL
VHL Rodrigo	Meetings of the National Committee on Research Programme and Projects	SLCARP

Officer/s	Subject/Theme	Organization
VHL Rodrigo	Workshop on Carbon Estimate	Forest Department
VHL Rodrigo	Presidential Award Ceremony	National Research Council
KVV S Kudaligama	Forestry and Environment Symposium	University of Sri Jayawardhenepura

Visits

Advisory - 5 visits
Experimental - 106 visits
Miscellaneous - 35 visits

Special events

Dr V H L Rodrigo received the Presidential Awards for Research for his international publications in 2004, 2005 and 2006.

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, field latex in different locations was assessed for the percentage dry rubber content (%DRC) with both Metrolac charts and then samples were collected for the laboratory based %DRC. Deviation of Metrolac based %DRC values from the laboratory based %DRC was calculated. Newly developed temperature corrected ready reckoner was able to reduce error on average by *ca.* 50% (*i.e.* 9% against 18% in existing chart) (Table 1). The reduction in error was greater when the temperature range was higher. However, the Metrolac in both cases was able to explain only 88% of the variation in %DRC (Fig. 1).

Portable digital system to measure the dry rubber content in latex

BCP/LT&M/2006/1

The research project was aimed to develop a user friendly digitized electronic appliance to measure the dry rubber content of latex. 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 view of identifying the relationship between latex density with %DRC and total solid content (TSC), several latex samples were analysed for the same parameters. Latex density was in the range of 0.955-0.99 g ml^{-1} and it accounted for only 80-88%

variation of %DRC. Similar association of latex density was shown with TSC (Fig. 2 and 3).

Table 1. *Mean % deviation in the estimated percentage of Dry Rubber Content (%DRC) in rubber latex using Metrolac from the laboratory determined %DRC for the samples taken from different locations of the country*

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.)
Samples collected from other locations	28	-8	-5	26.5 (min.) 28.0(max.)
mean		-18	-9	

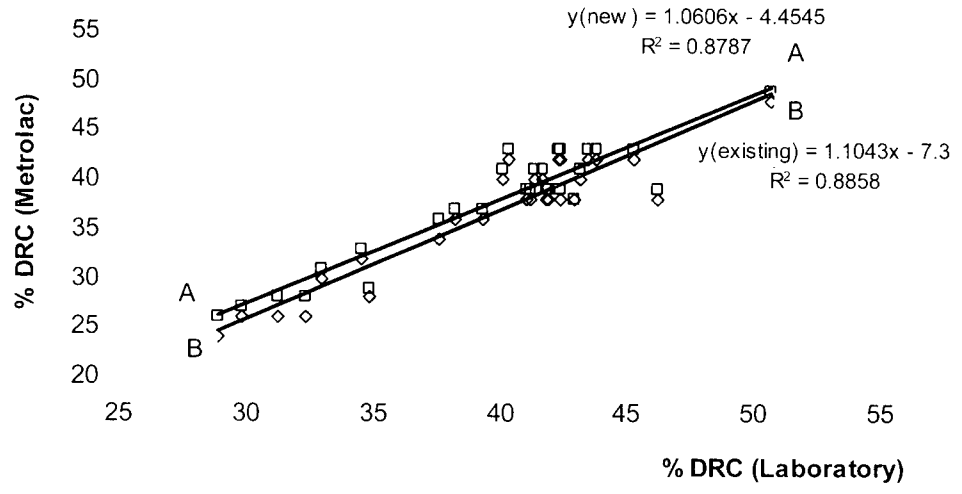


Fig. 1. Variation of percentage dry rubber content (%DRC) of latex measured with Metrolac against the laboratory based %DRC. Trend lines fitted for the readings made with newly developed temperature corrected ready reckoner (□) and existing ready reckoner (♀) are shown as 'AA' and 'BB', respectively (K V V S Kudaligama, V H L Rodrigo, G V L Nilmini, P D J Rodrigo and D Ramawickrama).

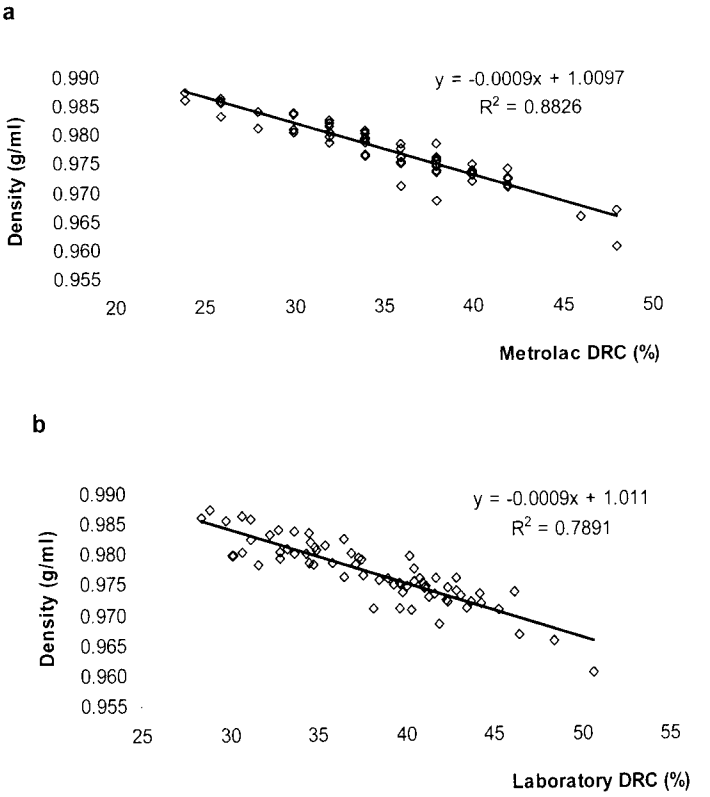


Fig. 2. Association of latex density with percentage dry rubber content (%DRC) measured using Metrolac (a) and laboratory procedures (b).

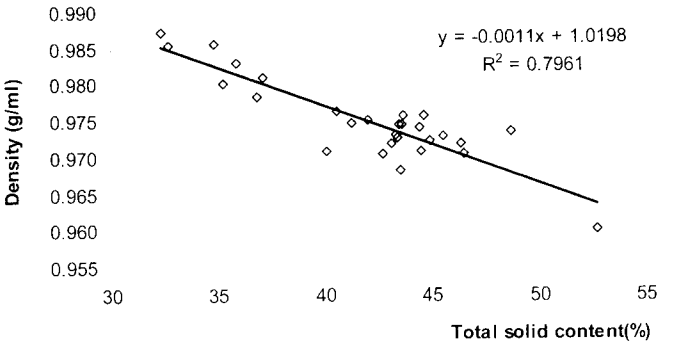


Fig. 3. Association of latex density with total solid content (%) (V H L Rodrigo, K V V S Kudaligama and R P S Randunu)

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

This project was terminated since this was undertaken by the Polymer Chemistry Department as a thrust area of their research (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
BCP/LFT(G)/2005/1
RRIMFLOW method
G-Flex method

Determination of the suitable gassing protocol for ethylene in Control Upward Tapping (CUT) of Sri Lankan clones was the main focus in this experiment. Several field trials were conducted at commercial scale and the gassing interval of 30 days was found to be suitable. There was no significant difference between the overall yields obtained under 15 and 30 days gassing intervals.

The protocol developed is given below.

- Suitable fields - d2 clones, trees having BI-1 panel harvested completely
- Gassing frequency - At 30 days intervals (gassing at 15 days intervals could be allowed during last two years before uprooting)
- Dose of stimulant - 15ml per gassing
- Tapping frequency - d3 or d4
- Length of cut - $1/8^{th}$ of the spiral upward (S/8U)

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

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. Basically, harvesting the rubber tree once in four (S/2 d4) and six (S/2 d6) days were tested. 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 S/2 d7 instead of the S/2 d6 tapping system. After the revision of stimulation protocol in October 2009 (details were given in the Annual Review, 2009), the yields obtained under S/2 d4 and S/2 d6 frequencies are given in Table 2. Yields given by S/2 d4 harvesting was found be comparable to that of S/2 d2 with monthly stimulation of 3.3% Ethephon.

Table 2. *Performance of different low frequency systems at each location tested. Parameters IPH, YPT and YPH refer to intake per harvester, yield per tree per year and yield per hectare per year, respectively*

Site	Clone	Tapping system	IPH (kg)	YPT (kg)	YPH (kg/ha/yr)	% yield recovered	%TPD trees
Dartonfield	RRIC 100	S/2 d2	10.2	6.12	2449	-	5.6
		S/2 d3	14.63	5.9	2361	96.4	8.3
		S/2 d4	17.39	5.22	2086	85.2	5.3
		S/2 d6	24.42	4.88	1954	79.8	4.3
	RRIC 102	S/2 d2	9.52	5.71	2284	-	2.7
		S/2 d3	13.44	5.42	2168	94.9	8.3
		S/2 d4	17.83	5.35	2140	93.7	4.0
		S/2 d6	21.24	4.25	1699	74.4	5.3
	RRIC 121	S/2 d2	8.25	3.75	1500	-	4.3
		S/2 d3	9.02	3.64	1455	97.0	2.7
		S/2 d4	11.6	3.48	1392	92.8	8.3
		S/2 d6	18.38	3.68	1470	98.0	9.3
	RRIC 130	S/2 d2	13.56	8.14	3255	-	10.0
		S/2 d3	15.92	6.42	2568	-	4.0
		S/2 d4	29.86	8.96	3583	139.5	4.0
		S/2 d6	32.45	6.49	2596	101.1	5.0
Kuruwita	RRIC 100	S/2 d2	7.57	4.54	1817	-	16.0
		S/2 d3	12.19	4.92	1966	108.2	8.0
		S/2 d4	15.04	4.51	1805	99.3	16.0
		S/2 d6	18.12	3.62	1450	79.8	4.0
Udapola	RRIC 102	S/2 d2	8.25	4.95	1980	-	8.0
		S/2 d3	10.32	4.16	1666	84.1	16.0
		S/2 d4	16.38	4.92	1966	99.3	12.0
		S/2 d6	15.75	3.15	1260	63.6	12.0

Yield performance of S/2 d7 harvesting is shown in Table 3 and it was able to provide 95% of the yield given by the traditional S/2 d2 harvesting.

Table 3. *Performance of S/2 d7 systems at Kuruwita Sub station. Parameters IPH, YPT and YPH refer to intake per harvester, yield per tree per year and yield per hectare per year, respectively*

Site	Clone	Tapping system	IPH (kg)	YPT (kg)	YPH (kg/ha/yr)	% yield recovered over d2	% TPD trees
Kuruwita	RRIC 121	S/2 d2	10.53	6.32	2528	-	1.3
		S/2 d7	34.55	5.99	2396	94.8	1.4

Commercial testing

The S/2 d4 system which gave promising yields in experiments was selected for wide scale commercial testing. All plantation companies were invited to test this system and suitable sites were selected for collaborative trials.

Low intensity tapping systems
BCP/LIT/2007/1

This experiment was commenced at Kuruwita sub-station to investigate the possibility of minimising the bark consumption with shorter tapping 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 performance was monitored. S/4 d3 and S/4 d4 systems were identified for further testing. The system of S/4 d3 gave yields comparable to S/4 d2 system with the final revision of stimulation protocol in October, 2009 (Table 4).

Table 4. *Performance of different low intensity systems at RRISL sub station, Kuruwita. Parameters IPH, YPT and YPH refer to intake per harvester, yield per tree per year and yield per hectare per year, respectively*

Site	Clone	Tapping system	IPH (kg)	YPT (kg)	YPH (kg/ha/yr)	% yield recovered over S/2 d2	%TPD trees
Kuruwita	RRIC 121	S/2 d2	10.53	6.32	2528	-	1.3
		S/4 d3	14.65	5.91	2364	93.5	1.6
		S/4 d4	14.69	4.41	1764	69.8	1.2

Commercial testing

Since the S/4 d3 system gave promising performance, it was selected for commercial testing along with S/2 d4. Suitable sites were selected from different Plantation Companies (V H L Rodrigo, K V V S Kudaligama, P D J Rodrigo and R P S Randunu).

Variation of latex and raw rubber properties of different *Hevea* genotypes
BCP/LD/2007/1

This experiment was met to investigate the variation of major latex and raw rubber properties in promising Sri Lankan *Hevea* genotypes. Assessments on unfractioned unbleached latex crepe from different clones were completed and investigations on fractioned bleached latex crepe began in October, 2010 (Table 5).

Further, multi-locational study was commenced for wider representation. In total, 12 latex samples from 06 clones were assessed for nine latex and raw rubber properties (*i.e.* DRC%, TSC%, Acetone extractable non rubber%, Initial plasticity, Plasticity retention index, Mooney viscosity, Lovibond colour, nitrogen% and Ash%,). However, sampling was badly affected with heavy rains.

Table 5. *Latex and raw rubber (fractioned bleached latex crepe) properties of six* Hevea *genotypes tested from October - December, 2010*

Clone	DRC%	TSC%	Po	PRI	V_R	Colour	Ash%
RRISL 203	39.16	41.24	56	75	97	1.5	0.20
RRISL 208	47.43	49.71	47	74	83	1.5	0.16
RRISL 211	42.59	44.73	54	72	88	1.5	0.21
RRISL 216	42.38	44.68	54	64	97	1.8	0.20
RRISL 219	40.68	43.10	43	68	81	1.3	0.15
RRISL 223	31.27	33.38	47	74	80	1.3	0.15

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

ADVISORY SERVICES

Several important extension and advisory projects were carried out at national and regional levels to increase the land productivity of rubber smallholders in all rubber growing areas of the country.

Five thousand three hundred and ninety nine planned advisory visits and 581 special advisory visit on requests of rubber growers were conducted by REOo to solve technology adoption problems.

An extension strategy focused on farmer participatory development of rubber smallholdings was conducted. As a result, REOo were able to up grade 292 immature holdings and 196 mature holdings as model rubber holdings. Extension services were provided to motivate and support 306 rubber smallholders to rehabilitate 202.49 ha of selected substandard immature rubber holdings. Mucuna cover crop was successfully introduced in 280 immature rubber holdings. Rain guarding was promoted and 87 demonstrations were successfully established in 225.95 ha of mature rubber lands.

One hundred and thirteen farmer training programmes were conducted to improve the knowledge and skill levels of 3900 rubber smallholders and Introduce 82 new rubber tappers as a solution to the tapper shortage in the rubber industry through five tapper training programmes 525 semi skilled rubber tappers were trained to improve their quality of tapping.

A team of REOo were mobilized in the Monaragala district to conduct a special extension campaign on the request of the Ministry of Plantation Industries, to accelerate the rubber development programme of the IFAD project. As a result preliminary land inspection reports for 1909 rubber holdings selected for the project in the year 2010 was successfully completed. Advisory visits were conducted to up grade the knowledge and skills of 88 selected rubber holdings. Twenty two farmer awareness raising programmes were conducted for the benefit of nearly 1300 rubber growers on immature up keep and latex exploitation recommendations. Two tapper training programmes were conducted in collaboration with private sector rubber companies and introduce 80 new rubber tappers for Badalkumbura and Siyabalagune areas in the Monaragala district. A special village level group extension strategy, "Vihidum Sathkara" was implemented in the Monaragala district to speed up the technology transfer process with the aim of improving the productivity of rubber smallholdings.

ADVISORY SERVICES

A Dissanayake

DETAILED REVIEW

Staff

The Head of the Department, two Regional Advisory Officers (RAOo), five Divisional Rubber Extension Officers (DREOo) and twenty one Rubber Extension Officers (REOo) were on duty throughout the period. Mr U L R A Perera continued covering up duties of the post of Regional Advisory Officer, Kalutara and Mr W Siriwardana continued covering up duties of the post of Assistant Training Officer. Mr H H Jayasignhe, Acting RAO, Galle and Mr Upul Ananda, Office Assistant resigned from services with effect from 28th and 26th July 2010 respectively. Mr D Podimahaththaya acting RAO, Kegalle region retired from services with effect from 23rd March and 1st October, 2010. Services of 03 REOo were extended for a period of one year.

Conferences/Meetings/Seminars/Workshops attended

Officer/s	Subject/s	Organization/s
A Dissanayake	Analysis of training needs of the rubber smallholder sector	National Institute of Plantation Management
A Dissanayake	Extension programme development for the rubber smallholder sector in the Monaragala district	Lalan Rubber (Pvt.) Ltd.
A Dissanayake	Organizing tapper training and other extension programmes for rubber smallholders in the Monaragala district	Dipped Products (Pvt.) Ltd.
A Dissanayake AH Kularathna	International workshop on White root disease of *Hevea* Rubber	Rubber Research Institute of Sri Lanka
A Dissanayake AH Kularathna	Scientific Committee Meetings	Rubber Research Institute of Sri Lanka
A Dissanayake AH Kularathna PKKS Gunarathna	Quarterly progress review meeting of the ASD	Advisory Services Department of Rubber Research Institute of Sri Lanka
AH Kularathna PKKS Gunarathna	3rd Crop Symposium on Plantation Crop Research	Crop Research Institutes of Sri Lanka
AH Kularathna PKKS Gunarathna	Monthly Progress Review Meetings of the ASD	Advisory Services Department of Rubber Research Institute of Sri Lanka

In- service training programmes

Two in -service training programmes were conducted for Rubber Extension officers of the Advisory Services Department, at the RRISL training center,

PROJECTS AND SERVICES

Advisory visits

Advisory visits on requests of rubber smallholders

Eight hundred and eighty one advisory visits were conducted by Rubber extension officers on special requests made by rubber small holders, to solve their technology adoption problems related to rubber cultivation and processing. All such visits were followed by detailed visit reports covering the entire problems and forwarded to the Head of the Department for relevant future actions (Table 1).

Table 1. *No. of advisory visits conducted by REOo on requests of rubber smallholders to solve their specific problems*

Region	Total No. of advisory visits conducted by Extension Officers	Type and number of advisory visit		
		Immature up keep	Mature up keep	Rubber processing and quality improvement of RSS
Colombo	173	110	48	15
Kegalle	324	213	95	16
Kalutara	228	161	62	5
Rathnapura	117	63	44	10
Galle/Matara	39	12	18	9
Total	**881**	**554**	**267**	**55**

Projects related advisory visits

In addition to above on- call visits 5,399 regular advisory visits were made by rubber extension officers to increase the adoption rates of recommended agronomic and processing practices and to monitor the progress agricultural operations undertaken by rubber smallholders (Table 2).

Participatory development of selected rubber holdings as model rubber farms

Participatory development of rubber smallholdings was an extension strategy extensively aimed at holistic development of rubber smallholdings as model rubber farms. The strategy focused on farmer participation and integration of all relevant government and private sector organizations for successful implementation of the programme.

Accordingly, REOo selected 435 immature rubber holdings and 277 mature rubber holdings for up grading as model rubber holdings. Special extension and advisory programmes were conducted to transfer technologies to improve the

agronomic standards of rubber holdings and to improve the management skills of smallholders. Input supply and other supporting services were arranged with relevant private sector and government agencies to enhance the technology adoption and implementation processes. REOo were able to successfully upgrade 202 immature holdings and 196 mature holdings during the year 2010 (Table 3).

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

Region	Number of advisory visits							
	Participatory development of immature rubber small holders as model holdings	Participatory development of mature rubber small holders as model holdings	Participatory up grading of processing centres as modal process	Rehabilitation of Substandard Holdings	Introduction & establishment of Mucuna cover crop	Introduction of rubber based intercropping systems	Introduction of rain guard technology	Construction and maintenance of Processing centers
Col.	186	129	28	118	54	21	62	41
K'glle	557	348	59	360	234	50	58	58
K'tara	599	357	93	291	189	42	104	59
R'pura	333	193	72	208	145	14	30	27
Galle	96	46	19	57	31	7	18	6

Total 5,393

Table 3. *Participatory development of selected rubber smallholdings as model rubber farmers*

Region	Immature holdings				Mature holdings			
	No. of holdings selected	No. of holdings successfully upgraded as immature model farms	No. of advisory visits	Extent (ha)	No. of holdings selected	No. of holdings successfully upgraded as mature model farms	No. of advisory visits	Extent (ha)
Col.	45	30	180	33.4	30	24	129	28.4
K'glle	150	102	557	74.2	97	61	348	45.9
K'tara	129	89	599	72.7	80	64	357	48.3
R'pura	75	50	333	46.4	50	35	193	42.8
Galle	30	21	96	25.5	20	12	46	14.6
Total	435	292	1,765	252.2	277	196	1,073	180

The project will be continued in the year 2011.

Participatory development of selected Rubber Processing Centers as model Rubber Processing Centers

Continuous increment of RSS prices in the country has created a high demand for rubber processing technologies from the smallholding sector. Therefore a special technology transfer programme was carried out to upgrade selected rubber processing centres, as model rubber processing centres, for the purpose of demonstrating the value of adopting recommended technologies for quality and product improvement. Accordingly REOo conducted technology transfer programme to up grade the operational standards and production efficiencies of 71 RSS processing centres with the total capacity of 49,997 kg (Table 4).

Table 4. *Upgrading of Rubber Processing Centres as model Rubber Processing Centres*

Region	No. of RSS production centers select for up- grading	No. of RSS centres successfully upgraded as model processing centres	No. of Advisory visits conducted by REOo	No. of RSS producers benefited	Total capacity of up- graded centers (Kgs)
Colombo/Gampaha	9	9	17	9	2,441
Kegalle	27	21	59	168	10,011
Kalutara	24	20	91	147	25,530
Ratnapura	15	15	63	56	9,500
Galle/Matara	9	6	17	18	2,515
Total	**84**	**71**	**247**	**398**	**49,997**

Rehabilitation of substandard immature rubber holdings

As a result of poor field management practices adopted by rubber smallholders during replanting and subsequent field establishments, a considerable number of immature clearings were substandard in terms of plant growth levels and soil fertility management. REOo identified 415 such substandard rubber holdings during their regular field visits. With the support of other government and private sector organization REOo were able to provide needed inputs such as planting materials for filling vacancies, pesticides and fertilizer *etc.* REOo conducted a series of special technology transfer programmes to educate the owners of selected substandard holdings to follow recommended rehabilitation techniques Accordingly REOo were able to successfully rehabilitate 276 substandard rubber holdings with the total extent of 205.49 ha during the year 2010 (Table 5).

Table 5. *Progress of rehabilitation of substandard immature rubber smallholdings*

	No. of substandard smallholdings identified for rehabilitation	No of advisory visit conducted	No. of substandard holdings successfully rehabilitated	Extent of rehabilitated holdings (ha.)
Col.	45	138	32	27.4
Kegalle	145	360	116	65.3
Kaluatara	120	291	80	48.93
R"pura	75	208	21	43.7
Galle	30	57	27	20.16
Total	**415**	**1,054**	**276**	**205.49**

Eradication of white root disease to increase the land use efficiency and productivity of rubber smallholders

According to field inspection reports submitted by REOo, it was observed that the White root disease is spreading very fast, causing loss of crop production and massive economic setback due loss of potential revenue. In some areas of the wet zone, it was reported that more than 20% of the smallholdings are severely affected by this devastating disease. Therefore a decision was taken to accelerate the technology transfer programs to educate rubber smallholders on diagnosis and efficient management strategies of the disease.

Accordingly, 14 regional level farmer training programmes were conducted in collaboration with private sector rubber industries to train 1,183 selected rubber smallholders on identification, prevention and control of the disease paying special attention on pre planting, plating and post planting activities of rubber smallholders (Table 6).

Table 6. *No. of Farmer training programmes conducted on diagnosis, and efficient management strategies of white root disease*

Region	No. of training programmes conducted	No of farmers benefited
Col.	2	152
Kegalle	5	545
Kaluatara	4	263
R"pura	2	186
Galle	1	37
Total	**14**	**1,183**

Establishment of Mucuna cover crop for soil fertility improvement of rubber smallholdings

Since the soil erosion and weeding costs are higher during the land preparation and immature period of new cleanings, special extension programmes were conducted to motivate rubber growers to establish Mucuna cover crops prior to up rooting and during the immature period, to improve the soil fertility management of smallholdings. REOo made 383 advisory visits to successfully motivate 169 rubber growers selected from the immature phase of rubber cultivations to establish Mucuna cover crop in 114.26 ha during the year 2010 (Table 7).

Table 7. *Progress of establishment of Mucuna cover crop*

Region	No. of farmers selected for establishment of Mucuna	No of advisory visits made by REOo	No. of farmers successfully established Mucuna (success rate >50%)	Total extent of holdings (ha)
Col/Gampaha	30	54	22	12.09
Kegalle	100	164	62	52
Kaluatara	80	89	48	25.2
R'pura	50	45	32	18.1
Galle/Matara	20	31	05	6.6
Total	**280**	**383**	**169**	**114.26**

Promotion of area specific rubber based Intercropping systems

REOo conducted 97 advisory visits to encourage rubber smallholders to establish suitable intercropping systems as a strategy for a sustainable income generating source, during the immature phase of new clearings. Forty demonstration plots were set up successfully to motivate rubber smallholders (Table 8).

Table 8. *Introduction of area specific rubber based inter cropping systems*

Region	**Total No. of demonstration plots established**	**Total extent of rubber holdings (ha)**	**No. of advisory visits conducted by REOo**
Col/Gampaha	6	9.79	21
Kegalle	11	17.4	50
Kaluatara	15	9.79	15
R'pura	4	2.8	4
Galle/Matara	4	2.2	7
Total	**40**	**79.78**	**97**

Promotion of rain guard fixing for productivity improvement in the rubber smallholdings sector

As a short term strategy to increase the rubber production by minimizing the number of tapping days lost due to rain interference, awareness campaigns and training programmes were conducted to motivate rubber smallholders for rain guarding. REOo were able to motivate 87 smallholders to establish rain guards demonstrations in 252.95 ha of mature rubber lands (Table 9).

Table 9. *Introduction of rain guarding in the rubber smallholder sector*

Region	No. of smallholders motivated for rain guarding	No. of advisory visits conducted	No. of trees fixed with rain guards	Total extent (ha)
Col/Gampaha	20	62	20,150	45.8
Kegalle	18	58	19,873	52.7
Kaluatara	26	104	34,932	84.95
R'pura	47	30	145	56.0
Galle/Matara	6	18	7,000	13.5
Total	**87**	**272**	**96,455**	**252.95**

Transfer of technology for quality improvement of RSS

Two types of technology transfer programme were conducted by REOo to improve to production efficiency of the rubber smallholdings sector.

a. Quality improvement of RSS
b. Technology transfer for construction and rehabilitation of processing centers.

Quality improvement of RSS

REOo conducted 31 field training and demonstration programmes to educate RSS produces on recommended processing technologies. Six hundred and five RSS producers were directly benefited from these training programmes (Table 10).

Table 10. *Field training and demonstration programmes conducted for RSS producers*

Region	**No. of field demonstration conducted**	**No. of RSS producers benefited**
Col/Gampaha	4	223
Kegalle	11	160
Kalutara	6	54
R'pura	8	139
Galle/Matara	2	29
Total	**31**	**605**

Technology transfer for construction and rehabilitation of rubber processing centers

Construction of 28 new processing centers and rehabilitation of 20 substandard processing centers were successfully completed with the extension and advisory support of REOo. 485 RSS producers who are centers were directly benefited (Table 11).

Table 11. *Technology transfer for construction and repair of rubber processing centers*

Region	No. of new processing centres selected for construction	No. of new processing centres successfully completed	No. of substandard processing centres selected for rehabilitation	No. of substandard processing centres successfully rehabilitated	No. of RSS producers benefited
Col/Gampaha	10	6	7	4	59
Kegalle	22	10	3	3	207
Kalutara	21	8	23	5	147
R'pura	08	2	14	6	51
Galle/Matara	2	2	2	2	21
Total	**63**	**28**	**49**	**20**	**485**

Educational and training programmes for rubber smallholders in traditional rubber growing area

Farmer training and awareness programmes were conducted for various categories of rubber smallholders to improve their knowledge and skill levels, on rubber cultivation and processing aspects. Each farmer training programme was carefully organized after analyzing the technology and institutional needs of target groups. Private sector rubber companies extended their corporation by providing financial assistance for the successful completion of these training programmes. Accordingly, 113 farmer training programmes were successfully conducted for the benefit of 3,867 rubber smallholders in traditional rubber growing districts (Table 12).

Table 12. *Farmer training programmes conducted in the year 2010*

Region	AWP (Self)		AWP (Joint)		TSD (for tappers in model farmers)		TSD (General)		WRD		TTS	
	No. of programmes	No. of farmers benefitted	No. of programmes	No. of farmers benefitted	No. of programmes	No. of farmers benefitted	No. of programme	No. of farmers benefitted	No. of programme	No. of farmers benefitted	No. of programmes	No. of farmers benefitted
Col/Gampaha	4	174	11	438	01	20	04	76	2	52	0	0
Kegalle	8	409	12	580	1	18	10	194	0	0	3	53
Kaluatara	1	70	6	593	4	24	10	125	4	63	2	29
R'pura	4	251	4	230	0	0	9	119	1	86	0	0
Galle/Matara	6	226	0	0	5	26	1	11	0	0	0	0
Total	**23**	**1130**	**33**	**1841**	**11**	**88**	**34**	**525**	**7**	**201**	**5**	**82**

Total No. of Programmes 113 Total No. of Farmer benefited 3867

AWP (self) - General Awareness Programmes organized by individual REOo for selected rubber re-planters, model farm owners and medium scale rubber growers in the range.

AWP (joint) - General Awareness Programmes jointly conducted by group of REOo for selected re-planters, model farm owners and medium scale rubber growers in district levels.

TSD - Skill Development Programmes for semi skilled rubber tappers

TTS - Tapper Training Programmes to train and introduce new rubber tappers as a solution for the shortage of rubber tappers in the industry.

WRD - Training programmes to educate rubber smallholders on identification and control of White root disease.

Transfer of technology for rubber smallholders in non-traditional rubber growing areas

Monaragala district has been identified as a high potential area for rubber cultivation. But, non existence of Rubber Extension Officers in this area hinders the advisory support services for rubber smallholders and this identified as a major obstacle for the successful implementation of rubber development projects undertaken by various government and private sector development agencies as well. However, Advisory Services Department of RRISL was able conduct following extension programmes in the Monaragala district successfully.

1. **Awareness raising on recommended practices of rubber farmers**
   Twenty two awareness programmes which consisted of lectures and practical demonstrations were conducted for nearly 1,300 selected rubber smallholders in rubber growing villages in the Monaragala district, in collaboration with the IFAD project and Dipped Products Pvt. Ltd. Under this, four farmer training programmes were conducted to transfer relevant technologies and improvement needed to increase the land productivity of nearly 400 smallholdings in Badalkumura and Siyambalagune areas with the assistance of Dipped Products Pvt. Ltd.
   Also, training of around 900 selected rubber farmers (2008/2009) on immature upkeep was successfully carried out in Tenwatta, Bogahapellessa, Naranwatta, Godawila, Karandagama, Usbedda, Radalliyadda, Kanwegalla, Nagala, Nakkala, Ankada, Alupotha, Attalawala, Lunugala colony and Pusbedda villages on the request of IFAD project management.

2. **Tapper training programmes**
   Two Tapper training programmes were successfully completed, and 80 new rubber tappers were introduced as a solution for the shortage of skilled rubber tappers in Badalkumbura and Siyambalagune areas. These programmes was sponsored by the Dipped Product Pvt. Ltd.

3. **Land Suitability evaluation programme**
   Physical verification of lands applied for new rubber plantations in 2010, was attended on the special request made by the Ministry of Plantation Industries and IFAD project. This was carried out in Bibile, Badalkumbura, Medagama, Buttala, Madulla, Wellawaya and Monaragala areas for 1900 lands and completed data set was submitted to the project management.

4. **"Vehidum Sathkara" Programme**
   A Special village level group extension strategy was implemented in collaboration with the IFAD project Monaragala to speed up the technology

transfer process, to educate rubber smallholders on all aspects of rubber cultivation In this programme, upgrading of existing rubber lands through on farm advisory and extension support was delivered for 88 lands in Karamattiya and Medagama areas. Also, around 100 rubber smallholdings were inspected in Buttala, Medagama and Badalkumbura areas with the assistance of Dipped Product Pvt. Ltd.

Other extension and advisory projects

Rubber Extension Officers identified different area specific extension and institutional needs of rubber smallholders in relation to their field management practices. Accordingly, advisory and extension activities were conducted to address following issues and problems.

1. Correction of un-economical latex harvesting practices of rubber smallholders,
2. Introduction and demonstrations of technically improved new tapping knife,
3. Technology transfer activities on contour lining for holing and soil conservation,
4. Training programmes on quality improvement of tapping.

Strength properties of gloves produced out of 87:13 NR/polyvinyl acetate (PVAc) latex blends at factory scale were at an acceptable level. Ageing properties and swelling in water of these gloves were also evaluated. Tensile properties of gloves produced according to different dipping techniques were evaluated and heat sensitive coagulant dipping technique gave the best properties. Cast films were produced out of a nano clay filled glove compound and the strength properties of these films were superior to those of the conventional clay filled cast films. Natural rubber latex foam based boxing/ karate glove pads were developed at the request of an entrepreneur. Trials on the development of articles out of rubberized twisted-coir were initiated.

The patented low cost, eco-friendly "Power Mat" invented by the department won the "National Science and Technology Award 2010" under the category "Development of eco material/eco-friendly processes for the industry". Evaluation of the physico-mechanical properties of NR/BR/reclaimed rubber composites prepared according to different ternary blend ratios revealed that 80:10:20 NR/BR/reclaimed rubber composite is the most suitable for a tyre tread and the single-stage mixing technique showed better properties than the different masterbatch mixing techniques. Physico-mechanical properties of the blend compounds prepared according to different blend ratios of virgin NR and foam waste, modified with lauric acid were evaluated. Abrasion resistance of these blend compounds was found to be superior to that of the 100% NR compound. Properties of the rubber compound produced with the aim of developing corrugated drainage sheets used in hospitals were evaluated. Physico-mechanical properties of five 70:30:55 NR/NBR/CB composites prepared by varying the amount of compatibilizer from 1 to 10 phr were evaluated. Physico-mechanical properties of the composites prepared with natural fibres such as coir and baggasse as well as waste newspaper sludge at different loadings were evaluated.

Rubber compound and product testing services were provided to the industry and several small and medium scale entrepreneurs were given advice and assistance on setting up rubber based cottage industries. Several workshops on "Rubber based Products Manufacture at Cottage Level" were conducted in collaboration with Thurusaviya Fund, 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.

RUBBER TECHNOLOGY AND DEVELOPMENT

Dilhara Edirisinghe

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 was on duty throughout the year.

Mrs M K Mahanama, Mrs S I Yapa, Mrs P C Wettasinghe, Mr S L G Ranjith, Mr P L Perera and Mrs Priyanthi Perera, Experimental Officers were also on duty throughout the year. Mr T A A I Siriwardena, Experimental Officer resigned from the Institute on 3rd November.

Research students

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

- Miss Champani Premachandra, a MSc (Analytical Chemistry) student from the University of Colombo continued her research project on "Evaluation of suitability of rubber seeds for production of bio-diesel" 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, completed her research on "Study of the variation in thickness, % elongation at break and tensile strength of examination gloves based on the dipping technique used" and "Development of a nano clay filled glove compound" 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, completed 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 Amila Nishshanka, a BSc (Chemistry Special) undergraduate student from the University of Sri Jayewardenepura, Sri Lanka, completed his research project on "Development of neoprene rubber compatibilized, carbon black filled NR/NBR composites" under the supervision of Mrs G D D Seneviratne.

- Mr P D S Kulathilaka, a BSc (Chemistry Special) undergraduate student from the University of Sri Jayawardenepura, Sri Lanka carried out his research project under the supervision of Mrs G D D Seneviratne.

- Lasantha Ranawaka, a MSc (Polymer Science and Technology) student from the University of Sri Jayawardenepura, Sri Lanka carried out his research project under the supervision of Mrs G D D Seneviratne.

- Mr M M W W Bandara (Elastomeric Technologies (Pvt.) Ltd.), Ms T H Niroshani (Hanwella Rubber Products Ltd.), Ms Nisansala Kannangara (Textrip Ltd.) and A S R S Perera (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 M K Mahanama. Also, Mr T Charith Silva (Associated Motorways (Pvt.) Ltd., Mr H P Niluka Dushan (Jafferjee Brothers Exports), Mr V R S Priyantha (Elastomeric Technologies (Pvt.) Ltd.), Mr H M Janaka Pushpakumara (Lalan Rubbers (Pvt.) Ltd.) and Mr Nishantha Bandara Herath (Mapa Lalan (Pvt.) Ltd.), DPRI students carried out their research projects under the supervision of Mrs G D D Seneviratne.

Seminars/Training/Conferences//Workshops/Meetings attended

Officer/s	Subject/Theme	Organization
DG Edirisinghe	Policy Making Discussion on Coir Research and Development Institute (CRDI)	Coconut Development Authority
DG Edirisinghe	Annual General Meeting	Senior Scientists Forum of the National Science and Technology Commission
DG Edirisinghe	Sectoral Committee Meetings on Chemical and Polymer Technology	Sri Lanka Standards Institution
DG Edirisinghe and GDD Seneviratne	Seminar on "Research Writing"	Sri Lanka Association for the Advancement of Science
DG Edirisinghe and GDD Seneviratne	3rd Symposium on Plantation Crop Research	RRI, CRI, TRI and SRI
DG Edirisinghe and GDD Seneviratne	Scientific Committee Meetings	Rubber Research Institute of Sri Lanka

Officer/s	Subject/Theme	Organization
A Nugawela, DG Edirisinghe and MK Mahanama	National Science & Technology Awards Ceremony	National Science Foundation and Ministry of Science and Technology
GDD Seneviratne	The importance and benefits of GC/MS for the analysis of residues in food, land and environmental applications	Analytical Instruments
SLG Ranjith	Advanced training programme on "Tyre technology"	Ministry of Industry and Commerce
Priyanthi Perera	Annual General Meeting	Young Scientists Forum of the National Science and Technology Commission

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

Officer/s	Subject/Theme	Beneficiary/Client
DG Edirisinghe	General properties of NR latex and latex technology	Students of the DPRI Course – PRISL
DG Edirisinghe	Degradation and stabilization of polymers	MSc Students (Polymer Science and Technology) – University of Sri Jayewardenepura
GDD Seneviratne	Study of effects of dynamic vulcanization and electron beam irradiation on the properties of Polypropylene (PP) Recycled Acrylonitrile Butadiene (rNBR) Blends	RRI, CRI, TRI and SRI – 3rd Symposium on Plantation Crop Research
GDD Seneviratne	Manufacture of concentrated latex and tests on latex and property Evaluation	Students of the DPRI Course – PRISL
MK Mahanama	Manufacture of RSS, Crepe and TSR	Students of the DPRI Course – PRISL
MK Mahanama	Compounding ingredients (dry rubber and latex) Processing techniques (latex)	Students of the Basic Course in Rubber Technology – PRISL
MK Mahanama	Workshop on newly developed "Power Mat"	Malwatta Valley Plantations
MK Mahanama	Workshop on "Rubber based products manufacture" in Anuradhapura, Galle, Maharagama and Badulla	National Institute of Education
MK Mahanama	Two workshops on "Rubber based products manufacture at cottage level" in Kalutara and Gampaha	Thurusaviya Fund

Officer/s	Subject/Theme	Beneficiary/Client
MK Mahanama	Two workshops on "Rubber based products manufacture at cottage level" in Wennappuwa and Meegahatenna	Rubber Development Department
MK Mahanama	Entrepreneur day 2010	University of Sri Jayewardenepura
PL Perera	Educational and Trade Exhibition	Leeds International School, Galle
DG Edirisinghe, GDD Seneviratne, MK Mahanama, PC Wettasinghe, SI Yapa, SLG Ranjith, PL Perera, and Priyanthi Perera	Practical training on "Rubber Technology"	MSc (Polymer Science and Technology) students - University of Sri Jayewardenepura
DG Edirisinghe, MK Mahanama, SLG Ranjith, PL Perera and TAA Siriwardena	"Deyata Kirula" National Development Exhibition (4^{th} -10^{th} February)	Ministry of Plantation Industries
DG Edirisinghe, MK Mahanama, PC Wettasinghe and PL Perera	"Vidatha Vidu Dekma 2010", Science and Technology Exhibition, Baduraliya (29^{th}-30^{th} October)	Vidatha Centre, Kalutara
Priyanthi Perera	Structure-Property Relationship of Polymers	Students of the Basic Course in Rubber Technology – PRISL
Staff of the department	Rubber Technology	Students of Davisamara Maha Vidyalaya, Seeduwa

Industrial visits

The following industries were visited during the year for research project collaboration/trouble shooting work.

Officer	Industry/Organization
DG Edirisinghe and MK Mahanama	Laugfs Corporation (Rubber) Ltd.
DG Edirisinghe, PC Wettasinghe and Priyanthi Perera	Lalan Gloves, Biyagama
DG Edirisinghe and GDD Seneviratne	Associated Motorways Ltd.
GDD Seneviratne	Jet Holdings (Pvt.) Ltd., Homagama
SLG Ranjith	Hiniduma Tea Estate
PL Perera	Lefurn Factory, Avissawella

LABORATORY INVESTIGATIONS

Latex technology

Development of NR/synthetic polymer latex blends for different applications

NR/polyvinyl acetate latex blends for manufacture of dipped products

In earlier annual reviews we reported that 87:13 NR/PVAc blends exhibit high tensile, tear and puncture strength properties. Hence, a large quantity of centrifuged latex was prepared at the Dartonfield factory in order to carry out a factory trial of the developed 87:13 NR/PVAc blend and for confirmation of properties.

Factory scale production of examination gloves using 87:13 NR/PVAc latex blends, prepared according to a special blending technique was carried out at Lalan Gloves, Biyagama. Vulcanization of the gloves was performed at 120°C for 25 min. The examination gloves produced were of good texture. Tensile properties and puncture strength were tested at the laboratory of Lalan Gloves and they were at an acceptable level. Results of tensile properties of the gloves tested at the Rubber Technology & Development department are given in Table 1. It is apparent from the results that percentage retention of tensile properties of the gloves after ageing at 70°C for 168 hours are beyond 70%. Percentage swelling of these gloves in water was found to be 3.5% (D G Edirisinghe, Priyanthi Perera and P C Wettasinghe).

Table 1. *Tensile property results of gloves prepared out of 87:13 NR/PVAc latex blend*

	Mod. at 100% (MPa)	**Mod. at 300% (MPa)**	**Mod. at 500% (MPa)**	**Tensile strength (MPa)**	**Elongation at break (%)**
Before ageing	0.37	1.43	6.66	16.42	723
After ageing	0.46	1.68	4.91	13.09	736
% Retention	124	117	74	80	102

NR/synthetic polymer latex blends as a fabric coating material

A styrene-acrylic copolymer latex was identified as a synthetic latex to blend with NR latex to use as a coating for fabrics. Features of coatings produced out of this synthetic latex include; excellent alkaline and water resistance, high pigment acceptance, long term durability, good binder power. A literature survey on this development was initiated (D G Edirisinghe and Priyanthi Perera).

A study on the variation of properties of examination gloves with dipping technique

Examination gloves were produced according to straight dipping, coagulant dipping and heat sensitive dipping and heat sensitive coagulant dipping techniques. Physical properties, tested in accordance with ISO Standards are given in Table 2 for comparison.

Table 2. *Physical property results of gloves produced according to different dipping techniques*

	Mod. at 100% (MPa)	Mod. at 300% (MPa)	Mod. at 500% (MPa)	Tensile strength (MPa)	Elongation at break (%)
Straight dipping	0.25	0.63	0.94	7.63	646
Coagulant dipping	0.39	0.78	1.15	17.84	883
Heat sensitive dipping	0.00	0.00	0.41	6.70	853
Heat sensitive coagulant dipping	0.42	0.88	1.84	20.26	939

Table 2 indicates that out of the dipping techniques employed, gloves produced in accordance with heat sensitive coagulant dipping technique give the highest tensile property results (W M G Seneviratne, L M K Tillekeratne - Dept. of Chemistry, University of Sri Jayewardenepura, Priyanthi Perera and Kanchana - BSc undergraduate student, University of Sri Jayewardenepura).

Development of a nano clay filled glove compound

A latex compound, according to a glove formulation was produced using nano clay. As the dipped films did not indicate good dispersion of the filler, another trial was carried out by modifying the method of preparation of the compound. Dispersion of the nano filler in latex was found to be good and hence gloves were produced in the laboratory by dipping a glove former into the latex compound. Cast films were also produced from the same latex compound containing the nano filler. Results of mechanical properties *i.e.*, tensile properties and tear strength of cast films made out of conventional clay and nano clay are given in Table 3 for comparison.

Table 3 indicates that except elongation at break, all the other tensile properties and tear strength of nano clay filled cast films are superior to those of the conventional clay filled cast films (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).

Table 3. *Mechanical properties of cast films made out of conventional clay and nano clay*

	Mod. at 100% (MPa)	Mod. at 300% (MPa)	Mod. at 500% (MPa)	Tensile strength (MPa)	Elongation at break, %	Tear strength (kN/m)
Conventional clay	0.10	0.32	0.45	9.4	948	35.45
Nano clay	0.17	0.53	5.80	19.8	688	47.98

Development of natural rubber latex foam for specialized applications

Few trials were conducted to develop natural rubber latex foam based boxing/karate glove pads at the request of an entrepreneur. A mould was specially fabricated for this purpose and the quality of the articles produced using this mould was in accordance with the requirement. This development is an ideal replacement for the imported original pads made out of polyurethane foam (D G Edirisinghe, S L G Ranjith and S I Yapa).

Development of rubberized twisted-coir articles

Trials on the development of pots and floor mats using rubberized twisted-coir were initiated (D G Edirisinghe and M K Mahanama).

Dry rubber technology

Development of weed control mats out of dipped products waste

A patent (No: 14908) was obtained for the "Power Mat" produced out of dipped product waste. Large scale production of "Power Mats" was initiated at the factory of Laugfs Corporation (Rubber) Ltd., Millewa, Horana in collaboration with the department. A leaflet on this mat was also produced to distribute among the plantation, agriculture and horticulture sectors. Approximately one thousand mats were handed over by Laugfs Corporation (Rubber) Ltd. to several plantation companies at their request.

The low cost, eco-friendly "Power Mat" won the "National Science and Technology Award - 2010" under the category "Development of eco material/eco-friendly processes for the industry" (A Nugawela, D G Edirisinghe and M K Mahanama).

Development of NR/polybutadiene rubber (BR)/reclaimed rubber composites for tyre treads

A series of NR/BR/reclaimed rubber composites was prepared by varying the composition of the three rubber components. Thereafter, the cure characteristics and physico-mechanical properties of these composites were evaluated to find the best composition in terms of these properties. Sheets prepared according to the SS drying

system (SSDR) were used as the NR grade. Results indicated that 80:10:20 NR/BR/reclaimed rubber composite is the most suitable for a tyre tread (Table 4). Heat build-up properties of this composite were also evaluated using the Goodrich Flexometer at Loadstar (Pvt.) Ltd.

Table 4. *Physico-mechanical properties of single stage, filled NR (SSDR)/BR/RR composites*

NR(SSDR)/ BR/RR ratio	Tensile strength (N/mm^2)	Tear strength (N/mm)	Hardness (IRHD)	Abrasion weight loss (g)	Rebound resilience (%)
80/20/0	6.64	80.80	60.7	0.093	65
80/10/20	18.84	127.80	67.9	0.122	56
70/10/40	10.51	96.37	70.0	0.121	54
60/10/60	8.21	67.36	66.8	0.140	50
70/20/20	6.12	69.93	64.0	0.117	64
60/20/40	8.20	82.28	69	0.107	54
50/20/60	9.72	84.69	73.4	0.149	46

As the second stage of the project, seven composites were produced by varying the distribution of carbon black of the 80:10:20 NR/BR/reclaimed rubber composite. Out of these composites six were prepared according to masterbatch mixing technique and the composite prepared according to single-stage mixing technique was designated as the control. Cure characteristics and physico-mechanical properties of all the seven composites were evaluated. Dynamic properties of this series of rubber composites were also evaluated.

Figures 1 to 5 show that in overall the physico-mechanical properties of the composite prepared according to the single stage mixing technique are superior to those of the composites prepared according to masterbatch mixing technique (D G Edirisinghe, S L G Ranjith and Maheshi Perera - MSc Polymer Science & Technology student, University of Sri Jayewardenepura).

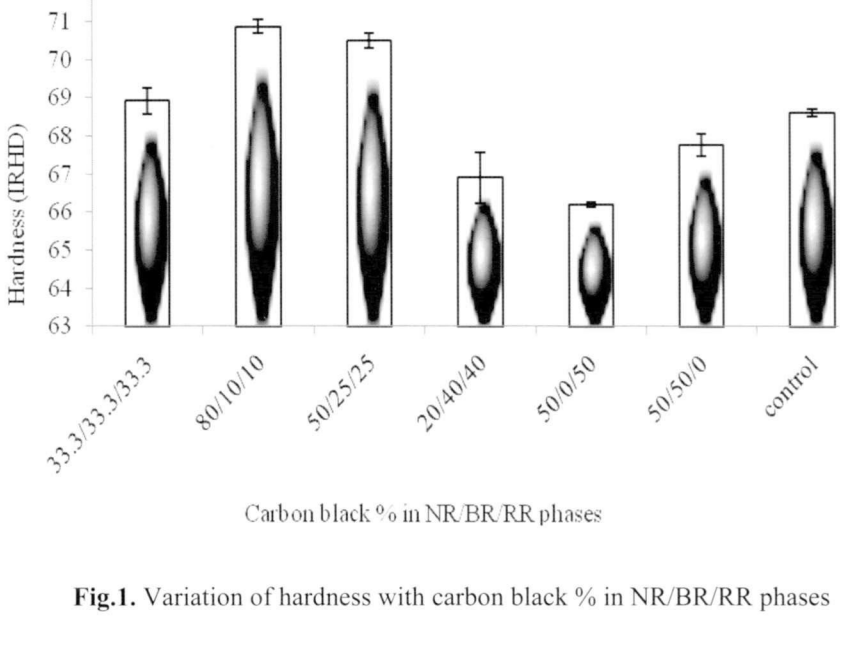


Fig.1. Variation of hardness with carbon black % in NR/BR/RR phases

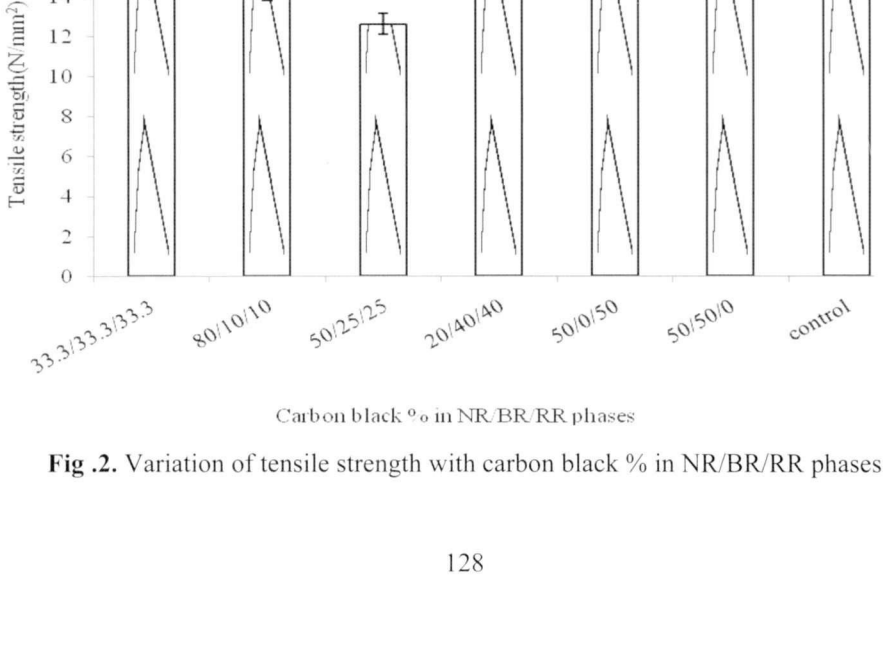


Fig .2. Variation of tensile strength with carbon black % in NR/BR/RR phases

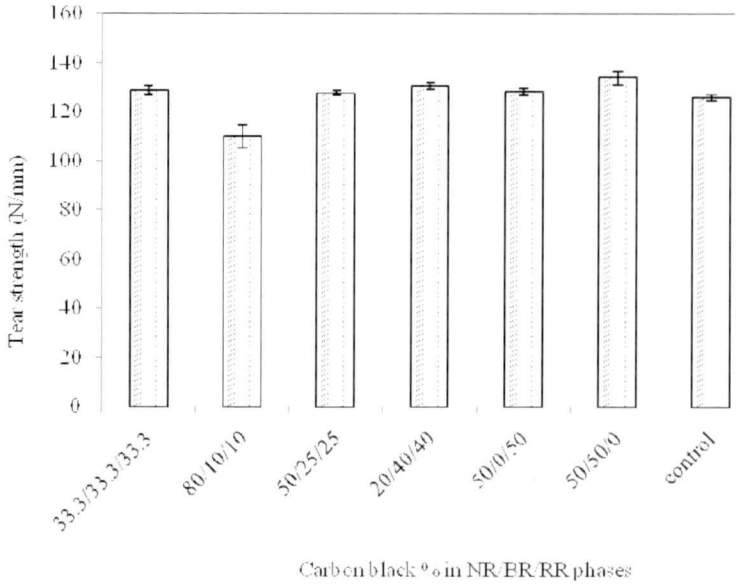


Fig.3. Variation of tear strength with carbon black % in NR/BR/RR phases

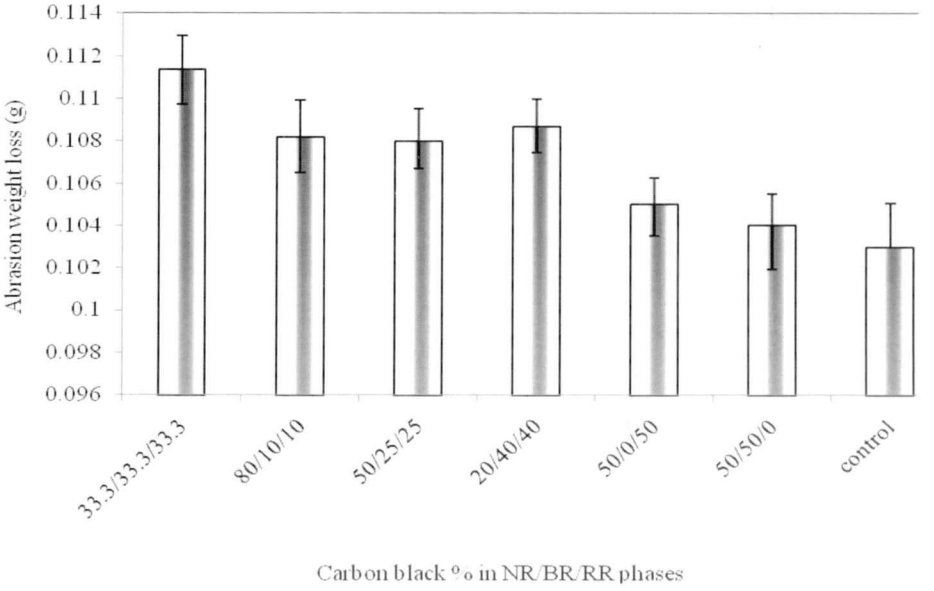


Fig.4. Variation of abrasion weight loss with carbon black % in NR/BR/RR phases

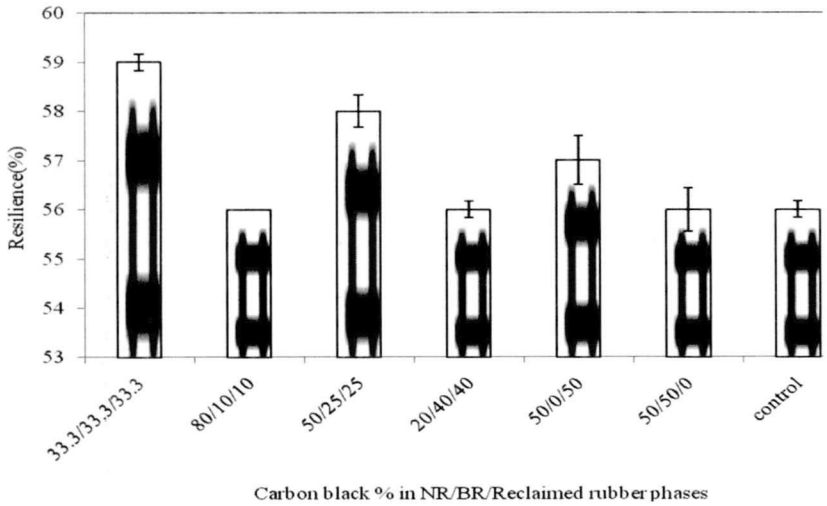


Fig.5. Variation of resilience with carbon black % in NR/BR/RR phases

Development of neoprene rubber compatibilized, carbon black filled NR/NBR composites

The composite based on 70/30/55 NR/NBR/carbon black (CB), which showed optimum composite properties was selected to compatibilize with neoprene rubber after evaluation of properties of the three composites *i.e.*, 30/70/55, 50/50/55 & 70/30/55 NR/NBR/CB. Five composites were developed by increasing the loading of the compatibilizer from 1 to 10 phr. Determination of physico-mechanical properties of the composites was initiated. Thesis based on first part of the work was submitted to University of Sri Jayawardenepura for evaluation (G D D Seneviratne, P L Perera and Amila Nishshanka - a BSc undergraduate student, University of Sri Jayewardenepura).

Development of rubber components for bio-medical applications

Work on this project was continued. Physical and ageing properties of the rubber compound produced with the aim of developing corrugated drainage sheets used in hospitals were evaluated. Hardness, tensile strength, tear strength and elongation at break of the compound were found to be 61 (Shore A), 14.73 (MPa), 37.5 (kN/m) and 433 (%), respectively (D G Edirisinghe and Priyanthi Perera).

Development of a nano clay filled, NR based tyre tread compound

Polymer nano-composites are a new class of materials with a great deal of future promise for potential applications as high-performance materials. Besides

traditional polymer composites, nano-composites become the most versatile industrial advanced materials. As such, this project was initiated to investigate the effect of addition of nano clay as a filler, as a replacement for china clay into the NR compound. Four composites were prepared using 60 phr of china clay and 3, 5 and 10 phr of nano clay. All physical properties tested improved with addition of nanoclay and properties further improved with increasing amount of nanoclay in the composites (Figs. 6,7,8,9,10) (G D D Seneviratne, P L Perera, L M K Tillekeratne - Dept. of Chemistry, University of Sri Jayewardenepura and Sanjaya Atapattu - BSc (Chemistry Special) undergraduate student, University of Sri Jayawardenepura).

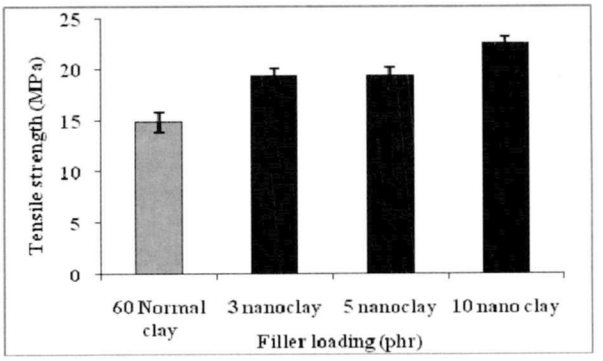


Fig.6. Variation of tensile strength of the four composites

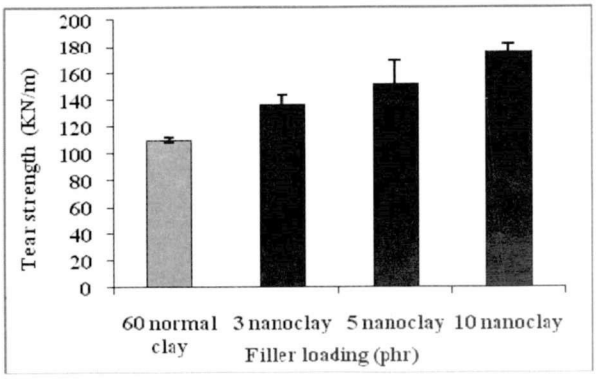


Fig.7. Variation of tear strength of the four composites

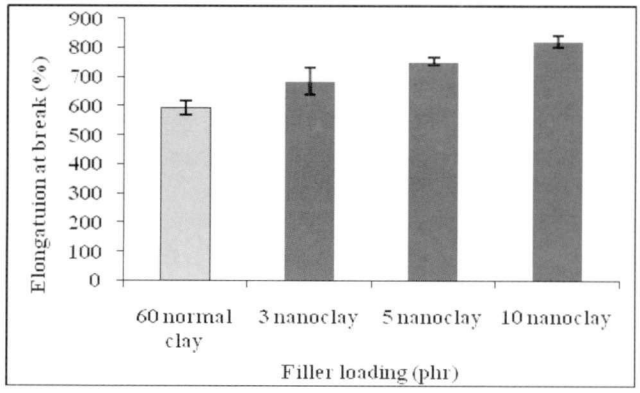


Fig.8. Variation of elongation at break of the four composites

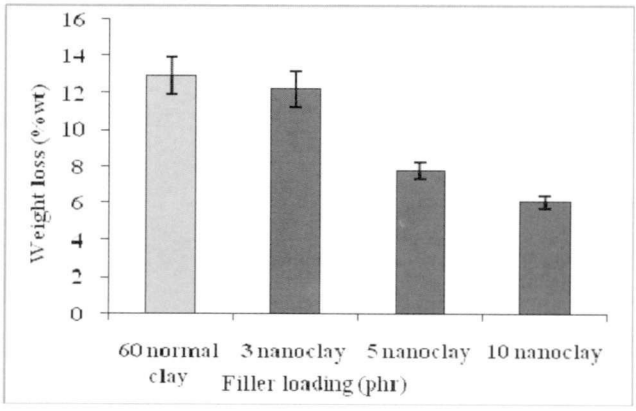


Fig. 9. Variation of abrasion resistance of the four composites

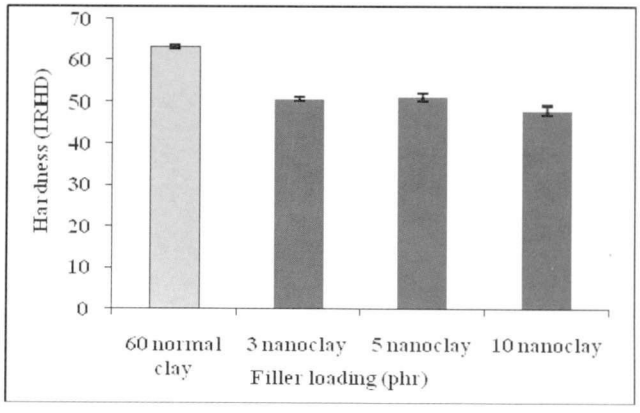


Fig.10. Variation of hardness of the four composites

Development of environmental friendly, biodegradable, natural fibre filled rubber composites

Natural fibers are abundantly produced as waste particularly from agricultural product processing. It has been reported that incorporation of these materials into NR matrix as a filler results in an improvement of physical properties. This project was initiated to investigate the effects of different types of fibre and fibre loadings on NR composites. With their low cost, high specific mechanical property natural fibres represent a good, renewable and biodegradable alternative to the most common synthetic reinforcement. A wide variety of natural fibres like coir, bagasse, banana, jute, palm, *etc.* can be used to reinforce the polymer matrix. However, incompatibility of the fibres and poor resistance to moisture often reduce the potential use of natural fibres. Physical and chemical modifications of the fibres and matrices may be employed to overcome the problem. Therefore, this study was carried out to investigate the potential use of natural fibres as fillers for natural rubber and the effect of fibre modifications on the composite properties. Literature review and survey on availability of fibres were initiated.

Coir and baggasse filled composites were prepared by varying the fibre loading. The physico-mechanical properties of the two composites at different fibre loadings are given in Table 5.

Table 5. *Physico-mechanical properties of the two composites at different fibre loadings*

Composites	Fibre loading (phr)	Tensile strength (MPa)	Tear strength (kN/m)	Hardness (IRHD)	Abrasion weight loss (%)
Baggasse filled NR	30	3.0	23	44	11.4
	40	3.1	23	60	13.1
	50	2.6	20	66	11.1
Coir filled NR	30	2.9	23	68	8.5
	40	3.9	26	61	8.4
	50	1.5	26	65	9.3

It can be seen from the table that there is no great change in the properties with the variation of fibre loading (G D D Seneviratne, D G Edirisinghe and P C Wettasinghe).

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

Further work on this project, initiated with the aim of studying the effect of chemically treated foam waste on mechanical properties of blends with virgin NR for floor mats was carried out. Modification of foam waste by treating it chemically with stearic (saturated fatty acid) and oleic (unsaturated fatty acid) acids were carried out

during last year and a report on this work was submitted to the University of Kelaniya. Although modification of foam waste by treating it with lauric acid was carried out at the same time, evaluation of properties of the blend compounds could not be conducted. Hence, cure characteristics and physico-mechanical properties of the blend compounds prepared according to blend ratios 100:0, 90:10, 80:20, 70:30 and 60:40 virgin NR : foam waste modified with lauric acid were evaluated. The results of physico-mechanical properties are given in Table 6.

Table 6. *Physico-mechanical properties of virgin NR: modified (with lauric acid) foam waste composites*

Property	100:0 NR/mod. foam waste	90:10 NR/mod. foam waste	80:20 NR/mod. foam waste	70:30 NR/mod. foam waste	60:40 NR/mod. foam waste
Hardness (IRHD)	58	62	64	71	73
Mod. at 100% (MPa)	1.26	1.46	1.66	2.03	2.0
Tensile strength (MPa)	22.63	14.7	14.9	13.2	7.6
% Elongation at break	772	484	482	363	273
Tear strength (kN/m)	79.1	62.9	52.8	60.3	49.6
Abrasion weight loss (%)	6.45	5.94	6.07	5.10	5.70

Results indicate that abrasion resistance of virgin NR compounds increase with incorporation of 30-40% foam waste, modified with lauric acid. Reduction in strength properties and % elongation at break as well as the increase in hardness and modulus at 100% elongation may be due to incompatibility of modified foam waste with virgin NR. Increased abrasion resistance of NR: modified foam waste composites can be attributed to increased hardness of the same (D G Edirisinghe and P C Wettasinghe).

Waste paper sludge incorporated NR composites

This project was initiated to study the possibility of partial replacement of mineral fillers with waste materials as an environmentally friendly way to recycle waste materials as well as cost reduction of the final product. It was identified that used newspapers are one of the commonly available organic waste materials that

could be used as a filler for the rubber composites. Waste newspaper sludge (NPS) was prepared by grinding newspapers, which were soaked in water for few days. NPS was dried in open air and oven dried at 80°C overnight before use. Three composites were prepared and properties were evaluated. There was no significant variation in all the examined composite properties among the three different loadings. Further work is in progress to improve the properties (G D D Seneviratne and P C Wettasinghe).

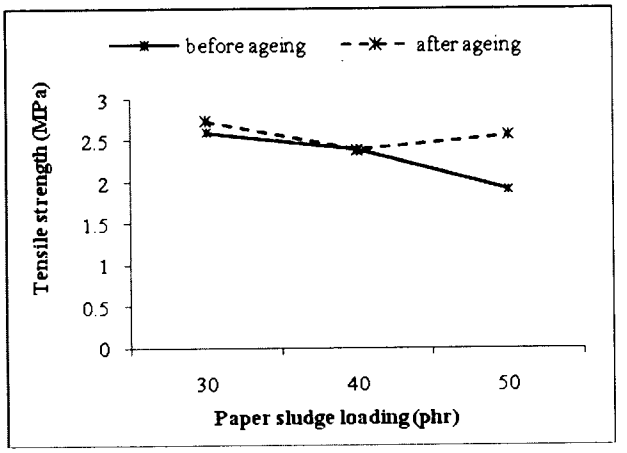


Fig.11. Tensile strength *vs* filler loading

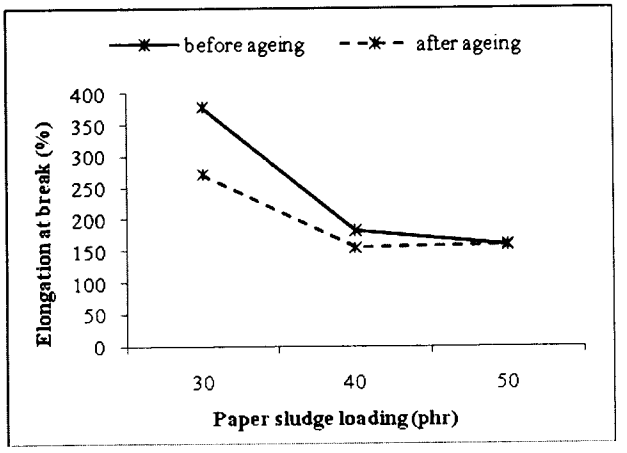


Fig.12. Elongation at break *vs* filler loading

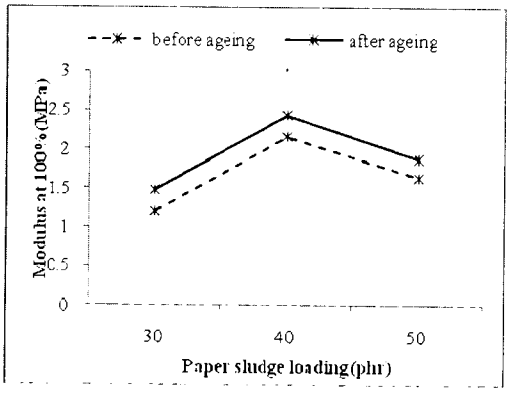


Fig.13. Modulus at 100% *vs* filler loading

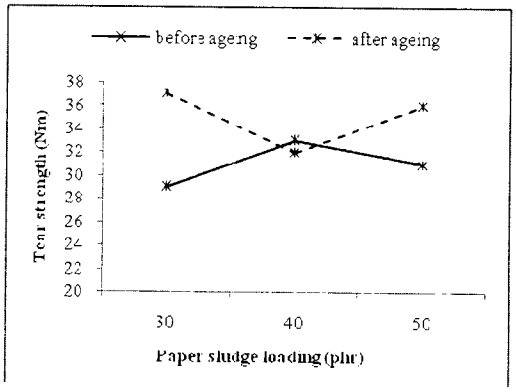


Fig.14. Tear strength *vs* filler loading

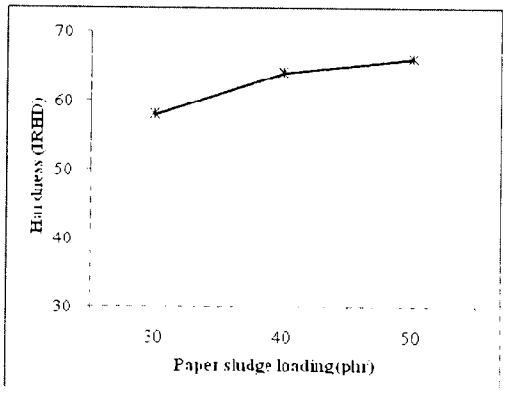


Fig.15. Hardness *vs* filler loading

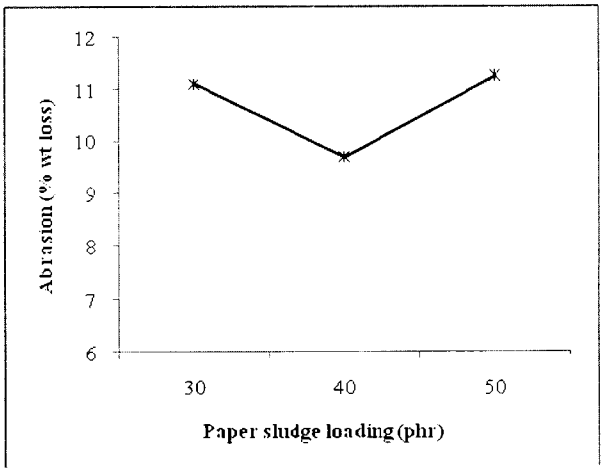


Fig.16. Abrasion resistance *vs* filler loading

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. pH adjustments were carried out to get the maximum amount of the end product. Evaluation of properties and FTIR analysis of the extracted oil were carried out (Ramani Wijesekera – Prof. of Chemistry, University of Colombo, Champani – MSc student, University of Colombo, W M G Seneviratne, D G Edirisinghe and M K Mahanama).

Industrial extension

The following services were provided to a number of rubber companies at their request.

Service	No. of companies
Testing physico-mechanical properties of rubber compounds	8
Testing physico-mechanical properties of rubber products	6
Testing hardness of sole crepe samples	3

In addition to the services rendered to rubber industries, a large number of entrepreneurs visited to the Department were provided with advice and assistance on setting up NR latex based cottage industries as well as dry rubber based industries.

POLYMER CHEMISTRY

Two formulations based on waste natural rubber and natural rubber latex was developed to produce cost effective rain guard sealant.

A machine was developed to manufacture rain guard sealant in order to maintain consistency and minimize batch to batch variation occurred during hand mix operation.

Fluid resistance properties of NR/NVC blend were successfully evaluated.

Skim rubber (5%) incorporated to EPDM formulation without affecting physical properties of the blend and improved cure characteristics.

Environmental friendly preservative system is being developed to preserve natural rubber latex.

Development of rubber based paint for latex strips has completed successfully.

NR based soaker hose developed by the department is being applied for different plantations in dry zone.

Several technology transfer programmes based on development of natural rubber based adhesives and rubber wood treatment was carried out for cottage industries.

POLYMER CHEMISTRY

A H L Renuka Nilmini

DETAILED REVIEW

Staff

Dr (Mrs) A H L Nilmini, Senior Research Officer and Mr H N K K Chandralal, Research Officer, were on duty throughout the year. Mrs Indra Denawaka, Mrs Chitra Kuruppu, Mrs Nirmala Jayawardena and Mr Ananda Samarakoon, Experimental Officers were on duty throughout the year.

Research students

- Mr K S Jayaraj MSc in Polymer Technology student from Sri Jayawardenapura University commenced 6 month research project on Variation of compound viscosity with ammonia and soap concentration, under supervision of A H L R Nilmini and H N K K Chandralal.

- Ms Amali Weerakoon, MSc in Polymer Technology student from Sri Jayawardenapura University completed 6 month project on Evaluation of property improvement of Ethylene Propylene Diene rubber presence of skim rubber, under supervision of A H L R Nilmini.

- Dr Renuka Nilmini served as an external examiner to evaluate the thesis of two MSc (Polymer Science and Technology) students of the University of Moratruwa.

Seminars/Training/Workshops/Conferences attended

Officer/s	Subject/Theme	Organization
AHLR Nilmini & HNKK Chandralal	Symposium on plantation crop research	Rubber Research Institute of Sri Lanka
AHLR Nilmini & HNKK Chandralal	Scientific Committee Meetings	Rubber Research Institute of Sri Lanka
AHLR Nilmini	Physical properties of polymers & Rheology and rubber elasticity	University of Sri Jayawardenapura – BSc in Polymer Chemistry
AHLR Nilmini	Adhesives and surface coatings	University of Moratuwa – MSc in Polymer Technology

Officer/s	Subject/Theme	Organization
AHLR Nilmini	Wood Manufacturers Organization	National Enterprise Development Authority
HNKK Chandralal	Rubber Chemistry and Technology	PRI-DPRI course
HNKK Chandralal	Colloidal chemistry and surface coatings	University of Sri Jayawardenapura – MSc in polymer Science and Technology
HNKK Chandralal	Adhesives and surface coatings	University of Moratuwa Diploma in Polymer Technology

Seminars/Training/Workshops/Exhibitions conducted

Officer/s	Subject/Theme	Beneficiary/Client
AHLR Nilmini	preparation of low cost rain guard sealant	Small holders of rubber estates
HNKK Chandralal	"Deyata Kirula" exhibition	Small – medium entrepreneurs, School children

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
AHL R Nilmini and HNKK Chandralal	Rubber Wood treatment	Aitken Spence Plantations
AHLR Nilmini, HNKK Chandralal and A Samarakoon	Preparation of rain guard sealant	Kuruwita Sub-station
AHLR Nilmini, HNKK Chandralal and A Samarakoon	Preparation of rain guard sealant	Frocester estate

Experimental

Manufacture of rain guard sealant making machine

The major problem associated with rain guard sealant manufacture was inconsistency of the products manufactured at different batches. Hence a solution for above problem was requested by Lalan Rubbers (Pvt) Ltd. The inconsistency of the

final product was a result of inadequate stirring and heating in hand mixing manufacturing process. To overcome those problems, a "prototype" machine with a sigma blade stirrer and controlled heating facility was developed at Sapumalkanda Estate of Lalan Rubbers (Pvt) Ltd. The machine manufactured sealant was found to be superior compared with the sealant which is being used by hand mixing. Further manufacturing time of the sealant was reduced by one hour compared to the time taken for hand mix sealant production.

As "prototype" machine was successful, hand mixing machine with 140Kg capacity was fabricated for the same estate with 1/8" thick MS plate. A suitable fireplace for the machine was manufactured using fire bricks. The machine was installed at Sapumalkande estate and quotations were called to manufacture both hand and machine operated machines for Dartonfield estate (A H L Nilmini, H N K K Chandralal).

Preparation of low cost sealant for rainguard

Two low cost formulations for rain guard sealant were confirmed after several trials carried out in laboratory as well as in plantation. Rubber component of one formulation is natural rubber latex and in other waste natural rubber gloves. Final products of both formulations were with superior qualities compared to sealant which is being used at present. Introduction of new sealants to plantation companies is being in progress (A H L Nilmini, H N K K Chandralal and Ananda Samarakoon).

Study of fluid resistance property in blend compounds based on natural rubber with NBR/PVC

Natural Rubber is not resistance 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 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 (Table 1) were prepared using Crepe rubber as the NR raw material and compounded and cured based on conventional sulphur vulcanization and compared the solvent resistance.

Table 1. *Compounding formulation*

	Blend 1	Blend 2	Blend 3	Blend 4	Blend 5	Blend 6	Blend 7
NR	100	80	60	50	40	20	0
NBR	-	14	28	35	42	56	70
PVC	-	06	12	15	18	24	30

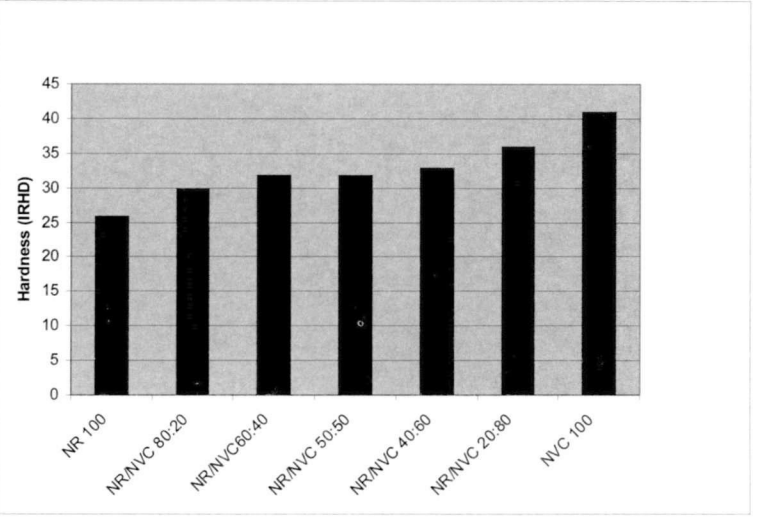


Fig.1. Variation of IRHD hardeness of various NR/NVC blends

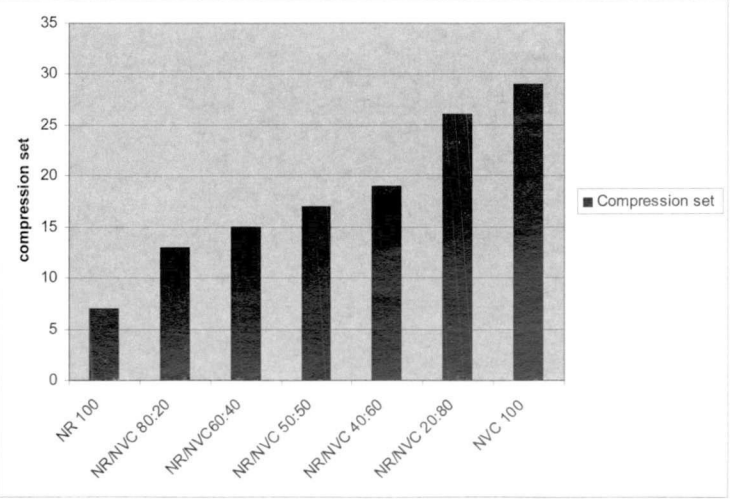


Fig.2. Variation of compression set of various NR/NVC blends

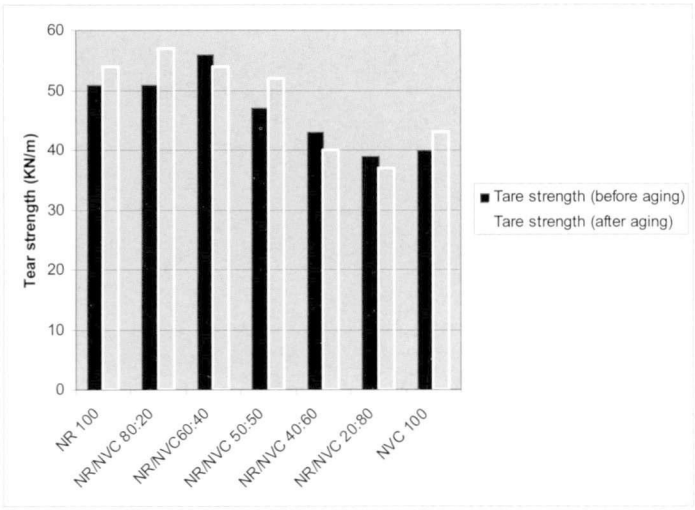


Fig.3. Variation of tear strength of various NR/NVC blends

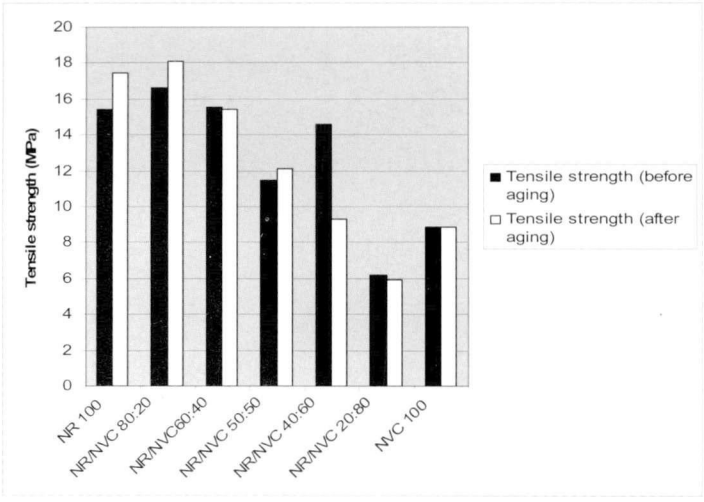


Fig.4. Variation of tensile strength of various NR/NVC blends

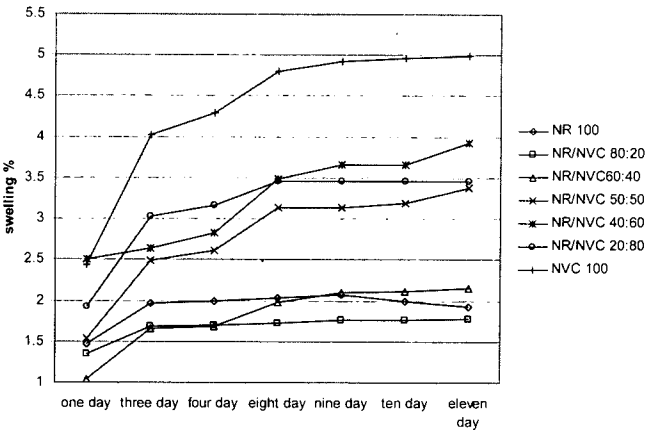


Fig.5. Swelling behaviour of NR/NVC blends in brake fluid

Brake fluids are subtype of hydraulic fluid with high boiling point and low viscosity variation with temperature. Composition wise mineral oil, glycol, organophosphate esters and silicone oils are used as brake fluids. Physical properties such as hardness (Fig. 1), compression set (Fig. 2), tear strength (Fig. 3); tensile strength (Fig. 4) and swelling in glycol type brake fluid (Fig. 5) were evaluated for series of NR/NVC blend. NR/NVC 80:20 blend possesses good oil resistance properties and comparatively good physical properties (A H L R Nilmini, H N K K Chandralal and Indra Denawaka).

Evaluation of property improvement of Ethylene Propylene Diene rubber presence of skim rubber

A project is initiated to evaluate property improvement of EPDm rubber in the presence of skim rubber as an additive. Complete characterization of skim rubber was done to calculate amount of non rubber and free fatty acid presence in skim rubber. Suitable formulation (Table 2) was developed and several compounds were prepared by varying amount of skim rubber in each formulation. TMTD/MBT accelerator system was used to characterize blend properties.

Following formulation was selected as compound A and compound B,C and D were prepared adding fractionated bleached crepe (4.0g), skim rubber (5.0g) and skim rubber (10.0g) for the above formulation respectively. These systems were analyzed using TMTD/MBT accelerator system.

Table 2. *Compounding formulation*

Ingredient	Loading (phr)
EPDM	100
Carbon black HAF 330	80
Naphthenic oil	50
ZnO	5
Sulphur	1.5
TMTD	1.0
MBT	0.5
Stearic acid	1.0

Mooney viscosities of the compounds are not appreciably altered by the addition of skim rubber (Table 3). Cure characteristics of the compounds are influenced by the added amount of skim rubber. Optimum cure time of the compounds progressively decreases from compound A to compound D with the increment of the added amount of non-rubber ingredients. Fractionated bleached crepe rubber contains 1.81% proteins and 0.45% fatty acids. Skim rubber contains 3.64% free fatty acids and 15% proteins. The compound with 10 phr skim (D) has shown shorter cure time whilst the compound without any non-rubber ingredients showed the highest cure time. The optimum cure time of compounds indicate the role of non-rubber ingredients as co-activators for the vulcanization of EPDM. The natural fatty acids, amino acids and peptide linkages of decomposed products of proteins function by the mechanism similar to that of stearic acid, the conventional activator adopted in conjunction with Zinc oxide.

Table 3. *Mooney viscosity and cure characteristics of the compounds with TMTD/MBT accelerator system*

Sample	Mooney viscosity ML 1+4, 100^0C	Torque difference M_H-M_L (dNm)	Scorch time T_s1 (seconds)	Optimum cure time t_c 90 (seconds)
A	22.5	69.67	89.90	665.70
B	23	147.58	60.74	658.11
C	23	154.67	73.78	625.10
D	23.5	37.87	70.46	447.09

Hardness, rebound resilience, aged and unaged tensile strength (Table 3) increased from compound A to C and whilst vulcanizate D showed minimum value for the each property.

Table 4. *Hardness, rebound resilience, tear strength and tensile strength of the compounds with TMTD/MBT accelerator system*

Vulcanizate	Hardness (IRHD)	Rebound resilience	Tear strength (N/mm)	Un aged tensile strength (Mpa)	Aged tensile strength (Mpa)
A	50.9 ± 0.4	33 ± 2	33.38± 0.05	8.38 ± 0.08	7.37 ± 0.05
B	52.1 ± 0.5	34 ± 2	32.26 ± 0.06	8.74 ± 0.04	7.84 ± 0.03
C	56.6 ± 0.5	37 ± 2	30.93 ± 0.03	9.35 ± 0.05	8.95 ± 0.02
D	38.3 ± 0.7	32 ± 3	39.52 ± 0.02	5.27 ± 0.02	4.97 ± 0.06

The optimum hardness value with 5 phr skim rubber indicates greater cross link density in the vulcanizate C. The lowest hardness value, rebound resilience and tensile strength of vulcanizate C indicates lowest crosslink density of the compound which could be result of cure incompatibility of NR and EPDM. The project was successfully completed confirming incorporation of 5% skim rubber in conventional EPDM formulation without affecting physical properties of the blend (A H L R Nilmini, H N K K Chandralal, Chitra Kuruppu and Amali Weerakoon).

Production of PRI improved crepe/RSS

This project was initiated to improve PRI of natural rubber using water-soluble linear polymer. The results have shown that both Po and PRI have been improved significantly in crepe rubber using this polymer. Further trials have to be conducted to do the same for skim rubber and RSS. However, due to lack of the water-soluble polymer, the project has been abandoned (A H L R Nilmini and Chitra Kuruppu).

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

This project is being continued from last year. The best concentration of preventol, which is effectively, reduces the VFA development against control (TMTD/ZnO) system, have been identified conducting several trials using different preventol concentration levels (Fig. 6). The physical properties of preventol incorporated latex films are being analyzed.

In addition to preventol another water soluble polymer was tested as a preservative system for natural rubber latex. Different concentration ranges of new chemical were applied to field latex and stability action was tested for 56 days. According to the results, latex which has been preserved using 0.01% of new

chemical has shown low VFA development compared to the other concentrations used. Another series of experiments are being planned to analyze preservative action of this chemical with centrifuged latex.

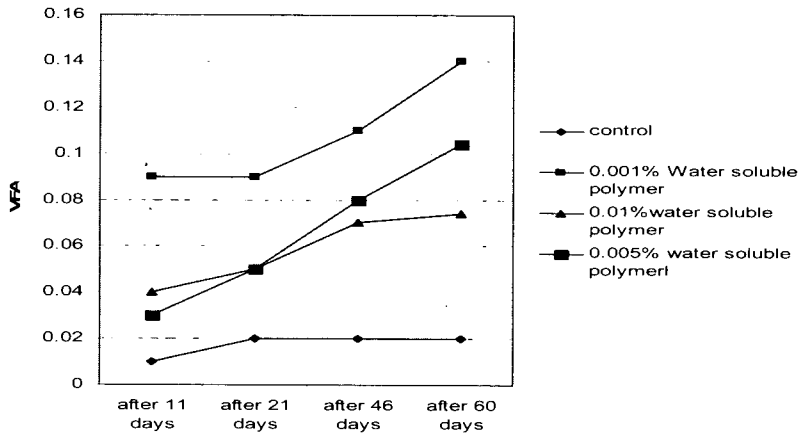


Fig. 6. Variation of VFA in field latex with different concentration of water soluble polymer (A H L R Nilmini, H N K K Chandralal, Indra Denewaka, Chitra Kuruppu, Nirmala Jayawardena and A Samarakoon)

Soaker hose for drip irrigation

Efficient irrigating system for rubber plantations in drought area 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 reservoir) 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 (A H L R Nilmini, H N K K Chadralal and A Samarakoon).

Development of rubber based paint for latex strips

A latex based industry requested to develop a non-staining rubber based paint used in application of trademark on latex strips instead of imported paint has been used at present. Easy application, gloss nature and adhesive strength of the paint are the major areas of the targets. Several trials conducted using crepe rubber as the binder and different solvent system was used to achieve quick drying ability of the paint. Two pack system of the paint was successfully developed where dissolved

accelerator system has to be applied at the final stage of the application (A H L R Nilmini, Chitra Kuruppu and Nirmala Jayawardena).

Technology transfer programmes

Three technology transfer programmes were held for cottage industrialist to support their adhesives industries based on substrate such as plywood, carpet backings and shoe sole. Complete demonstration was done on preparation of several types of adhesives including both with natural and synthetic rubber (A H L R Nilmini, H N K K Chandralal and Chitra Kuruppu).

Industrial extension

- DSI
- Sri Lanka Army
- Water Board
- Quality Latex Products
- Lalan Rubber (Pvt) Ltd
- AMW
- ITI
- Polymer Products (Pvt) Ltd.

RAW RUBBER AND CHEMICAL ANALYSIS

A total number of 136 raw rubber analytical certificates of TSR samples were issued after testing the samples for raw rubber properties for grading and shipping purposes. Seven hundred samples of different grades processed raw rubber were tested for quality assessment for both export and local consumption purposes. Four hundred and nineteen numbers of latex samples were analyzed for evaluation of technical properties in accordance with ISO standards. Thirty six umber of rubber chemicals were tested for their percentage purity assessments. The department also involved in testing of rubber products such as natural rubber content in vulcanized product.

A research aimed to investigate the effect of ethephon stimulation on NR latex properties and development of new preservative system for stimulated latex was continued.

Initial trials were conducted to investigate the correlation between the potassium hydroxide number, Volatile fatty acid number and conductivity of natural rubber latex.

Preliminary study on effect of NR latex with different TMTD/ZnO content storage period on physical properties of latex concentrate was started.

A study on variations of raw rubber properties of new clones were studied and the project has to be continued in order to achieve reasonable judgment of the raw rubber properties of new clones introduced by the rubber research Institute of Sri Lanka.

A project based on "The effect of KOH Number under aerobic and anaerobic storage conditions of centrifuged Natural rubber latex" was completed as a partial fulfillment for the Diploma in Rubber Technology student from Lalan Rubber Pvt. Ltd. in collaboration with the Rubber Research Institute.

A student from University of Sri Jayawardenapura carried out her final year project to investigate the effect of residual magnesium and phosphate ions on latex based dipped products and new methodology was introduced to determine the residual DAHP content in centrifuged latex.

RAW RUBBER AND CHEMICAL ANALYSIS

Anusha Attanayake

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, 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 through out the year.

Experimental Officer Ms H S Weeraman retired on 3rd September 2010 after excellent service of 36 years to the rubber industry.

Instrument Technician Mr L G P Lelwela, was on duty through out the year.

Research students

- G Thusitha Sampath Dharmawardhana, DPRI student from Lalan Rubbers Pvt (Ltd) carried out his DPRI project on "The effect of KOH Number under aerobic and anaerobic storage conditions of centrifuged Natural rubber latex" under the supervision of Anusha Attanayake.

- G D S Dilshani, BSc undergraduate student from University of Sri Jayawardenapura carried out her final year project on "Novel Method to Determine the Residual DAHP Content in Natural Rubber Centrifuged Latex and Effect of Residual Magnesium and Phosphate ions on Latex Based Dipped Products" under the supervision of Anusha Attanayake.

Seminars/Training/Workshops/Conferences attended

Officer/s	Subject/Theme	Organization
AP Attanayake	Symposium on Plantation Crop Research	Cinnamon Grand Hotel, Colombo
AP Attanayake	International Workshop on "White Root Disease"	International Rubber Research & Development Board, Hotel Janaki, Colombo
LP Vitharana	Dayata Kirula Exhibition	Pallekele, Kandy

Seminars/Training/Workshops/Conferences/Exhibition conducted

Officer/s	Subject/Theme	Beneficiary/Client
AP Attanayake	Raw rubber properties of new clones	Scientific Committee Meeting, RRISL
Dept. staff	Raw rubber analysis	NDT Polymer Science students, University of Moratuwa
Dept. staff	Latex testing	B W A N Baddevithana, University of Ruhuna
Dept. staff	Raw rubber testing	NDT 2nd year Chemical Engineering Technology students

LABORATORY INVESTIGATIONS

The effect of KOH number under aerobic and anaerobic storage conditions of centrifuged natural rubber latex (DPRI Project)

KOH No. of Centrifuged natural rubber latex is defined as the "number of grams of potassium hydroxide equivalent to the acid radicals combined with ammonia in latex containing 100g of total solids". This indicates the total fatty acid content of the latex. As per the specifications given in ISO 2004; (4th edition -1997) KOH No. in Centrifuged latex should be less than 1.0. KOH No. of latex will be affected due to added fatty acid stabilizers, formation of volatile fatty acids *etc.* Current study was carried out to investigate the effect of aerobic and anaerobic storage conditions on the KOH No. of Centrifuged natural rubber latex. Centrifuged Latex samples were obtained from two latex centrifuging facilities of Lalan Rubbers (Pvt) Ltd, situated at Bulathsinghala and Warakapola of Sri Lanka. Samples were transported to the Central Laboratory of Lalan Rubbers (Pvt) Ltd for storage and laboratory testing. Samples were tested for KOH No. and VFA No. after 21 days. Rise in KOH No. is greater of the samples stored under aerobic conditions than the samples stored under anaerobic conditions. KOH No. of Centrifuged natural rubber latex increases with the time and it is affected due to the storage conditions in which the latex is stored. Increase in KOH No. is greater when the latex is stored under aerobic conditions than it is stored under anaerobic conditions as shown in Fig.1.

Test results of current study confirms the statement that difference between the KOH No. and the VFA No. is greater when latex is stored under the aerobic conditions with compared to that under the anaerobic conditions. Increase in KOH of latex during the storage is independent of the increase in VFA No. KOH number of Centrifuged latex is affected due to the dosage of added fatty acid stabilizers. KOH number of Centrifuged natural rubber latex increases with the time and it is affected due to the storage conditions in

which the latex is stored. Increase in KOH number is greater when the latex is stored under aerobic conditions than it is stored under anaerobic conditions (G Thusitha Sampath Dharmawardhana, E C de Alwis Karunarathna and A Attanayake).

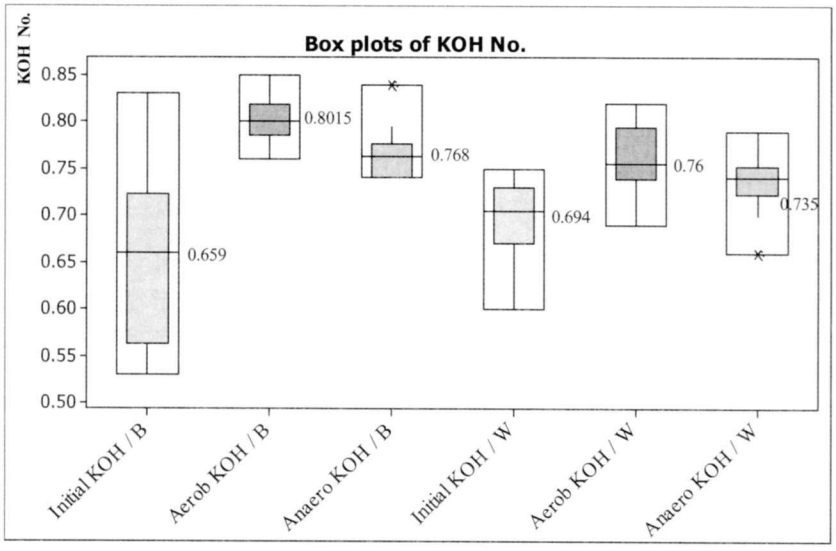


Fig.1. Box plot graph for the variation of potassium hydroxide number under aerobic and anaerobic conditions

Effect of ethephone stimulation on NR latex properties and development of new preservative system for stimulated latex (RR&CA/L/ES/10/01)

Recent year's consumer interest has been focused on quality as well as quantity of rubber. One aspect of great concern was increasing yield and different types of chemicals have been tested for yield stimulation. When stimulation was introduced, the objective was to get higher yield and stimulant was applied only on renewed bark. But during the last two decades, the NR industry is threatened by constrains like lack of skilled tappers, reduced tapper productivity and high cost of production. To alleviate some of these, low intensity tapping system was introduced. A new experiment was started to investigate the effect of ethephone stimulation on NR latex properties.

This project aims to identify the effect of Ethephone stimulation on latex dry rubber properties and introduce non-toxic, effective new preservative system for stimulated latex.

Samples were collected from RRIC 100 and experimental blocks were selected from Gallewatta division of Dartonfield estate. Properties of field latex, Centrifuged latex and crepe rubber were assessed on monthly basis.

From the preliminary trials RRIC 100 was selected for seasonal variation studies. Two experimental blocks from mono clonal (RRIC 100) mature rubber trees were selected, one is ethephon applied and the other block is ethephon free. Two tapping frequencies; tapping a tree once in two days (d/2), three days (d/3), were imposed on each clone keeping five replicate plots to each frequency. The treatment plots were set up allocating 25 trees to each plot. No stimulants were used in the traditional system of d/2 (Control). In d/3, tapping block, stimulation done once in three months with 2.5% Ethephon.

The latex samples were collected monthly from each treatment plot and initially analysed to asses any changes in the latex properties given in Table 1.

Table 1. *Latex properties tested*

Latex property	Test method
Total solid content	ISO 124
Dry rubber content	ISO 126
Volatile fatty acid No.	ISO 506
Alkalinity (Latex phase)	ISO 125
Viscosity (Brookfield)	ISO 1652
Magnesium content	RRISL
Conductivity	-

Then samples are processed in to lace crepe and assessed for raw rubber properties given in Table 2.

Table 2. *Raw rubber properties tested*

Raw rubber property	Method used
Initial Plasticity (Po)	ISO 2007
Plasticity Retention Index (PRI)	ISO 2930
Moony viscosity	ISO 289
Lovibond colour	ISO 4660
Nitrogen content	ISO 1656
Ash content	ISO 247

(A Attanayake, C Lokuge and N Karunathilake)

Novel method to determine the residual DAHP content in natural rubber centrifuged latex and effect of residual magnesium and phosphate ions on latex based dipped products

Natural rubber latex is the pre-eminent raw material in dipped product industry. It has outstanding ability to form smooth, continuous film on drying and its

vulcanizates have high strength and elastic properties. Several articles are made out of latex. Important among them are different types of gloves (surgical, examination, industrial, household, electrician, beautician, *etc.*), condoms, teats and soothers, meteorological and toy balloons, catheters, bladders, elastic thread, latex tubing, carpet backing, rubberised coir products, foam rubber, latex adhesives, cast toys and so many others. These articles are generally made out of concentrated latex, obtained by either centrifuging or creaming of preserved field latex.

Latex contains considerable amount of magnesium ions (Mg^{2+}) and during wintering period this amount increases due to defoliation. Despite of that some clones have higher amount of magnesium in heredity. However, increase in concentration of Mg^{2+} facilitates enhanced VFA formation in latex. Hence, prior to concentration process, metallic ions like Mg^{2+} are removed by the addition of diammonium hydrogen phosphate (DAHP) as water insoluble magnesium ammonium phosphate, which is removed by sedimentation as sludge. When DAHP is added to remove Mg^{2+} ions from the latex there may be some adverse effects due to the excess amount of PO_4^{3-} ions.

The objective of this study is to find out a method to calculate the residual DHAP content in natural rubber latex to minimize the problems in production process. The samples were prepared by adding known amount of different dosage of DAHP (Table 3). After addition of stabilizer samples were kept for overnight in air tight containers. Sludge was removed by separate centrifugation of each sample. Mg^{2+} and residual PO_4^{3-} contents were measured at the laboratory (Table 4). Residual PO_4^{3-} content was detected by a novel titrimetric method. Dipped cast films were prepared using compounded latex and tensile properties analysed in each film, in order to check the effect of residual Mg^{2+} and PO_4^{3-} ions in dipped products.

It is evident from the results that impact of residual DAHP content is more prominent than residual Mg^{2+} content on tensile properties of dipped films.

Table 3. *Samples prepared to investigate property variations with residual phosphate and Magnesium concentrations*

Sample	Added amount of 15% DAHP/g
1	6.71
2	4.71
3	2.71
4	1.71
5	1.21

Table 4. *Residual Magnesium and Phosphate content in centrifuged latex*

Sample	Residual Magnesium content/ppm	Residual Phosphate content/ppm
1	17.78	63.9
2	38.45	Nil
3	56.19	Nil
4	69.78	Nil
5	95.55	Nil

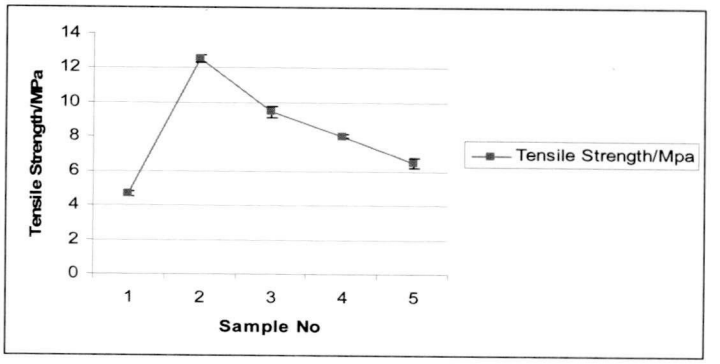


Fig.2. Variation of tensile strength with residual magnesium and Phosphate content

The tensile strength of sample 2,3,4,5 decreases with increasing residual Mg^{2+} ion content (Fig. 2). The maximum increase in tensile strength value was shown by the sample No-2, which had been treated with excess phosphate ions, but the sample which contained residual phosphate shows minimum tensile strength.

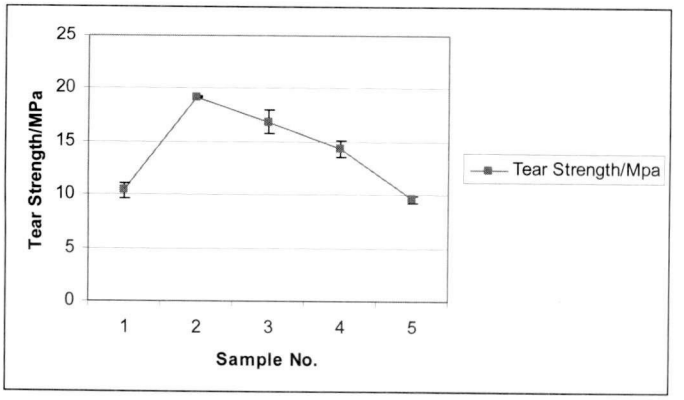


Fig.3. Variation of tear strength with residual Magnesium and Phosphate content

Tear strength of the film also change same as the tensile strength (Fig. 3). It is evident from the results that, according to the residual magnesium and phosphate content, the mechanical properties also affected. In this study only one sample has been detected with residual phosphate. Hence proper conclusion cannot be made in terms of excess phosphate presence in the sample. This has to be further studied with varying amount of residual phosphate.

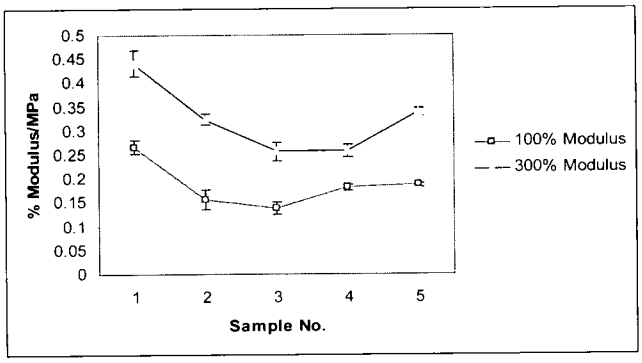


Fig.4. Variation of modulus with residual Magnesium and Phosphate content

According to the Figure 4, control sample which has 56.19ppm magnesium content showed lowest modulus values. Gradual increasing of magnesium content showed increasing modulus values. This effect can be explained by the activator effect of magnesium ions on cross linking density of the sample. Similarly by increasing phosphate ion content also resulted in increasing of modulus values.

The excess of Mg^{2+} content in latex promote bacterial proliferation. Thus the volatile fatty acid content in latex increase and thus formed destabilized latex by lowering pH below 4.5. Also the excess addition of water soluble phosphate reduces the mechanical stability of latex. The reduction of the stability is caused by increasing the ionic strength of the serum and also action of soap may be inhibited by adding excess phosphate to the medium by removing ammonia from the medium as $Mg(NH_4)PO_4$. This result in inhibiting the ability of added soap molecules to stabilize the rubber particles. Natural rubber lattices with a PO_4^{3-} ion level of 30ppm showed much better stability during storage and thereby provided better film properties in latex products.

Direct measurement of free phosphate in latex is not possible by colourimetric method, because the serum remaining after coagulation of rubber and protein gives cloudiness with the molybdate reagent. The precipitate responsible for cloudiness is yellow. Therefore proposed titrimetric method can be used to estimate the strength of the DAHP sample and residual phosphate content in natural rubber

latex (A P Attanayake, C Lokuge, G D S Dilshani, BSc undergraduate student from University of Sri Jayawardenapura).

Effect of NR latex with different TMTD/ZnO content storage period on physical properties of latex concentrate (RR&CA/L/PRE/10/4)

Five series of Centrifuged latex samples were prepared with different TMTD/ZnO concentrations and latex properties were tested according to ISO std. NR latex films were prepared from each sample of latex and tensile properties were tested. Above samples were stored at room temperature and raw rubber and tensile properties were tested with different storage periods (Anusha Attanayake and L P Vitharana).

Evaluation of raw rubber properties of new clones (RR&CA/Rub/New Clones/10/5)

Studies were initiated on a request made by Rubber plantation companies at the 30th Scientific Committee Meeting.

Fourteen newly developed clones were selected from three different locations (Table 5) and RRISL 100, RRISL 121 were set as the control for the study.

Table 5. *Selected clones with their field site and year of planting*

Clone	Site	Year of planting
RRISL 216	Galewatta Division, Dartonfield Estate	1994
RRISL 219		1994
RRISL 211		1994
RRISL 203		1987
RRISL 205	Pallegoda Estate	1995
RRISL 206		1995
RRISL 2000		1998
RRISL 2001		1995
RRISL 201	Kuruwita Sub-Station	1994
RRISL217		1995
RRISL 202		
RRISL 222		
RRISL 100 (Control)	Galewatta Division	
RRISL 121 (Control)		

From each clone five samples of fractioned, bleached crepe rubber were prepared and raw rubber properties were evaluated. Samples have to be drawn from each clone up to 12 months in order to study the seasonal variations of each clone.

No stimulants were used in the traditional system of d/2. Latex samples have to be collected monthly from each treatment plot and analyzed for latex properties

according to the ISO standard. Variations of Ash content, Nitrogen content, Plasticity number, Plasticity retention Index, Mooney viscosity and Lovibond colour index with the type of clone is shown by Fig.5 - Fig.10 respectively.

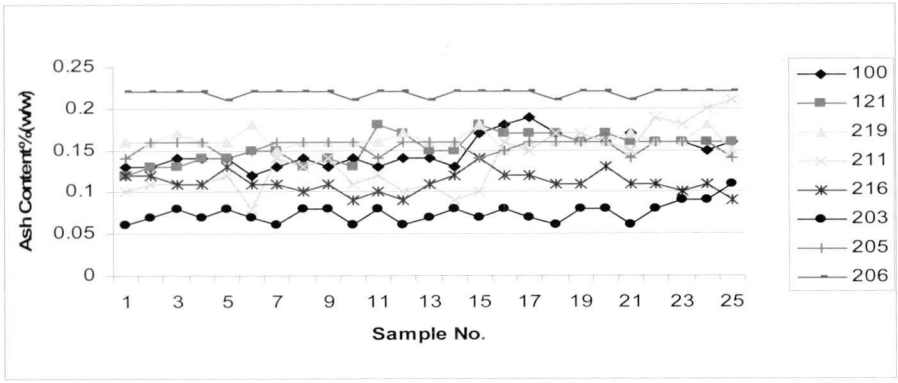


Fig. 5. Variation of ash content with type of clone

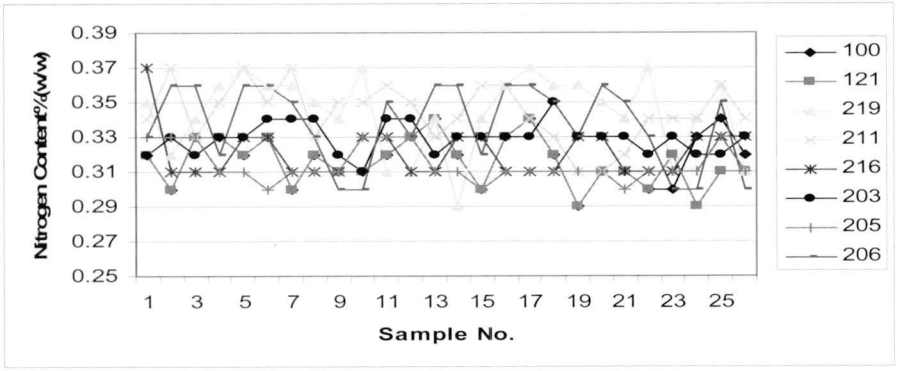


Fig. 6. Variation of nitrogen content with type of clone

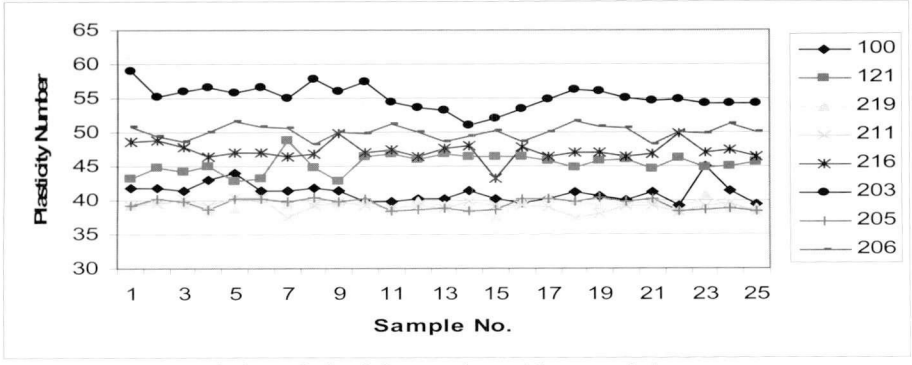


Fig. 7. Variation of plasticity number with type of clone

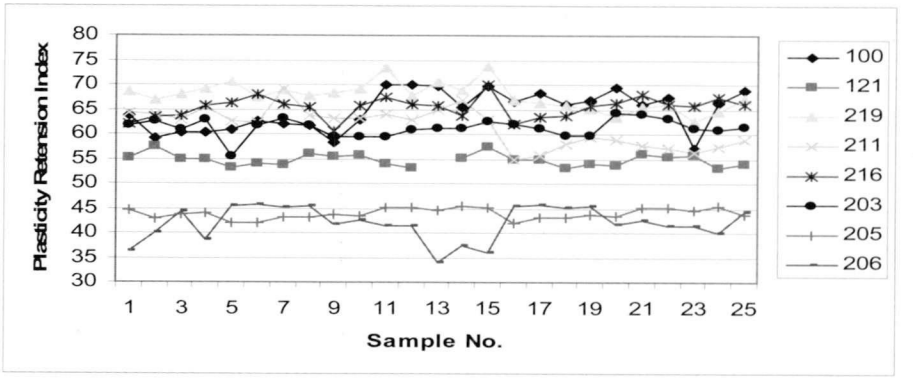


Fig. 8. Variation of ash plasticity retension index with type of clone

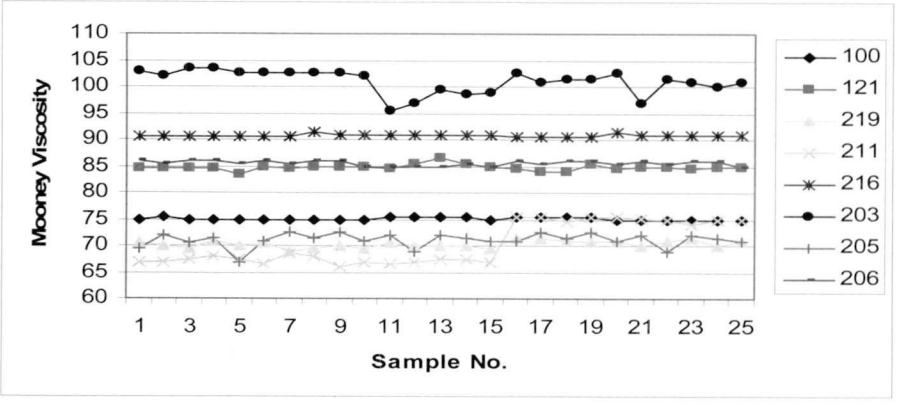


Fig. 9. Variation of mooney viscosity with type of clone

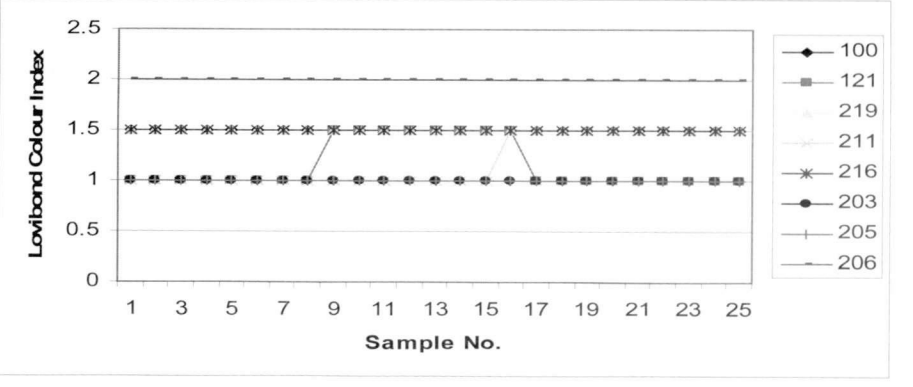


Fig. 10. Variation of lovibond colour index with type of clone

Present work is carried out on laboratory scale within short period of time. Further study should be carried out at least for one year to make a conclusion on clonal properties including seasonal variations.

Clonal differences may be regarded as an adverse factor as regards consistency, and in practice this effect is reduced as generally latices from several clones are mixed before being processed into dry rubber. Perhaps in the future greater emphasis will be placed on the properties of the latex rather than improvement of rubber yield in the development of new clones for planting (A P Attanayake, L Wanigathunga and N Karunathilake).

Services

Trouble shooting activities

a). A private factory which is a rubber based industry engaged in manufacturing and marketing slippers and sandals based on NR and other polymers made a complain that they have observed pieces of metal wires embedded in few straps of rubber. The raw materials used in the production were NR and re-claim rubber.

They made a request to examine the reclaim rubber they have in stock and submit a report for them. Two officers of the department was engaged in this matter and samples were collected by them were subjected for ash test.

Ash content is a analytical method of ascertaining mineral matter content of rubber. In general ash content of commercial grades of rubber varies between 0.1-1 the maximum being in scrap grade of rubber. However on visual inspection, protruding fine steel fibers could be seen in all samples. During the production of reclaim rubber, rubber based articles such as tyres are subjected for grinding initially prior to subsequent reclaiming process. As such there is a possibility of contamination of fine pieces of steel in the final product of reclaim rubber unless efficient iron removal is not carried out after grinding of tyres (A Attanayake, L P Vitharana and N Karunathilake).

b). A leading Rubber company have imported raw scrap container from Bangladesh and the custom has requested the approval from environmental authority to release the container. Environmental authority requested the RRI certificate stating that the rubber samples are non-toxic.

As per the request made by the rubber company, the samples were drawn for testing by the two officers from the department and issued certificate confirming the grade of rubber. However this consignment of rubber has been subjected to pesticide control to overcome the maggot formation during the long storage at customs (A P Attanayake and N Karunathilake).

Calibration of latex tanks

Calibration of latex tanks carried out as per the requests made by the Superintendent, Kuruwita sub- station for accurate measurements of the quantity of latex.

Analytical services

Samples tested during the year were as follows:

Service	No. of samples
TSR analysis	
Le-Ferne Block Rubber Factory, Getahetta, Nathupana	27
Sandagiri Block Rubber Factory, Dompe	109
Miscellaneous analysis	
Raw rubber samples	704
Latex samples	419
Chemical samples	36
Bleaching agent samples	72
Testing certificates	1367

RAW RUBBER PROCESS DEVELOPMENT AND CHEMICAL ENGINEERING

Preliminary studies carried out on drying of crepe rubber revealed the possibility of cutting down the conventional drying period of crepe rubber by 75%. Based on the results, a dryer was designed and fabrication was commenced in the end of the year. A collaborative research project was carried out with Lalan Rubbers (Pvt) Ltd. to study the seasonal variations of NR field latex. The results showed that there were no significant quality variations that could be assessed by the available local laboratory facilities. Investigation was carried out on utilization of sludge, a by-product from centrifuged latex industry, as filler for natural rubber compounds. A simple procedure was established for the preparation of filler from the sludge. The results of the experiments carried out during the year have revealed that filler derived from sludge could be used as a functional filler while offering specific properties to the NR compounds. Experiments were conducted with a view to reduce the milling operations in crepe rubber manufacture as another preliminary work in line with the mechanization of crepe rubber manufacturing process. An optimum coagulum particle size was established for crepe rubber manufacture and it was shown the possibility of reducing the number of mills and number of milling passes in the manufacturing process. The factory scale trial carried out on the coagulum braking device was not successful due to its complexity despite its possibility of reducing labour cost and improving working environment.

A significant number of raw rubber process development projects were supported and guided by the technical staff of the department particularly on the RSS manufacture and single day drying process for the RSS producers in estate sector as well as the small and medium sector. In addition, routing testing services such as waste water samples and processing water samples, and trouble shooting consultancies were provided as requested by the clients.

RAW RUBBER PROCESS DEVELOPMENT AND CHEMICAL ENGINEERING

S Siriwardena

DETAILED REVIEW

Staff

Dr Susantha Siriwardane, Head of the department was on duty throughout the year. Dr Upul Rathnayake, Rubber Chemist was granted a further one year no pay leave from 01st June 2010 to continue a research assignment at Sri Lanka Institute of Nano Technology (Pvt.) Ltd. (SLINTEC). Mr P H Sarath Kumara, Assistant Rubber Chemist resigned from the Institute from 01st April, 2010 to join a private Natural Rubber Latex Processing Company.

Messrs Chandana Senanayake, T A S Siriwardane, Mrs Chandrika Nalini, Mrs Shirani Priyanka, A K D Warnajith Prasad and Mrs C Rohanadepa, Experimental Officers and Mrs Ruckmani Liyanage, Store Keeper were on duty throughout the year. Mrs Anusha Paranavithana, Typist/Clerk, who served for more than 30 years at RRISL retired on 19th July, 2010.

Research students

- Ajith Kumara, final year undergraduate student of the Department of Chemistry, University of Sri Jayewardenapura carried out his final year industrial research projects on "Development of simple method to detect higher dilution of NR latex in the field" under the supervision of Mr P H Sarath Kumara.

Seminars/Trainings/Workshops/Conferences/Meetings attended

Officer/s	Subject	Organisation
WMG Seneviratne	Development of a Proposed Science Park	NSF
WMG Seneviratne	CRI Review Meeting	NASTEC
WMG Seneviratne	Rubber City Development Project	MPI
WMG Seneviratne	NSPC Meeting on Carbon Trading	ANRPC
WMG Seneviratne	Meeting on Joint Venture Operations of SRMC Factories	MPI
WMG Seneviratne	Directors Forum	TRI
S Siriwardena	A meeting on Establishment of Large Scale RSS Factory	Lalan Rubbers (Pvt) Ltd.

Officer/s	Subject	Organisation
S Siriwardena	SSF Annual General Meeting	NASTEC
S Siriwardena	Rubber Sector Meeting	NIPM
S Siriwardena	Progress Review Meeting	MPI
S Siriwardena	Panel discussion on the establishment of rubber cluster	SRI
Department staff	'Deyata Kirula" National Development Exhibition	MPI

Seminars/Trainings/Workshops/Exhibitions conducted

Officer/s	Subject	Beneficiary/Organisation
WMG Seneviratne	ISO audit on laboratory accreditation	Dipped Products Ltd.
S Siriwardena	A training program on "manufacture and grading of raw rubber"	Richard Peries Company
UMS Priyanka, AKD Warnajith and Rohanadeepa	A training program on "correct use of Metrolac Instrument to estimate DRC"	Moralioya Estate, Ruwanwella
AKD Warnajith and Rohanadeepa	A training program on "Raw Rubber Processing"	Undergraduate students, UvaWellassa University

Experimental visits

Field of experiment	Number of visit
Raw rubber processing	12

Advisory visits

Services provided	No of factories/visits
Process and quality improvements	21
Waste water treatment	04
Designs for modifications of ETPs	04
Implementation of SS drying system in estate sector	03
Plans given for construction of new SS drying system with capacity less than 100 kg	25
Plans given for construction of new SS drying system and modifications of existing systems to new SS drying system with capacity more than 100 kg	07
Miscellaneous	02

Sample testing and certificates issued

Samples tested	Number of samples/certificates
Waste water - rubber related	139
Waste water - non rubber related	26
Processing water	03
Rubber samples for protein content	08
Certificates issued	
Waste water	80
Processing water	02
Rubber samples for protein content	08
Epidemic prevention	46

LABORATORY AND FIELD INVESTIGATIONS

Mechanization of crepe rubber manufacturing process (RRPD/D/MCM/2006/01)

A partitioning unit was fabricated with the generous financial assistance rendered by the Lalan Rubbers (Ltd.) and it was installed at DF rubber factory. Experimental trials carried out suggested to introduce a motorized system to control the upward and downward movements of the unit to make it easily handballed. Engineering experts were consulted to modify the coagulum partitioning unit to make it more user friendly. However, these slices were milled into crepe rubber using different milling programs as given in Table 1. Colour of the blanketed crepe sample which is the main factor used to grade the crepe rubber conventionally was compared with the blanket crepe rubber manufactured conventionally.

Table 1. *Milling programs studied*

Milling program	No. of passes		
	Macerator	Diamond mill	Smooth mill
01 (Normal passes)	03	04	01
02	-	05	01
03	-	04	01
04	-	03	01
05	-	02	01

It was found that colour of all the samples is similar and poorer than the laces manufactured using coagulum broken conventionally at the Dartonfield Rubber Factory. This observation suggests that surface area of the slices is not adequate for efficient removal of non rubbers. Therefore, it is decided to extend these studies to find the optimum size of the slices to get crepe laces in good colour. However, the results revealed that un-fractioned un-bleached (UFUB) crepe laces could be produced with only two diamond mill passes as the colour is not important in this

grade. This will save energy and labour cost and cut down the manufacture cost of UFUB rubber (Susantha Siriwardena, A K D Warnajith and T A S Siriwardena).

Development of an uninterrupted drying system for crepe rubber (RRPD/D/UDS/2007/17)

Based on the positive results of preliminary experiments carried out on crepe rubber drying, new drying system which utilizes forced heated air flow was designed in collaboration with Dharmadasa Engineering Firm with the following objectives.

(i). restriction of the drying period to few hours
(ii). reduction of the worker requirement
(iii). improvement of the quality of rubber
(iv). improvement of the working environment

The design was modified to introduce hot smoke as an optional source of heat to enable to utilize same drying chamber for drying of RSS. Fabrication of the drying unit at Dartonfield was started at end of the year (Susantha Siriwardena, A K D Warnajith and T A S Siriwardena).

A study of quality variations of NR latex and physical properties of natural rubber latex films from *Hevea brasiliensis* (RRPD/L/QVCL/2010/02)

Seasonal variations of NR latex at field level could affect the manufacturing process of centrifuged latex. Seasonal variations of centrifuged latex are also affected making variations in raw latex properties accordingly. As such there is a demand from the industry to ascertain these variations and to make recommendations to arrest the effect of these variations. Therefore, a project was carried out to collect the field latex as well as centrifuged latex to study this effect. Seven latex collecting routes were selected and representative latex samples were collected for a four month period. The results of the field latex quality parameters collected from different routes are tabulated in Tables 2a,2b,2c & 2d.

Table 2a. *DRC of field latex*

Sample data	Latex collecting route						
	Derani-yagala	Thal-gaswala	Ratna-pura	Mona-ragala	Horana	Mawatha-gama	Matale
1st August	31.16	30.19	31.35	20.9	30.36	31.43	27.64
1st September	30.68	31.12	28.35	19.41	30.00	31.69	26.10
27th September	30.71	30.68	33.18	23.84	30.97	28.27	29.05
18th October	32.17	30.37	33.21	18.88	-	-	-
10th November	32.17	29.8	34.7	21.66	30.41	-	-
01st December	33.25	-	-	20.9	20.90	-	-

Table 2b. *TSC of field latex*

Sample data	Latex collecting route						
	Derani-yagala	Thal-gaswala	Ratna-pura	Mona-ragala	Horana	Mawatha-gama	Matale
1st August	32.95	32.01	33.02	22.7	32.40	33.55	29.66
1st September	33.81	32.88	31.54	21.25	32.28	33.83	28.23
27th September	32.55	32.27	35.45	25.85	33.61	31.00	31.67
18th October	33.13	32.89	35.77	20.86	-	-	-
10th November	35.0	32.31	37.5	24.33	33.53	-	-
01st December	35.68			22.85	22.85	-	-

Table 2c. *VFA of field latex*

Sample data	Latex collecting route						
	Derani yagala	Thal-gaswala	Ratna-pura	Mona-ragala	Horana	Mawatha-gama	Matale
1st August	0.033	0.058	0.05	0.08	0.061	0.051	0.046
1st September.	0.091	0.04	0.06	0.07	0.080	0.045	0.061
27th September	0.045	0.04	0.08	0.07	0.086	0.066	0.269
18th October	0.085	0.124	0.07	0.08	-	-	-
10th November	0.069	0.06	0.08	0.1	0.051	-	-
01st December	0.063	-	-	0.1	0.085	-	-

Table 2d. *Mg^{2+} content of field latex*

Sample data	Latex collecting route						
	Derani-yagala	Thal-gaswala	Ratna-pura	Mona-ragala	Horana	Mawatha-gama	Matale
1st August	218	137	84	114	129	142	167
1st September	137	69	167	36	76	103	111
27th September	93	196	124	164	94	120	231
18th October	122	81	276	91			
10th November	91	99	-	146			
01st December	-	-	-				

These results show no significant variation in the above quality parameters tested with the locally available facilities. Variations with other factor such compositional variations and viscosity cannot be tested with a reliable accuracy due to the unavailability of advanced testing facilities and other resources (S Siriwardena, U M S Priyanka and Lalan Group).

Effect of metal ions on quality of latex crepe rubber (RRPD/D/EMC/2001/05)

The study was continued during the year to investigate the effect of remaining iron and copper ions in the fractioned and bleached (FB) crepe rubber on thermo-oxidative degradation and thereby effect on the oxidative stability of the natural rubber.

Further investigations, carried out to study the effect of oxidation state of iron, showed that not only ferric (Fe^{3+}) ions but also ferrous (Fe^{2+}) ions catalyses the oxidative degradation process of natural rubber (NR) (Fig. 1).

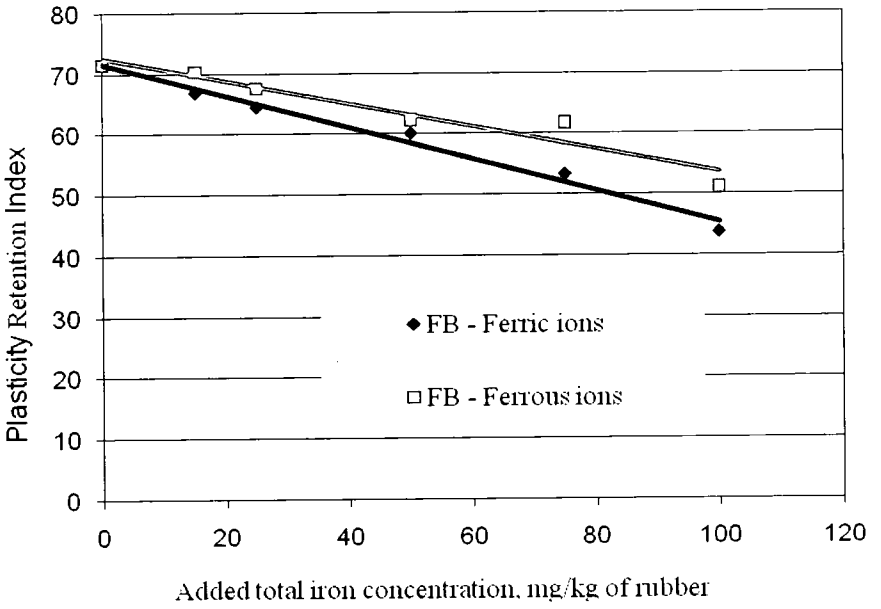


Fig.1. Effect of Fe^{3+} and Fe^{2+} ions on Plasticity Retention Index (PRI)

From this study, in adiition to the critical levels of metal ions in processing water and crepe rubber as reported in the last year annual review, following conclusions were made:

- Both remaining Fe^{3+} and Fe^{2+} ions in the crepe rubber significantly accelarate the thermal oxidatiion of the crepe rubber.
- However, thermoxidative stability of the FB crepe rubber is severly affected by Fe^{3+} ions.
- The presence of excessive concentration of Fe^{3+} ions in latex have a tendency to discolour the FB crepe rubber due to the conversion of part of aromatic thiol (bleaching agent) into a disulfides (U N Ratnayake, P H Saratha Kumara, T A S Siriwardena, A K D Warnajith Prasad and V C Rohanadeepa).

Development of sludge, a by-product from centrifuged latex industry, as a functional filler for natural rubber compounds

Sludge, a by-product from centrifuged latex manufacturing process, consists of an important chemical composition and has received little attention to make this waste product into a value added product (*i.e.* to make an economically value product). Therefore, a new project has been initiated:

- to characterize the sludge in detail
- to develop this inorganic matter as functional filler for rubber compounds

A simple drying method to remove surface moisture and grinding process to reduce the particle size are used to prepare the sludge powder. The sludge powder was characterized to its chemical composition. Table 3 shows the average percentages of important metal ions, in the sludge powder.

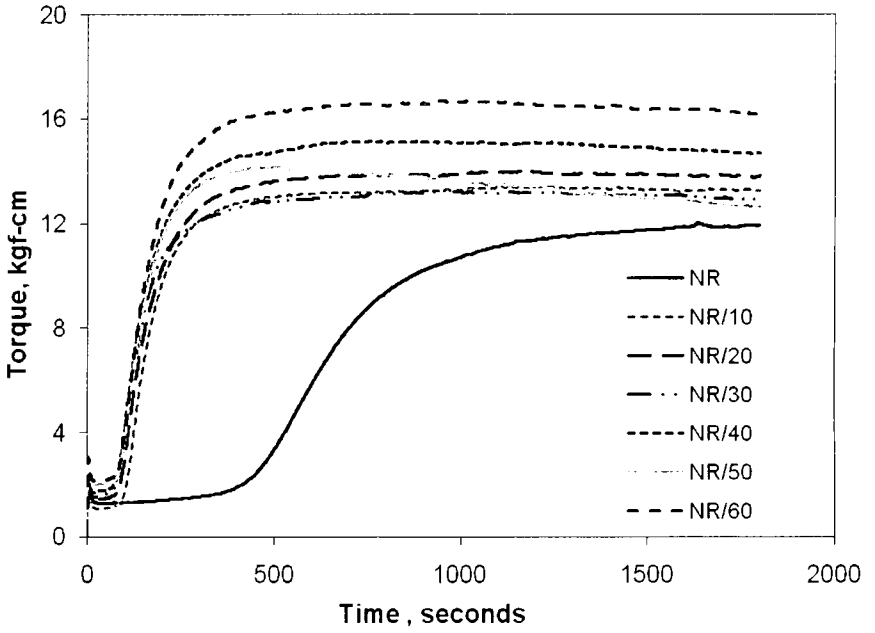
Table 3. *Some contents and their quantities in the skim sludge powder*

	Zn µg/g	Mg µg/g	Fe µg/g	Total nitrogen µg/g	Hydrocarbon %	Moisture %
Sludge powder	3376	70340	835	3100	8	20 - 25

As expected, the chemical composition of the sludge clearly indicates the high concentration of metal ions, especially Mg and Zn. In addition, latex particles are also trapped within this inorganic sludge.

Dried sludge powder was further dried for complete removal of volatile matter (mainly chemisorb water) and then it was incorporated into NR at different ratios to form rubber composites. The sludge loading level was varied from 10 phr to 60 phr in the natural rubber composite. Vulcanization behavior of the compounds comprising different concentrations of sludge powder are shown in Figure 2.

As shown in the rheographs, sludge accelerates the vulcanization process while reducing the processing safety of the compound. The studies on mechanism of vulcanization acceleration due to the sludge powder and the effect of sludge on mechanical properties of rubber composites are in progress (U N Ratnayake and Shirani Priyanka).



(NR/XX refers to rubber composite containing XX phr sludge powder)

Fig.2. Rheographs of NR compounds containing different levels of sludge powder

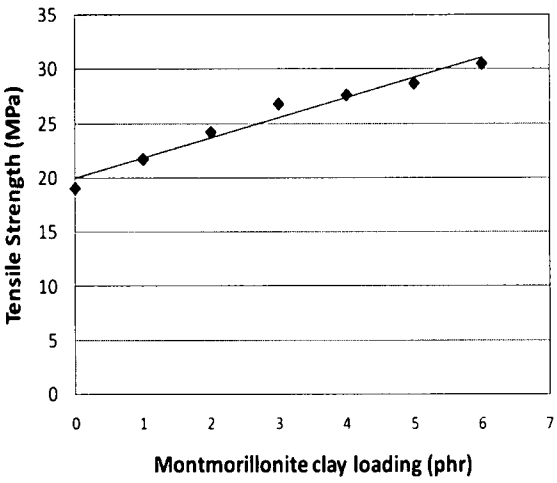
Development of Natural rubber latex/layered silicate nano composites for dipped products (RRPD/L/LCN/2007/01)

The project, which was initiated in collaboration with the Dept. of chemical and process engineering, University of Moratuwa, was continued throughout the year. Natural rubber (NR) latex/layered silicate nanocomposites were prepared by the incorporation of montmorillonite (MMT) clay, as an aqueous dispersion. Initial characterization of NR latex/clay nanocomposite structure showed that MMT clay particles are intercalated/exfoliated and dispersed uniformly within the latex films.

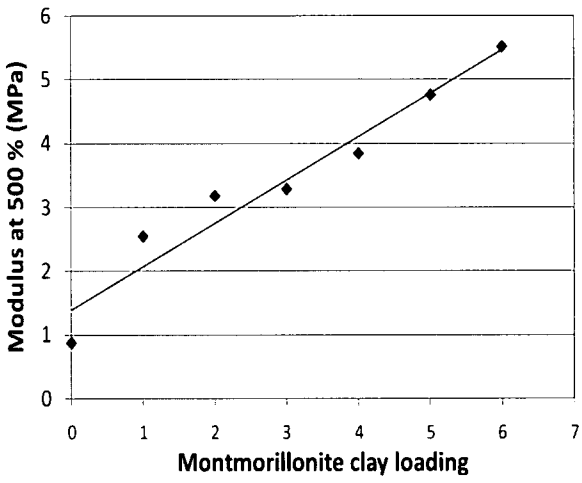
Reinforcing effect of MMT clay on vulcanized latex films was evaluated by tensile property measurements. Figure 3 shows the tensile properties of NR latex/clay nanocomposite films prepared by incorporating different loading levels of MMT.

As shown in Figure 3, tensile properties of NR latex nanocomposite based on MMT clay are significantly increased in comparison to the NR gum compound (*i.e.* NR latex films with no MMT clay). This is attributed to the fact MMT clay particles are exfoliated into smaller stacks, most probably at nano scale, in NR latex and as a result aspect ratio and specfic surface area of MMT clay platlets are increased

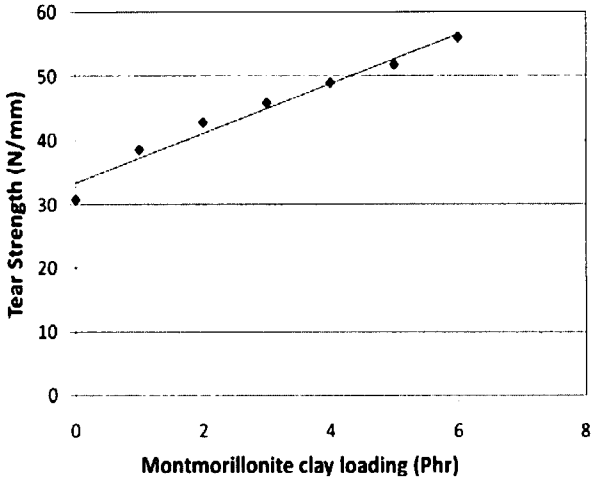
significantly (Research student: Ananda Amarasiri, Supervisors; U N Ratnayake, Shantaha Walpola (University of Moratuwa) and S Siriwardena).



(a)



(b)



(c)

Fig. 3. Tensile and tear properties of NR/clay nanocomposites; **(a).** Tensile strength, **(b).** Tensile modulus at 500 % elongation, **(c).** Tear strength

ADAPTIVE RESEARCH

Harvesting of rubber trees in Eastern Province was commenced with the presence of Hon. Minister of Plantation Industries. Also, office building complex of the Monaragala substation was inaugurated. Planting three paired rows of pineapple between two rubber rows is found to be effective in smallholder sector. Quality assessments on flower confirmed the feasibility of growing anthurium under rubber. Average yield curve of rubber clone RRIC 100 under commercial conditions was established. Inclusion carbon values and intercrops was found to increase the financial / economic viability of rubber plantation by about 6% and 60%, respectively. Yield curves of both component crops were established for rubber/tea intercropping system. Honey yield per colony reached the highest ever recoded value of 3.5 l at the RRISL. Awareness programmes on field establishment practices were conducted to smallholders in Mahaoya and Padiyathalawa in Eastern province. Rubber was established in 6 smallholdings covering an extent of 2 hectares in Northern Province.

ADAPTIVE RESEARCH

V H L Rodrigo and S M M Iqbal

DETAILED REVIEW

Staff

Dr V H L Rodrigo coordinated the activities of this unit. Dr S M M Iqbal (Agronomist), Assistant Agronomists Mr W A D D S Wettasinghe, Mrs B M D C Balasooriya, Dr (Ms) 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 P Udayakumara, Temporary Technical Assistant was on duty up to 6th July 2010 under the NSF/2005/AG/14 project. Ms N A A S Nallaperuma was on duty throughout this year as a Temporary Technical Assistant under the NSF/2008/AG/02 project.

Dr (Ms) E S Munasinghe obtained her PhD from the University of Sri Jayewardenepura with effect from 28.09.2009 for the study entitled "Growth, yield and economics of rubber cultivation in Sri Lanka".

Seminars/Training/Workshops/Exhibitions conducted

Officer/s	Subject/Theme	Beneficiary/Client
VHL Rodrigo, SMM Iqbal, ES Munasinghe	Workshop on Cultivating Rubber in Droughts and Rubber based Animal Husbandry	Rubber smallholders of Padiyathalawa and Mahaoya, Ampara district
ES Munasinghe	Rubber based Farming System	Manager - Loadstar Pvt. Ltd.
S M M Iqbal	Workshops on Rubber Cultivation	Smallholders in Padiyathalawa and Mahaoya in Ampara District
	Skill Development Programme-Rubber based Farming System	Rubber Field Officers for NIPM

Seminars/Training/Workshops/Meetings/Conferences attended

Officer/s	Subject/Theme	Organization
VHL Rodrigo ES Munasinghe	Workshop on Preparing National Green Carbon Inventory	Forest Department of Sri Lanka
VHL Rodrigo ES Munasinghe	Symposium on Climate Change & Adaptation	Centre for Environment Justice
VHL Rodrigo ES Munasinghe	International Conference on White Root Disease	RRISL & IRRDB

Officer/s	Subject/Theme	Organization
VHL Rodrigo, ES Munasinghe	Presented a poster on 'Impact of recent worker wage increase on the financial viability of the rubber crop; carbon market and smallholder involvement as relief measures' at the Third Symposium on Plantation Crop Research, Sri Lanka	RRISL, TRISL, CRISL & SRISL
SMM Iqbal	IRRDB Training Fellowship	Rubber Research Institute of Malaysia
SMM Iqbal, ES Munasinghe	Presidential Awards Ceremony	National Research Council
SMM Iqbal, DS Wettasinghe, BMDC Balasooriya, ES Munasinghe	Scientific Committee Meetings	RRISL
SMM Iqbal, DS Wettasinghe, BMDC Balasooriya, ES Munasinghe	Workshop on Scientific Writing	NSF
SMM Iqbal, VHL Rodrigo, DS Wettasinghe NAAS Nallaperuma	Presented a Working Paper on "Identification of suitable species and genotypes for cut foliage and flower cultivation on rubber lands Progress Review Seminar - 2010	NSF

Visits

Experimental visits - 110
Advisory visits - 10

FIELD INVESTIGATIONS

Adaptive research programme

***Beekeeping in rubber plantations* (ARU/BK/2004/1)**

Total number of bee colonies present in the apiaries under rubber at Dartonfield/RRISL and Kuruwita substation is given in Table 1.

Artificial feeding with sugar was carried out in wooden boxes during the dearth period. 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).

Table 1. *Details of the bee colonies available at Dartonfield and Kuruwita substation*

Site	Wooden boxes				Clay pots			
	Introduced	As at Jan 2010	Absconded	As at Dec 2010	Introduced	As at Jan 2010	Absconded	As at Dec 2010
Dartonfield	2	3	2	3	-	1	-	1
Kuruwita	1	2	1	2	-	5	1	4

Honey production during 2006-2010 in the apiaries under rubber at Dartonfield/RRISL and Kuruwita substation is given in Table 2.

Table 2. *Honey production in hives under rubber*

Year	2006	2007	2008	2009	2010
Honey volume/colony ml.	1275	1395	1014	735	3453

(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 actions taken to establish rubber in this region appeared in Annual Review 2004.

In brief, main activities conducted during the year were,

- Rubber planting was undertaken in 11 ha in 23 holdings
- Assessment of photosynthetic performance of rubber leaves
- Soil moisture measurements during dry spell
- 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
- Historic tapping of rubber trees in the east (smallholding in Komana village at Padiyatalawa) inaugurated by Hon. Minister of Plantation Industries

[S M M Iqbal, V H L Rodrigo, R S Dharmakeerthi and A Nugawela in collaboration with Rubber Development Department. This project is jointly funded by Negenahira 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 203 (planting distance 14' X 15').

Management of wild boar damages in rubber

In order to prevent the damage of wild boar, 750 gauge recycled black polythene was used to cover the base of the rubber tree in 2005 and 2006 replanting areas. Base of the rubber plants were covered up to two heights, *i.e.* 30 cm (12") and 45 cm (18"). Total usage of polythene was 200kg (Rs.33,000/=) and 20 labour days were involved to cover the tree base. This was successful although wild boar attacks prevailed with the chemical treatment introduced by PP&M department.

Branch induction trail

This study began in 2009 with the objective of assessing the effect of artificial branch induction on growth and development of rubber plant. The details are given in 2009 annual review. Data collection on tree girth and number of branches in the 2008 clearing was continued throughout this year and the summary is given in Table 3. It seems that no additional girthing can be expected from branch induction though it is useful to have a balance canopy. There was a tendency to have natural branches in better girthing trees.

Table 3. *Growth of rubber plants associated with branch induction in the trees planted in year 2008*

	2009		2010	
	Average girth (cm)	**Girth increment (cm/month)**	**Average girth (cm)**	**Girth increment (cm/month)**
Artificially induced (one year after planting)	10.22	0.62	20.97	0.891
Naturally branched (one year after planting)	11.42	0.68	23.468	1
Naturally branched (18 months after planting)	8.69	0.60	19.995	0.920
Naturally branched (30 months after planting)	7.76	0.52	15.595	0.728

Incorporation of coconut husks to planting holes as moisture conservation method

This study began with the objective of assessing the impact of incorporating coconut husks to the planting hole as a moisture conservation method. In 2010 clearing

(1ha), coconut husks were incorporated to the planting holes (*ca.* 10 husks per each) in four replicate plots each having *ca.* 60 planting holes. In the rest, coconut husks were not added to the planting holes. Clone RRISL 203 was established in the whole area.

Further, the experiment was extended to assess the plant to plant variability in the field by quantifying all possible variables such as presence of rocks, roots and trees, depth and size of the planting hole, position of the terrain and visible variation of the soil type. In addition, details of the plants such as overall weight, number of leaf whorls, diameter and height of the plants were gathered (B M D C Balasooriya, V H L Rodrigo, S M M Iqbal and E A T Senadeera in collaboration with Soils & Plant Nutrition Department).

Upkeep of crops

General maintenance of rubber/banana and rubber/cinnamon intercrops and also of, cashew plants was done. Harvests made in subsidiary crops with the income are shown in Table 4. In total, it was possible to generate an income of Rs.587,494/= during the year.

Table 4. *Crop yields and income status in Polgahawela Sub-station*

Crop	Yield	Income (Rs)
Banana	738 (bunches)	188,459.00
Coconut	1494 (nuts)	23,535.00
Old rubber (selling trees)	751 (trees)	375,500.00
Total		587,494.00

***Monaragala substation* (ARU/RCMR/2006/1)**

Construction of office building complex including the auditorium was completed and fully furnished. It was inaugurated by Hon. Minister of Plantation Industries with participation of Hon. Minister of Parliamentary Affairs and the Chairman of the Rubber Research Board.

In addition to the planting of flowering shrubs, forest plants including fruit bearing trees were used for the landscaping activity of the office complex surroundings.

A rain-gauge and a maximum-minimum thermometer were installed to monitor weather parameters (V H L Rodrigo, S M M Iqbal and E S Munasinghe in collaboration with all biological departments of RRISL).

***Rubber/Sugarcane intercrop - Experiment on planting time* (ARU/RS/2009/1)**

Information on growth parameters of rubber such as base girth, total height, leaf count and average leaf area per plant was gathered as a pre-treatment measure. Further, growth of rubber was assessed in terms of base girth in monthly intervals. General agronomic practices of both rubber and sugarcane were attended.

For the first year of growth, total cost of cultivating rubber/sugarcane intercrop (2.09 ha) was Rs.1 million. Cultivation of rubber comprised for 39% of the total cost hence the component of sugarcane was 61%. Labour cost had contributed to a share of 63% and the rest was for the material cost. The most costly activity was the planting, which accounted for 20% of the total cost. Land clearing and harvesting cane yields were at the second and third positions with 16% and 14% of the total cost, respectively. The cost of initial establishment on both crops was Rs.540,000 which contributed for 53% of the overall cost, and the rest 47% was for the first year maintenance. First harvest of cane yield (141.2 MT) was obtained and sold to Palwatta Sugar Industries Ltd. The revenue obtained was Rs.460,097.00 (Table 5).

Table 5. *Cost distribution of rubber/sugarcane intercrop for the first year of growth (Rs./2.09 ha)*

Activity	Rubber (Rs)	Sugarcane (Rs)	Total (Rs)
Land clearing/preparation	11,200	154,567	165,767
Fencing	95,576	0	95,576
Lining	6,720	0	6,720
Holing	36,288	0	36,288
Filling holes	22,848	0	22,848
Planting	92,764	109,008	201,772
Re-supplying	21,876	0	21,876
Manuring	34,715	40,472	75,187
Weeding	68,544	54,656	123,200
Harvesting	0	138,880	138,880
Clearing cane lines	0	35,840	35,840
Tools	5,000	0	5,000
Chemicals	0	13,000	13,000
Transport	0	83,000	83,000
Total	**395,531**	**629,423**	**1,024,954**

(E S Munasinghe, V H L Rodrigo, S M M Iqbal and G V D N Gunaseela)

***Assessment of different farming systems practiced in the smallholder sector* (ARU/FSSH/2009/01)**

This study was started in 2009 with the objective of identifying the level of deviation from recommended agronomic practices in intercropping under smallholder conditions and their impact on growth and productivity. Experimental design and details were reported in 2009 annual review. A detailed cost benefit analysis was done with the farm gate values in the smallholder conditions and summary is given in the Table 6. No effect of high density pineapple intercropping on rubber growth was observed.

Table 6. *Cost - benefit details of different systems*

System		Two row system (Rs)	Three row system (Rs)	Four row system (Rs)
1st year	Cost	319,300.00	388,900.00	442,400.00
	Income	-	-	-
	Profit	-	-	-
2nd year	Cost	258,700.00	312,900.00	364,900.00
	Income	1,128,000.00	1,414,000.00	1,730,000.00
	Profit	869,300.00	1,101,100.00	1,365,100.00
3rd year	Cost	66,200.00	74,400.00	79,200.00
	Income	220,000.00	275,000.00	330,000.00
	Profit	153,800.00	200,600.00	250,800.00
Total	Cost	644,200.00	776,200.00	886,500.00
	Income	1,348,000.00	1,689,000.00	2,060,000.00
	Profit	**703,800.00**	**912,800.00**	**1,173,500.00**

Assessment on the rubber banana system was commenced (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)**

Following standard mixture was used for repotting of Anthurium plants "Tropical Red".

a. Sand - 4 parts
b. Wood shavings - 4 parts
c. Coir dust - 1 part

Fertilizer Osmocote (10 g) and compost (40 g) were incorporated to each pot. Cutting off of the old stems were done and the stem pieces were kept in a nursery bed for the propagation of new plants.

Total number of cut flowers harvested during the quarter is shown in Table 7.

A detailed assessment of Tropical red Anthurium plants in the Anthurium trial was done at Dartonfield.

Status of the plants is as follows.

Plants with flowers - 2,290
Small plants (weak) - 208

Flowering assessment (variety Tropical red) under shade net and mature rubber is continued at weekly intervals. In addition to general maintenance, the following activities were carried out.

- Quality of flowers was in acceptable level with the majority in large flower size category (See Table 8, 9 &10 for comparison).

Table 7. *Total number of cut flowers at Dartonfield and Kuruwita substation*

Site	Number of plants	Total number of weak plants	Flowers harvested	Flowers damaged in the field	Flowers damaged by mites
Dartonfield	2,290	208	6,204	343	247
Kuruwita	148	-	388	79	204

Table 8. *Mean flower dimensions of Anthurium flowers under rubber*

Site	Flower width (cm)	Flower length (cm)	Stalk length (cm)
Dartonfield	6.60	8.81	35.49
Kuruwita	8.04	11.11	33.66

Table 9. *Mean flower dimensions of Anthurium flowers under artificial net at Dartonfield*

Flower width (cm)	Flower length (cm)	Stalk length (cm)
6.87	9.47	35.72

Table 10. *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

(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)**

Experiment 1: Planting systems of foliage under immature rubber plants

Cane palm, Croton and Polycia established under immature rubber as sole and mix systems were in progress. Details of the experiment appeared in the Annual Review of 2008. Refilling the casualties of Croton was carried out during the rainy period in May 2010. Monthly fertilizer application was done. Rabbit attack on Cane palm plants was controlled by covering the plants with a piece of mosquito nets.

Growth assessments of foliage plants were conducted. Stem height of croton and polycia and leaf count measurement of cane palm are shown in Table 11. There was no any significant difference in those parameters between planting systems (*i.e.* mixed and sole) of both croton and cane palm. However, stem height of polycia grown in the mixed system was significantly superior ($P<0.05$) to that in the sole system (Table 11).

Table 11. *Mean stem height of croton and polycia (a) and numbers of leaves of cane palm (b) in experiment 1. SED refers to standard error difference*

(a)

Plant type	Planting systems		Remarks
	Mean height (cm) Sole	Mean height (cm) Mix	
Croton	43.87	43.68	Not significant
Polycia	43.59	51.18*	Significant at $P<0.05$ SED ± 3.59

(b)

Plant type	Systems		Remarks
	Mean leaf number Sole	Mean leaf number Mix	
Cane palm	4	5	Not significant

Experiment 2: Planting systems of foliage under mature rubber plants

Cane palm, *Dracaena massengiana*, Chinese grass established under mature rubber as sole and mix systems were in progress. Details of the experiment appeared in the Annual Review of 2008. Monthly fertilizer application was done. Growth assessments of foliage plants were conducted.

According to the leaf count assessments of foliage plants, there was a significant difference between two planting systems (*i.e.* mixed and sole) of cane palm ($P<0.001$) and Chinese grass ($P<0.01$) with greater values in the sole system. However, no such difference was observed in *Dracaena massengiana* (Table 12).

Table 12. *Mean numbers of leaves in foliage plants in experiment 2*

Plant type	Systems		Remarks
	Mean leaf count (Sole)	Mean leaf count (Mix)	
Cane palm	4	2***	Significant at $P<0.001$ SED ± 0.281
Dracaena massengiana	13	13	Not significant
Chinese grass	68	62**	Significant at $P<0.01$ SED ± 2.087

Experiment 3: Planting systems of Anthurium under artificial shade and mature rubber plants

Reestablishment of "Tropical Red' Anthurium plants under artificial shade and mature rubber plants was continued. Planting systems are shown in Table 13. Establishment of sprinkler irrigation system was completed.

Table 13. *Planting systems of Anthurium*

Systems	Plant type	No. of replicates
Artificial shade (70%)	'Tropical Red' Anthurium	3
Mature rubber	'Tropical Red' Anthurium	3

(S M M Iqbal, W A D D S Wettasinghe and V H L Rodrigo. 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)**

Detailed investigation on the distribution of tapping days and yield variation showed that all smallholdings in traditional rubber growing areas of the country are tapped daily on seasonal basis although some smallholders expressed that their holdings are tapped on every other day (d2). The number of tapping days per annum varied in the range of 63-178 with the mean value of 119. The average latex yield per hectare per annum (YPH) was 1044 kg and in the range of 386-1813 kg. Despite the recommendation of 500 trees per hectare, eight smallholders had planted rubber at higher densities and therefore, three out of them had higher tree densities than the expected level by the time of the assessment. However, few had low tree densities. Mean percentage of trees affected with tapping panel dryness (TPD) was 8% but varied between 0-38%. Weak plants were in the range of 0-12%. Casualties due to diseases and wind were found only in three holdings. Average number of trees in tapping remained 350 per hectare. Although positive co-relation was expected between (YPH) and number of tappable trees of a particular site, it was not observed due to variations in quality of tapping and tree vigour. Latex yield per tree per tapping (g/t/t) was in the range of 9-51 g with the mean value of 28 g (Table 14).

Table 14. *Site details of smallholdings*

Site	Initial stand/ha	Present stand/ha	% TPD	% Weak plants	Trees in tapping/ha	Tapping days/year	Yield (kg/ha)	Yield (g/tree)
SH1	425	360	1.4	10.4	318	63	386	19.3
SH2	550	485	6.2	2.1	445	130	975	16.9
SH3	542	493	5.7	7.1	430	131	689	12.2
SH4	500	400	8.0	6.0	344	135	1609	34.6
SH5	400	350	0.0	7.1	325	119	893	23.1
SH6	368	322	4.7	2.1	300	96	1465	50.9
SH7	550	533	38.4	4.7	303	85	1316	51.0
SH8	508	432	3.5	1.2	412	155	581	9.1
SH9	500	412	19.4	11.7	268	85	726	31.9
SH10	500	472	0.7	1.2	460	105	736	15.2
SH11	667	645	4.4	0.5	593	108	1793	28.0
SH12	130	90	0.0	0.0	90	177	543	34.1
SH13	563	523	8.1	8.6	435	96	1618	38.8
SH14	563	435	8.0	2.3	390	105	1542	37.7
SH15	563	540	6.9	6.0	468	101	1813	38.4
SH16	400	222	10.8	5.4	186	122	923	40.7
SH17	450	348	15.1	1.2	291	137	647	16.2
SH18	500	424	2.1	4.2	397	137	501	9.2
SH19	500	325	5.8	7.7	281	116	759	23.3
SH20	500	325	7.7	3.8	288	109	1368	43.6
SH21	500	321	5.1	2.4	297	178	1045	19.8

(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)**

This study was completed and results were presented in the form of PhD thesis to the University of Sri Jayewardenepura [Munasinghe, E.S. (2009). Growth, yield, carbon fixation and economics of rubber cultivation in Sri Lanka. PhD Thesis, University of Sri Jayewardenepura, Sri Lanka].

Following conclusions were derived from the study,

- The ontogenetic diameter and height variations of the rubber tree could be explained using the logistic functions derived for Wet (WZ) and Intermediate (IZ) zones. With those, girth (at 150 cm height) and total height of 30 year old rubber tree (genotype RRIC 100) on average management conditions were estimated as 89 cm and 24 m, respectively for WZ whilst 88 cm and 21 m, respectively for IZ.

- Ontogenetic wood density of the rubber tree increased marginally with the age and reached to a mean value of 730 kgm^{-3} at full maturity (genotype RRIC 100). However, it decreased marginally along the height within a tree.
- The amount of total timber log volume, sawnable timber log volume, total biomass and total carbon available in a rubber tree could be explained using allometric relationships using tree diameter and total height. With those, an average rubber tree in WZ was capable of producing 0.73 m^3 of total timber log volume, 0.58 m^3 of sawnable timber log volume, 668 kg of biomass and fixing 274 kg of carbon at 30 years. Corresponding values on hectare basis were 208 m^3 of total timber log volume, 166 m^3 of sawnable timber log volume, 191 MT of total biomass and 79 MT of total carbon. The resultant values for IZ were *ca.* 16% less than those in the WZ.
- The time course variation of latex yield could be explained using quadratic by quadratic function; hence the total amount of latex that could be harvested from a hectare of rubber land during its 30 year lifespan was estimated as 25 MT. Nevertheless, there was 6% yield reduction for the IZ.
- The time course variation of tree density of a rubber plantation on average management conditions could be explained using linear by linear function. The number of trees remained at 30 years under such conditions was 285 per hectare.
- The Cost of Production (COP) of 1 kg of rubber was found to be Rs.102.00 with the fractional allocation of 45%, 18%, 14% and 11% to tapping, administration, weeding and fertilizer application, respectively.
- Meeting with the guidelines given for forestry based CDM projects, new plantings of rubber in non traditional areas have a potential of trading the CO_2 fixed by the trees.
- Rubber cultivation only for latex and timber (sale of trees at the end of lifespan, *i.e.* business as usual) was financially viable (at farmer level) with the Net Present Value (NPV) of Rs.1.66 million, Internal Rate of Return (IRR) of 22% and Benefit Cost Ratio (BCR) of 1.44.
- According to economic analyses, rubber cultivations were found to be more viable at national level than the farmer level with the NPV of Rs.3.9 million, IRR of 34% and BCR of 2.32 (business as usual).
- Inclusion of carbon values and intercrops increased the financial/economic viability by *ca.* 6% and *ca.* 60%, respectively.
- There is a potential to reduce the economic lifespan of rubber up to 23 years if at least 10% of the expected yield loss due to shortening the lifespan is recovered throughout the tapping period, *i.e.* in addition to the normal yield.
- Majority of smallholders having lands below 1 ha (87%) practiced intercropping and 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 key factors governing the profitability of banana cultivation in smallholdings were cropping intensity of banana, type of employment, education level and the total land extent of banana owned by the farmer. Cropping intensity of tea, availability of labour and total land extent belongs to the farmer affect mostly the profitability of tea intercropping in rubber lands.

Following proposals were made;

- Models developed in the study are capable of predicting growth and yield parameters under average growth conditions in both Wet and Intermediate zones. However, plant growth varies particularly with soil type, terrain and management conditions. Hence, models developed in this study are to be expanded further incorporating those factors to derive site specific values for growth and yield.
- The scenarios tested here for financial and economic viability of rubber cultivation were based on the most common and basic components that could easily be quantified and assessed. However, environmental costs and benefits of rubber cultivation (*e.g.* impact on soil erosion, influence of chemical use, potential use for recreation, maintaining biodiversity *etc.*) are yet be included in the analyses.
- With a coalition of governmental agencies on agriculture, formation of a special task force is proposed for effective adoption of rubber based intercrops. Also, working group is expected with funding for initial work under the Ministries of Plantation Industries, Environmental and Natural Resources and Public Administration for the development of a CDM project on rubber cultivation (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)

Collection and analyses of experimental yield data of rubber and tea in the rubber/tea intercropping 8' x 40' systems were done. Yield curves for both tea and rubber were established (Fig. 1 and 2). Validation of these models with the commercial data of rubber/tea 8' x 40' system and financial analysis are in progress. Yield profile establishment of the paired row rubber/tea system and financial analysis were also in progress.

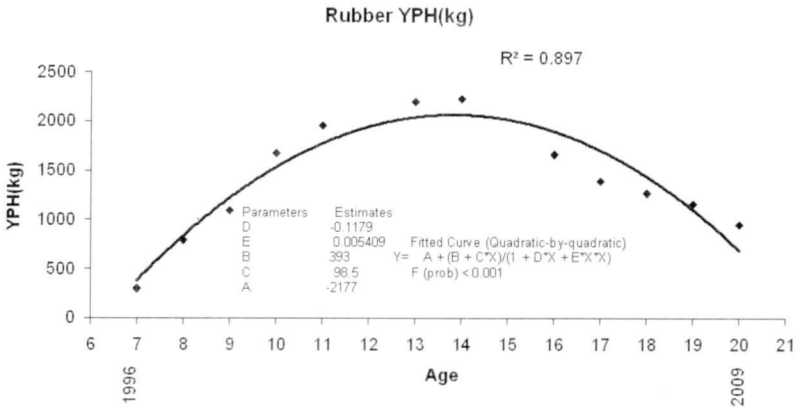


Fig. 1. Rubber yield in the 8' x 40 rubber'/tea intercropping system. YPH refers to the yield per hectare per year (Y= YPH ; X = Age)

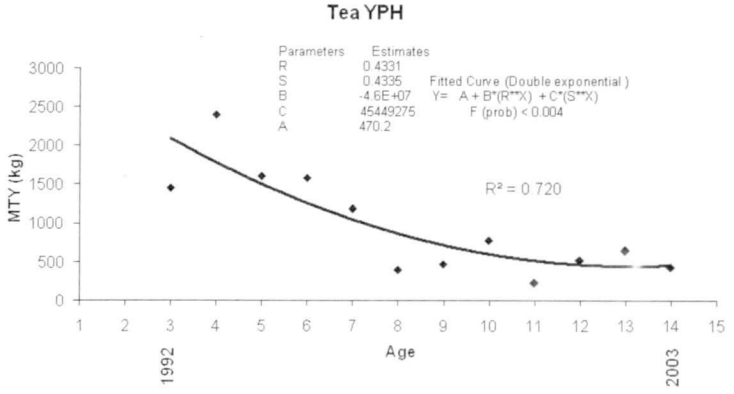


Fig. 2. Tea yield under 8' x 40 rubber'/tea intercropping system. YPH refers to the yield per hectare per year and MTY refers to the made tea yield (Y= MTY ; X= Age)
(S M M Iqbal)

Growing rubber in the north of Sri Lanka (ARU/RCNP/2010/1)

A feasibility study on cultivating rubber in Northern region of the country was commenced on the request made by Hon. Minister of Plantation, Mr Mahinda Samarasinghe. A study visit was made to potential areas and discussions with key informants were made together with secondary data gathering. The following observations and recommendations were made.

- Planting tree crops like rubber will enhance the livelihood of the poorest community, the farmers in the area concerned.
- Lands appeared to be not a limiting factor for the cultivation rubber in the area.
- Major clones recommended for the smallholder sector in traditional areas are to be tested in this area.
- Rubber cultivation should be combined with the existing farming systems of the area.
- Cultural practices for soil moisture conservation and rapid root expansion are strictly adhered to.
- Temporary shades to rubber plants are to be provided if intercrops are not sufficient enough to avoid high radiation loads.

Rubber was planted in 07 sites in Northern Province in the month of November (Table 15).

Table 15. *Site details rubber holdings established in Northern Province*

District	Name and Address	Extent (Ac)
Vavuniya South	Mr I Ruwan Jayasinghe, Madukanda	2
Vavuniya South	Mr Chamith Bandara, Nedunkulam, Madukanda	1.5
Kilinochchi	Army Camp, Ilakatchi	0.5
Vavuniya North	Mr M Muthukumaran, Rambaikulam, NedunKerny	0.5
Vavuniya North	Mr S Manoharan, Olimadu, Nedunkerny	0.5
Vavuniya North	Mr Kumaran Kandavale, Olimadu, Madurampatti Lane, Nedunkerny	0.5
Mullativu	Mr Kumaraswamy, Katchilimadu, Ottisuddan	0.5

V H L Rodrigo, S M M Iqbal and R S Dharmakeerthi in collaborations with all other departments.

BIOMETRY

Supporting other research departments of RRISL on requests such as; experimentation, data analysis, interpretation of results and database management are among the key activities of the Biometry section. The research program of the Biometry section focuses on Biometrical aspects especially on development and modification of statistical methodologies to suit the needs of the rubber sector. The specific areas explored during this year were time series analysis, boundary line fitting and statistical process control. Some useful maps were prepared using GIS to identify areas available for further expansion of rubber in the Moneragala district. Databases were satisfactorily maintained during the year under review on meteorological data collected at the meteorological station at Dartonfield and auction prices of rubber in the Colombo market.

BIOMETRY

Wasana Wijesuriya

DETAILED REVIEW

Staff

Dr (Ms) Wasana Wijesuriya (Biometrician), Mr Keminda Herath (Assistant Biometrician) and the Experimental Officers, Ms Chintha Munasinghe and Mr Vidura Abeywardene were on duty throughout the year.

Research students

- Miss W K Chaturangi majoring in Applied Economics and Business Management of the Faculty of Agriculture, University of Peradeniya underwent her in-plant training in the Biometry section. Later she completed her undergraduate research work on "Vulnerability and adaptation to climate change in the rubber sector" under the supervision of Dr (Ms) Wasana Wijesuriya.

- Miss M P Dhanushika from the department of Statistics and Computer Science of the University of Jayawardenepura completed the industrial training for 6 months and continued her study on "Estimating boundary lines for biological data" for the partial fulfillment of the degree programme under the supervision of Mr Keminda Herath.

Seminars/Conferences/Meetings/Workshops attended

Officer	Subject	Organization
Wasana Wijesuriya and Keminda Herath	Scientific committee meetings	Rubber Research Institute of Sri Lanka
Wasana Wijesuriya	Steering committee of the Senior Scientists' Forum	National Science and Technology Commission (NASTEC)
Wasana Wijesuriya	Committee on implementation of SAARC action plan on climate change	Climate change secretariat, Ministry of Environment & Natural Resources
Wasana Wijesuriya	CIO workshop on e-Government policy	Information Communication Technology Agency of Sri Lanka (ICTA)

Officer	Subject	Organization
Wasana Wijesuriya	Workshop on restructuring the undergraduate degree programme of the Faculty of Agriculture, University of Ruhuna	Faculty of Agriculture, University of Ruhuna
Wasana Wijesuriya	Research and industrial partnership development	Faculty of Agriculture, University of Ruhuna
Wasana Wijesuriya	Seminar on climate change adaptation	Department of Meteorology

Seminars/Conferences/Meetings/Workshops addressed

Officer	Subject	Organization
Wasana Wijesuriya	Presented a paper on "Priorities for technology transfer in non-traditional rubber growing areas of Sri Lanka" at 3rd symposium on plantation crop research	Rubber Research Institute of Sri Lanka
Keminda Herath	Presented a paper on "Statistical process control (SPC) in quality assurance of crepe rubber industry in Sri Lanka: An application of I-MR charts as an instrument" at 3rd symposium on plantation crop research	Rubber Research Institute of Sri Lanka

Services

Statistical analysis and interpretation

The Biometry section provided assistance to research departments on designing of experiments and questionnaires, statistical analyses, designing and developing databases and interpretation of experimental results. This service was also extended to undergraduate and postgraduate students of different Universities supervised by scientists of RRISL (Wasana Wijesuriya and Keminda 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 of the Department of Meteorology. Rainfall records received at the Dartonfield Station during the course of the year were also sent to National Building Research Organization (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 other organizations on request (W Wijesuriya, K Herath, C Munasinghe and V Abeywardene).

Auction prices of rubber

The information derived from the database on daily auction prices of rubber at the Colombo auction are presented below.

Prices of Ribbed Smoked Sheets (RSS)

The maximum auction price recorded for RSS1 was Rs.539.50 per kg on the 31st of December while the minimum, Rs.317.50 per kg was observed on the 5th of January. 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. This trend continued until April 2010 to about Rs.430 per kg and the prices were observed in the range of Rs.375 per kg and Rs.425 per kg till September. As can be seen from Fig. 1, the price/kg increased from Rs.375 in September to Rs.510 in December.

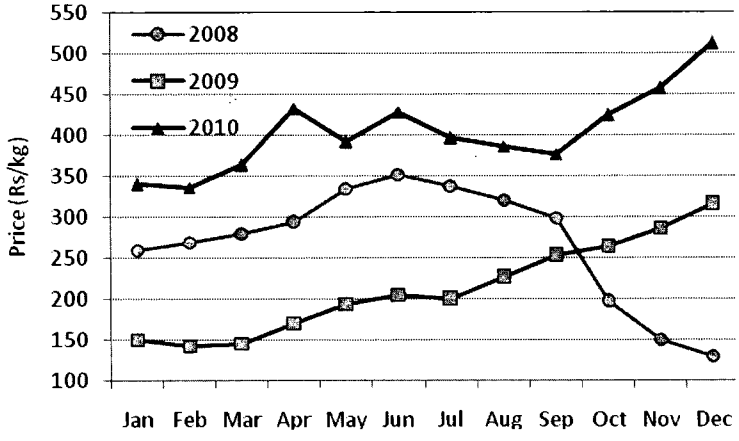


Fig. 1. Monthly variation of auction prices of RSS1 in 2008, 2009 & 2010

Prices of Latex Crepe (LC)

The prices of LC1X in 2010 ranged from Rs.310/kg (2nd February) to Rs.594/kg (23rd December). The upward trend in 2009 continued until July 2010 to about Rs.500 per kg. The prices dropped below Rs.500/kg in August and September but reached the maximum of Rs.570/kg in December (Fig. 2).

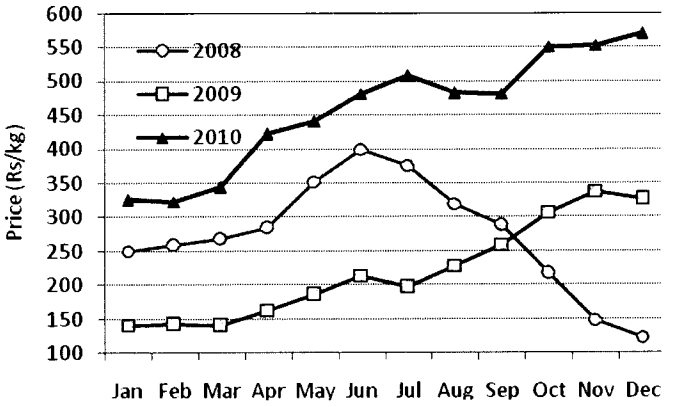


Fig. 2. Monthly variation of auction prices of LC1X in 2008, 2009 & 2010

Monthly averages of auction prices for different rubber grades; *viz.* RSS, latex crepe and scrap crepe are given in Table 1.

The changes in annual average prices from 2000 to 2010 for RSS1 and LC1X are presented in Fig. 3. The RSS1 prices were higher than the LC1X prices or more or less equal to LC1X prices from 2000 to 2009. The difference of annual average between LC1X and RSS1 in 2010 was Rs.49.00/kg. This difference accounts for a 13% increase in LC1X price over RSS1 price. Prices of LC1X were above the RSS1 prices from May to December in 2010 (Fig. 4). There was a difference of Rs.126/kg between these two grades in October but the difference narrowed down to Rs.60/kg in December.

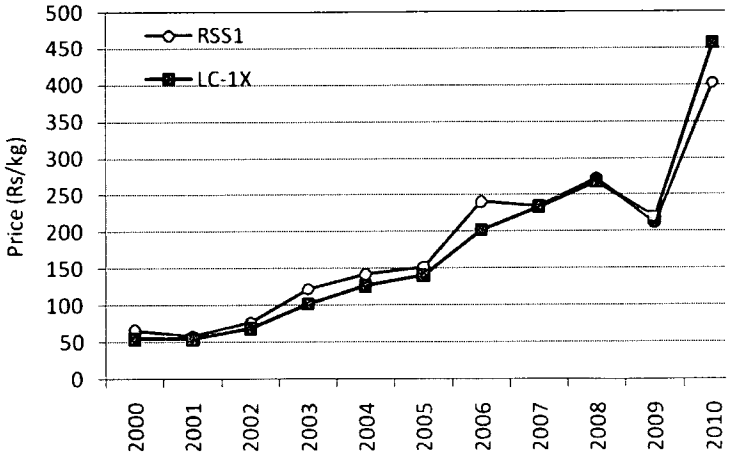


Fig. 3. Changes observed in yearly averages of auction prices for RSS1 and LC1X from 2000 to 2010

Table 1. *Monthly averages of auction prices for different rubber grades in 2010*

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	339	335	331	319	318	325	324	321	319	315	314	312	312	311
Feb	336	330	329	321	318	323	323	320	316	312	310	306	306	305
Mar	363	360	358	356	351	344	342	339	337	332	329	326	324	322
Apr	432	430	420	413	404	422	420	410	400	384	374	366	352	340
May	391	383	371	373	363	441	436	414	408	368	347	335	312	292
Jun	428	412	401	373	349	481	481	459	417	362	345	326	319	309
Jul	396	392	386	360	-	508	505	488	462	359	342	333	316	311
Aug	386	369	368	356	352	482	480	462	434	360	340	321	313	310
Sep	376	359	364	360	-	481	472	451	422	357	348	344	344	341
Oct	424	424	415	408	378	551	543	521	492	407	399	392	386	384
Nov	456	453	444	431	433	552	543	524	500	444	436	433	429	424
Dec	511	515	500	473	473	570	562	545	516	479	471	472	470	466
2010 average	*403*	*397*	*391*	*379*	*374*	*457*	*452*	*438*	*419*	*373*	*363*	*355*	*349*	*343*

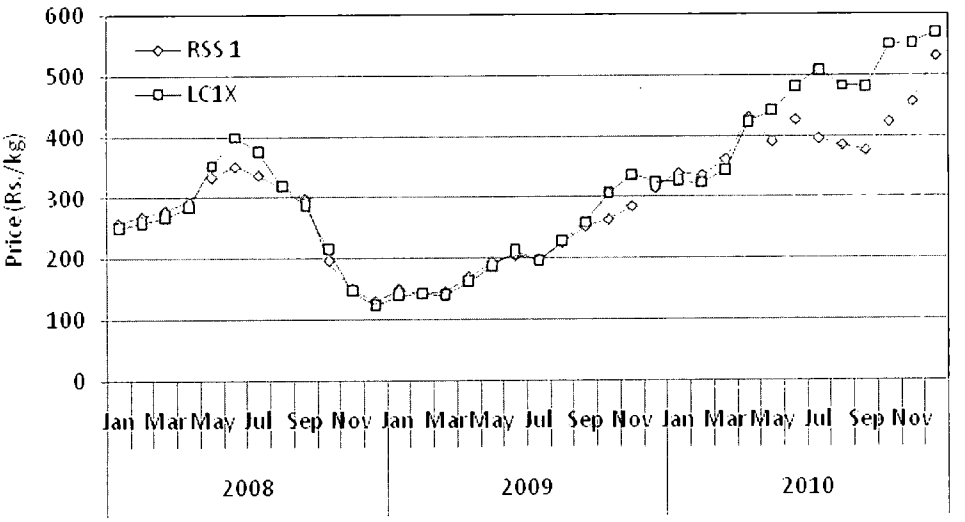


Fig. 4. Monthly variation of auction prices for RSS1 and LC1

RESEARCH

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. The project period ended on the 31st December, 2009 and the final report was submitted to the National Science Foundation during this year. The progress of this project has been reported in Annual Reviews since 2006 and some rubber related information in non-traditional rubber growing areas is reported below.

Physiographic conditions of rubber lands

Previous crop

Sugarcane and Banana were the major crops grown previously in rubber lands (Fig. 5). A considerable percentage of lands were shrub jungles before. Other crops which occupied included; corn, lime, chili, pepper, timber, coconut, manioc and *chena* cultivations.

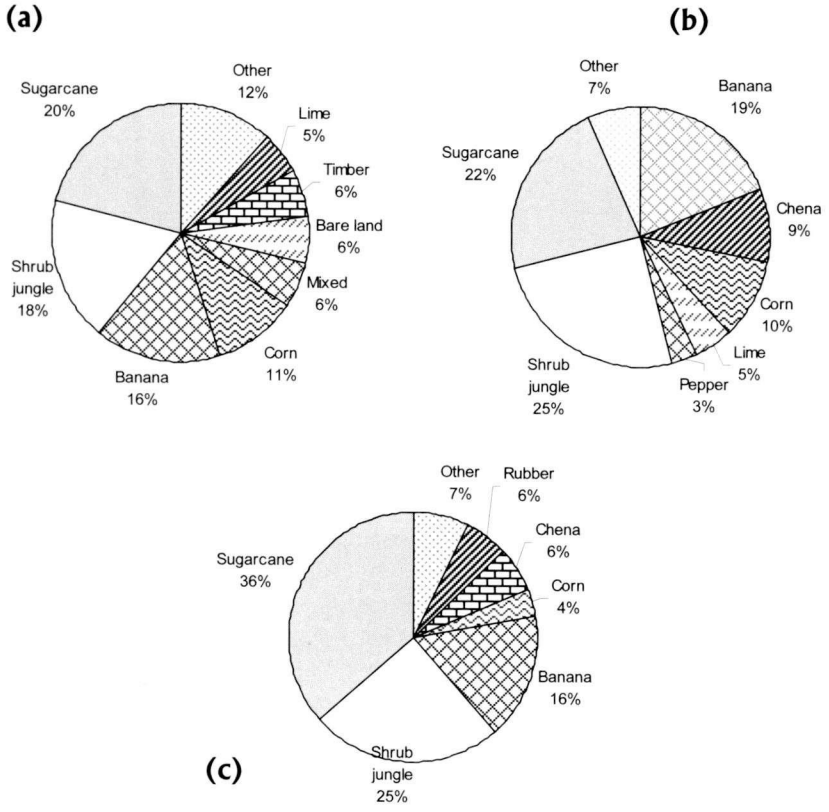


Fig. 5. *Previous crop in lands of (a) 'potential' rubber growers (b) immature lands and (c) mature lands*

Topography of land

The existing rubber lands consist mainly of lands with gentle slopes (67%) while only 5% are steep lands. The rest (29%) are flat lands. The lands of 'potential' rubber farmers consists of 60% under gentle slope category and 39% are flat lands.

Soil

Mixed soils are present in 66% of the rubber lands. Gravel soils are found in 14% of the holdings. Sandy and Clay soils are present in 10% and 11% of the fields, respectively.

Rockiness

Rockiness in rubber lands is expected to be less than 40%. Hence, desirable conditions exist in about 97% of the lands which is a favourable situation in non-traditional rubber growing areas.

Distance to the rubber land from home

Nearly 43% of the farmers live in their rubber field and altogether 80% live in the vicinity of 1 km. For about 75% of the lands, access by vehicles is possible. This assures better care on the upkeep of rubber plantations.

Status of immature rubber lands

Clone and planting material

The sample comprised of 85% lands that were planted after 2005. The majority (84%) of the farmers did not know the clone they were given by the Rubber Development Department (RDD) as planting material. Most of the immature fields (55%) were raised through young budding plants, while 27% used poly bagged plants. Some had practiced a different way by planting homemade poly bags (14%), while 5% had received bare roots as the planting material for their plantations. Government subsidy had provided the planting material in many instances (99%) while there were a few occasions where plating material was purchased from a private nursery.

Stand per acre

The recommended plants per ac (200 plants/ac) reduced to an average of 173 per acre due to various reasons. Impact of droughts was the most prominent with a value of 67% and 14% of the sample stated that poor quality plants provided through the subsidy was the cause of the death of plants. There were several other reasons such as, death of plants due to unknown reasons, diseases and animal damages, excess fertilizer, fire and improper transport.

Intercropping

Intercrops are grown in 79% of the immature rubber lands. Majority of the immature lands have banana as the intercrop (60%). Corn and pepper were found as intercrops in respective percentages of 7% and 4%. The other intercrops that were found in immature lands were cowpea and sugarcane.

Soil and moisture conservation

Cover crop is not present in 97% of the immature lands. Stone terraces are present in 37% of the fields while drains are present in 23% of the immature lands. It was stated that in 20% of the immature lands there is no need for soil conservation

practices. In the sample of immature lands 26% are flat lands which do not need extensive soil conservation measures.

Maintenance of existing drains and terraces was good in 68% of the subsample which had drains and terraces in their fields. Only 8 percent did not pay attention to maintain the drains/terraces and in the rest of the sample, state of maintenance was medium.

Weed control

Regular weed control is practiced in 98% of the immature holdings. Manual weed control was done in majority of the holdings (84%) while 12% practiced both manual and chemical methods and chemicals were solely used in 4% of the holdings. Family labour was used in 79% of the holdings for manual weed control while hired labour was used in 9% of the holdings. Both family and hired labour were used in 12% of the holdings.

The recommended method of weed control; *viz.* around the trees was practiced by 22% of the farmers. About half the sample (51%) clears the whole land while 27% practiced strip weeding. Strip weeding and clearing the whole land are not encouraged by RRISL since it causes land degradation and is an additional cost to the farmer. In response to a question on the last weed control practiced, the majority (79%) have stated that it was within the past 2 months which is a good indication of proper care on their immature fields. Only 6% stated that the last weed control operation was done before 5 months.

Disease control

Awareness on diseases was poor among these farmers. Yet, 17% of the sample had identified several diseases in their fields and treated accordingly.

Fertilizer application

All the farmers applied fertilizer that supplied to them through the subsidy. Fertilizer application was done in 78% of the holdings, leaving 22% of non adopters. Method of application was according to the recommendation in 60% of the holdings, while 32% applied fertilizer around the trees. Some farmers have placed fertilizer between trees. The fork, which is the recommended tool to disturb the soil for fertilizing was practiced by 32% of the sample. Although the mamoty is not recommended mainly because it can cause severe damage to the feeder roots of the plant, 60% of the sample used mamoty for this operation. '*Alavango*', although not recommended, cause no damage to the root system and 8% of the sample used this tool for fertilizer application. Broadcasting was done only by a single farmer in the sample.

Status of mature rubber lands

Clone and planting material

The majority of the farmers (53%) did not know about the clone in their field. Clone RRIC 100 is found in 23% of the lands and 17% of the land are occupied by PB 86. The remaining extent was occupied by RRIC 121 and RRIC 102.

Stand per hectare

Stand per ha. is one of the main determinants of the productivity of a rubber land. As depicted in Fig. 6, the number of trees present is reduced to an average of 414 trees/ha compared to 488 trees planted during establishment. Further, it was reduced to an average of 368 tappable trees/ha. Drought was the main cause for the reduced stand per ha. The other important reasons were poor quality of plants, animal and fire damages and tapping panel dryness (TPD).

Time taken for commencement of tapping

In 16% of the holdings tapping could be commenced before 6 years of age and in 40% of the holdings, the time taken for commencement of tapping was 6-7 years. More than 8 years were taken to achieve the tappabale girth in 20% of the holdings.

Intercropping

Different types of intercrops are present in 35% of the mature holdings. Among them, Cocoa and Banana are more popular while pepper, sugarcane and cinnamon are also present in several fields.

Soil and moisture conservation

Stone terraces are present in 40% of the fields while drains are present in 37% of the immature lands. It was stated that in 15% of the mature lands there is no need for soil conservation practices. In the sample of mature lands 32% are flat lands which do not need extensive soil conservation measures. Maintenance of existing drains and terraces was good in 28% of the subsample which had drains and terraces in their fields. Nearly 44 percent did not pay attention to maintain the drains/terraces.

Weed control

Weed control is practiced in almost all the fields except 2 occasions. Manual weed control was done in 92% of the holdings while 2% used chemicals and the rest used both manual and chemical methods. Family labour involvement was 68% for weed control and 24% employed hired labour. The rest (8%) employed both family and hired labour for weed control. In 48% of the sample, clearing the whole land was done and in 47% of the holdings strip weeding was practiced. Both these methods

are labour consuming and hence costly when compared to the recommended method; *i.e.* circular weeding which is practiced only by 5% of the sample.

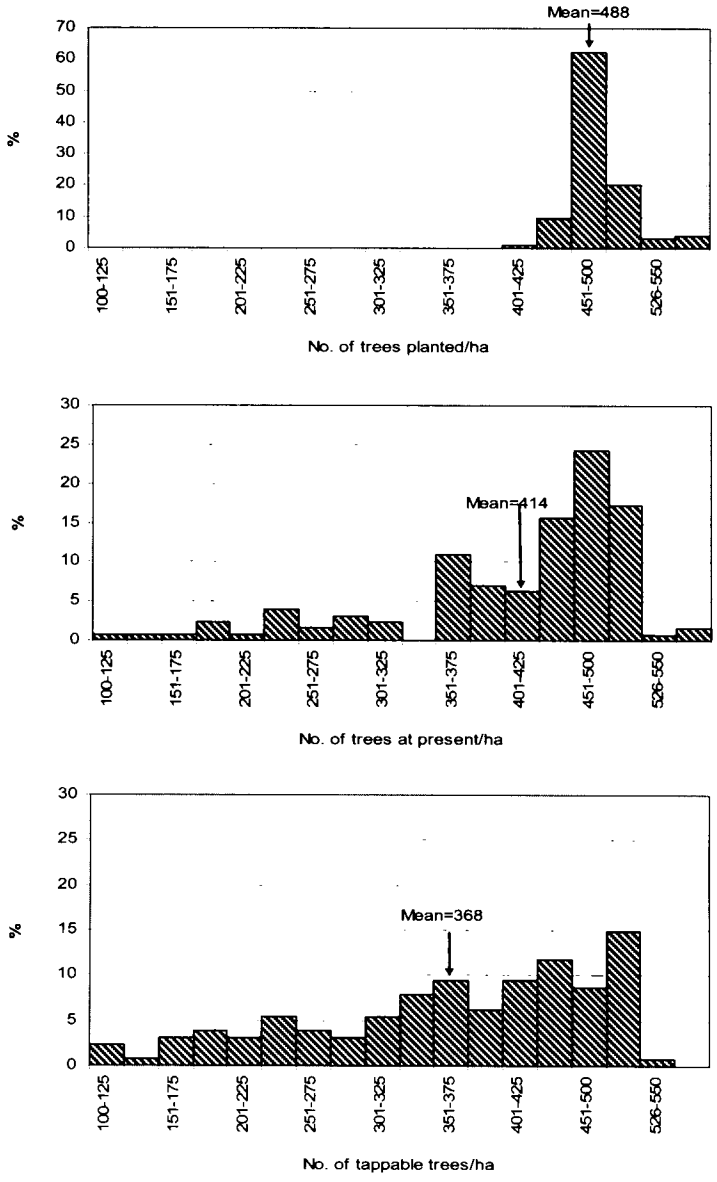


Fig. 6. The distribution of trees planted, trees at present and number of tappable trees per ha in non-traditional rubber growing areas

Disease control

Diseases or disorders were not identified in 44% of the holdings reported with diseases. In 38% of the holdings tapping panel dryness was observed and white root disease was present in 19% of the holdings.

Fertilizer application

Fertilizer application was not done in 54% of the mature holdings. From those who applied fertilizer, only 45% knew about the fertilizer mixture they applied. Fertilizer supplied through the subsidy scheme for mature rubber was used by 40% of the farmers, 53% had purchased from private places and 6% of the sample received fertilizer through *Thurusaviya* societies.

Method of application was according to the recommendation in 57% of the holdings, while 8% applied fertilizer around the trees. Some farmers (26%) have placed fertilizer between trees. The fork, which is the recommended tool to disturb the soil for fertilizing was practiced by 25% of the sample. Mamoty is not recommended mainly because it can cause severe damage to the feeder roots of the plant. Yet, 61% of the sample used mamoty for this operation. '*Alavango*', although not recommended cause no damage to the root system and 14% of the sample used this tool for fertilizer application.

Productivity of rubber lands

The upper boundary of the yield profile can be obtained under the situation prevailing in non-traditional rubber growing areas under non-limiting conditions as depicted in Fig.7. The yield ranged from 278 to 2,223 kg/ha/year averaging around 1,112 kg/ha/year. According to a survey done in traditional rubber growing areas, the yield ranged from 214 to 1,927 kg/ha/year with an average of 1,050 kg/ha/year. The productivity situation of different divisions in the Bibile estate is presented in Fig. 8 with an average yield of 1,329 kg/ha/year. It is apparent that some smallholdings produce promising yields and effective extension programmes can improve awareness and hence adoption to achieve better yields.

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. A map output generated from ARC GIS 9.2 is depicted in Fig.9 which illustrates the land suitability for rubber cultivation in Moneragala district. Fig.10 depicts the available land for rubber cultivation excluding forest areas, homesteads and existing rubber lands while Fig.11 demonstrates the suitability of

available lands. As can be seen from Fig.11, suitable or moderately suitable lands are available in Bibile, Madulla, Tanamalwila, Wellawaya and Siyambalanduwa DS divisions for further expansion of rubber cultivation (Wasana Wijesuriya, Keminda Herath, Senani Karunaratne [Wayamba University]).

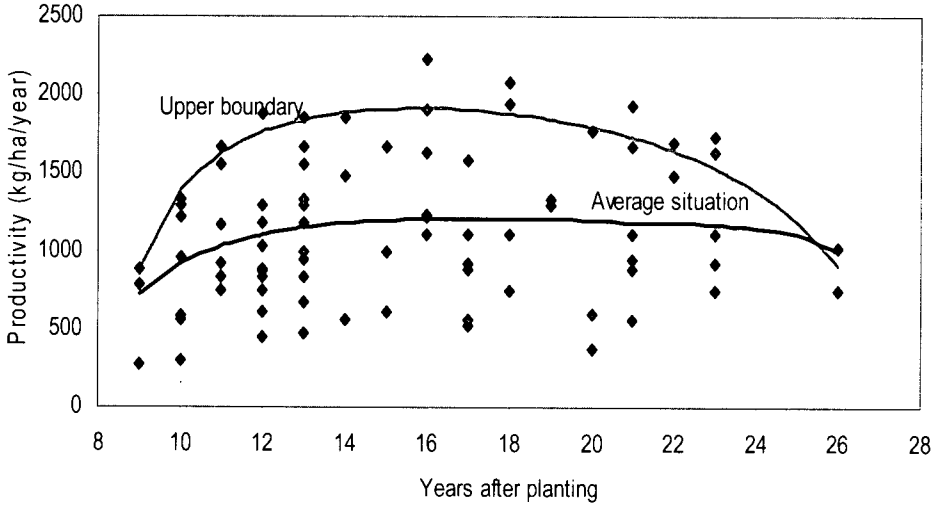


Fig. 7. The yield profile of rubber in non-traditional rubber growing areas together with the fitted upper boundary by quadratic-by-quadratic model

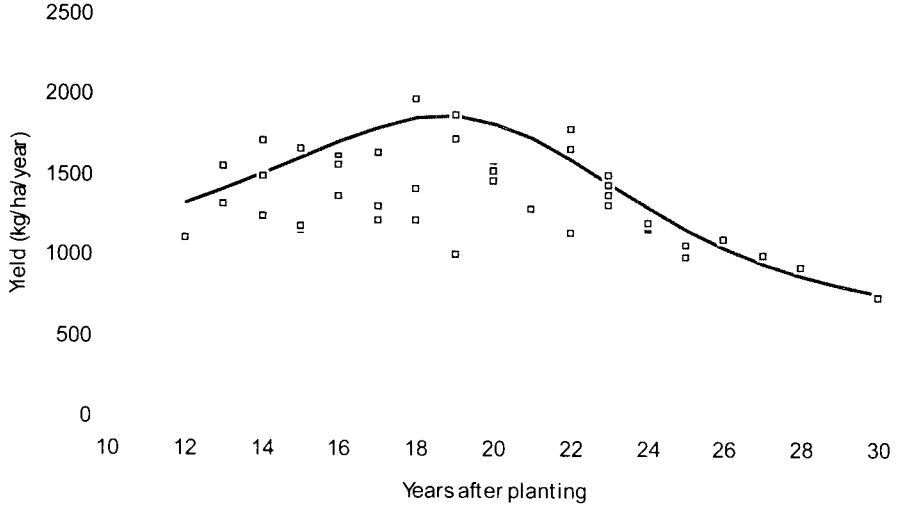


Fig. 8. The yield profile of rubber in Bibile estate together with the fitted upper boundary by quadratic-by-quadratic model

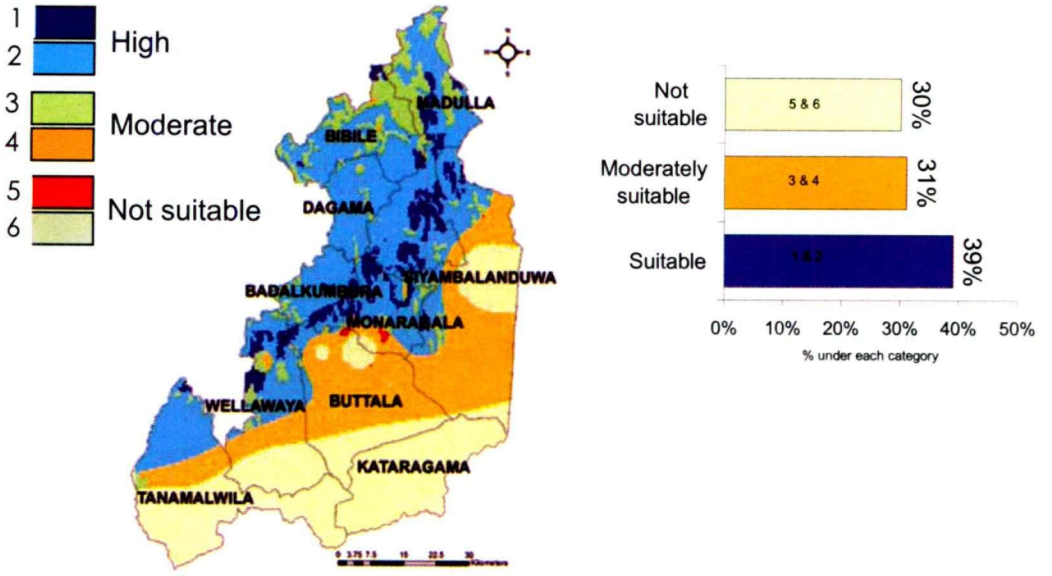


Fig. 9. Land suitability for rubber cultivation in Moneragala district

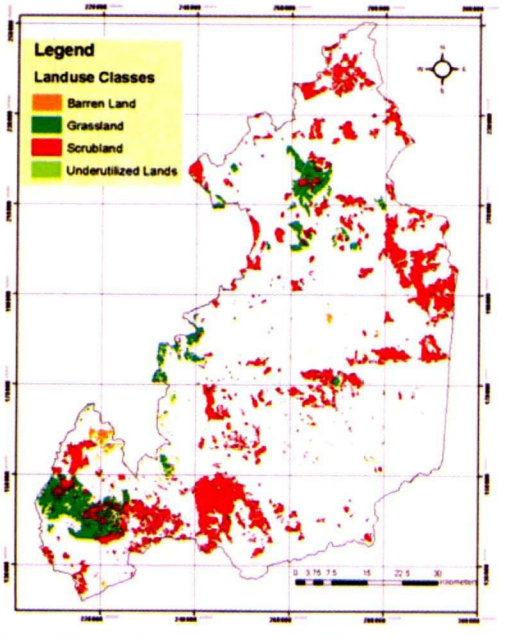


Fig. 10. Available lands for rubber cultivation

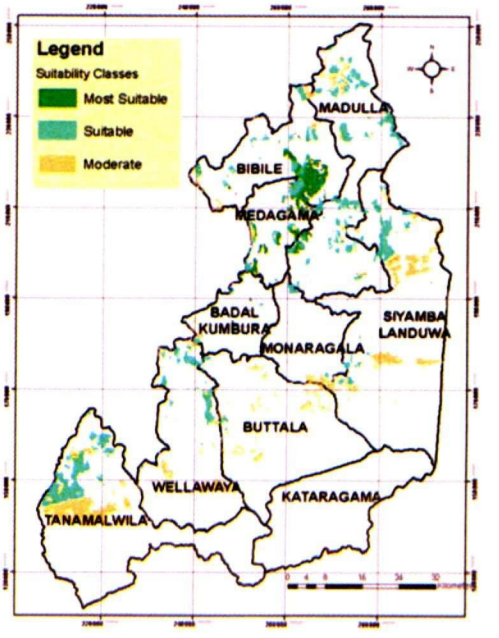


Fig. 11. Suitability of available lands for rubber cultivation

Studies on climate change

Biometry section was involved in developing the RRISL part for the SAARC action plan on climate change. During this year a study was initiated to estimate costs of adaptation measures to combat adverse environmental conditions relevant to the rubber sector. Two scientific communications were prepared using existing data and information; namely, a) Changes observed in climatic parameters in rubber growing areas of Sri Lanka and b) Responsibilities of local state institutions in confronting environmental changes: Special focus on the smallholder rubber sector in Sri Lanka (Wasana Wijesuriya and Keminda Herath).

Application and modification of statistical methods

Development of an appropriate time series model to forecast economic time series in the rubber sector

This project is in progress to identify an appropriate time series technique and also to suggest necessary improvements for modeling and forecasting economic time series in the rubber sector. During this year the problem of underlying volatility in raw rubber prices was studied which is a common issue in evaluating the behavior of them. Since, ARIMA models alone cannot handle the stochastic volatility; a study was carried out to identify an appropriate method to evaluate the dynamic behavior of mean and the variance of raw rubber prices. RSS1 and LC1X monthly auction prices were used in this study and all statistical computations were done using R, a software downloadable at http://www. R-project.org/.

Time series plots of auction prices of RSS1and LC1X and their first order differenced series are depicted in Fig.12. The issue of stochastic volatility is clearly illustrated by these plots.

It was found that the general procedures using ARMA and stochastic volatility models *viz.* ARCH & GARCH are not performing well and the possibility of mis-specifying the underlying model is high leading to get inconsistent parameter estimates. Further, this study suggested that fitting an ARMA model together with an ARCH or GARCH model to square root converted prices would be more appropriate and have a sound basis of statistical theory. Eventually, appropriate models to evaluate the dynamic behavior of RSS1 and LC1X prices are illustrated in Table 2.

Considerable amount of work is completed in this study. Yet, further studies with bootstrapping time series, application and improvements of state space models in time series analysis, and forecasting are in progress.

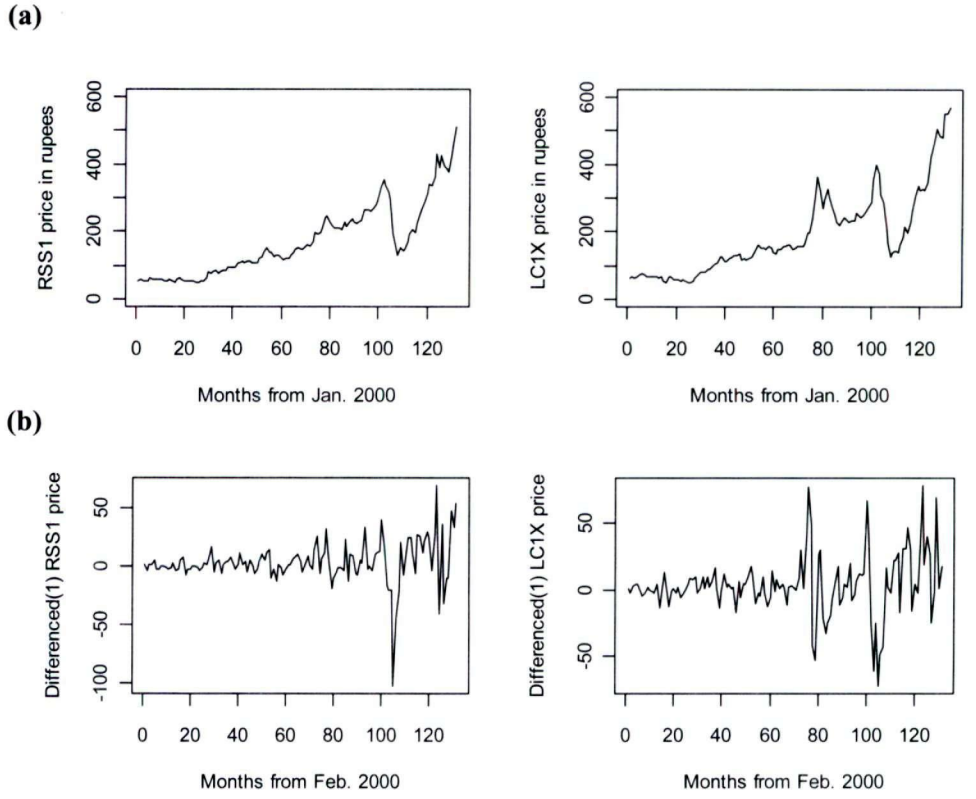


Fig. 12. Time series plots of (a) auction prices of RSS1and LC1X (Rs/kg) and (b)first order differenced series of them

Table 2. *Suitable model types for studying the dynamic behavior of mean and variance of rubber prices and returns in different forms*

Variable	Modeling RSS1	Modeling LC1X
Prices, p_t	[1]ARMA(1,1)-GARCH (1,1)	[1]ARMA(1,1)-GARCH (1,1)
Returns, r_t	AR(1)-ARCH(1)	AR(1)-ARCH(1)
Returns, $\Delta \ln(x_t) \approx r_t$	[1]ARMA(1, 1)-GARCH(1, 1)	[1]ARMA(1, 1)-GARCH(1, 1)

[1]ARIMA(1, 1, 1) can be fitted instead of ARMA(1,1) model since 1st order differenced data of prices are used in it.

Evaluating the 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. It is clear from this study that selection of maximum point in each bin as boundary points and matching particular y values, ($y_{i(max)}$) with the actual x values ($x_{i(max)}$) or nearest x values is very important in fitting an efficient model with a minimum MSE. Splitting data set into bins of equal number of observations was better than splitting data set into bins of equal width. Under these circumstances, the optimum sizes of groups that can be used to split a set of data for different sample sizes are provided in Table 3.

Table 3. *Optimum ranges of number of groups, which best fit polynomial and non linear model forms for different sample sizes and variance covariance structures*

Sample size (n)	Polynomial model form		Nonlinear model form	
	$\rho_{xy} = 0$	$\rho_{xy} = 0.7$	$\rho_{xy} = 0$	$\rho_{xy} = 0.7$
200	10-15 (10)	9-20 (11)	13-20 (14)	15-25 (17)
300	15-20 (18)	10-20 (13)	15-25 (15)	30-35 (32)
500	20-30 (26)	15-25 (19)	15-20 (17)	30-40 (37)
700	20-35 (29)	20-30 (23)	25-40 (10)	40-50 (43)
1000	30-40 (31)	20-30 (28)	10-25 (17)	40-60 (54)

* value in the parenthesis gives the optimum number of bins which yields the minimum MSE*.

Further studies on fitting boundary line are in progress (Keminda Herath and Wasana Wijesuriya).

Statistical process control in raw rubber manufacture

Quality and quality consistency in crepe rubber industry is of vital importance for the Natural Rubber (NR) industry. However, there is no widely accepted and effective system to monitor the manufacturing process of crepe rubber industry in achieving this goal. In this study, an attempt was taken to investigate the use of Statistical Process Control (SPC) in quality assurance in this industry with an application of Individual and Moving Range chart (I-MR chart).

The manufacturing process of crepe rubber was studied in detail and flow charts were developed Fig. 13 & 14. Potential quality parameters were identified and reported in Table 4. Data available at Dartonfield rubber factory during the period of

six years commencing from year 2004 were analyzed. Further, potential improvements that could be introduced to the conventional manufacturing process were identified. Reliable control limits of different quality parameters that could be used with conventional manufacturing process were established (Table 5) during this study. This study further revealed that I-MR charts could be effectively used in achieving the expected quality goals of crepe rubber industry. Related studies are in progress (Keminda Herath, Wasana Wijesuriya and Susantha Siriwardana).

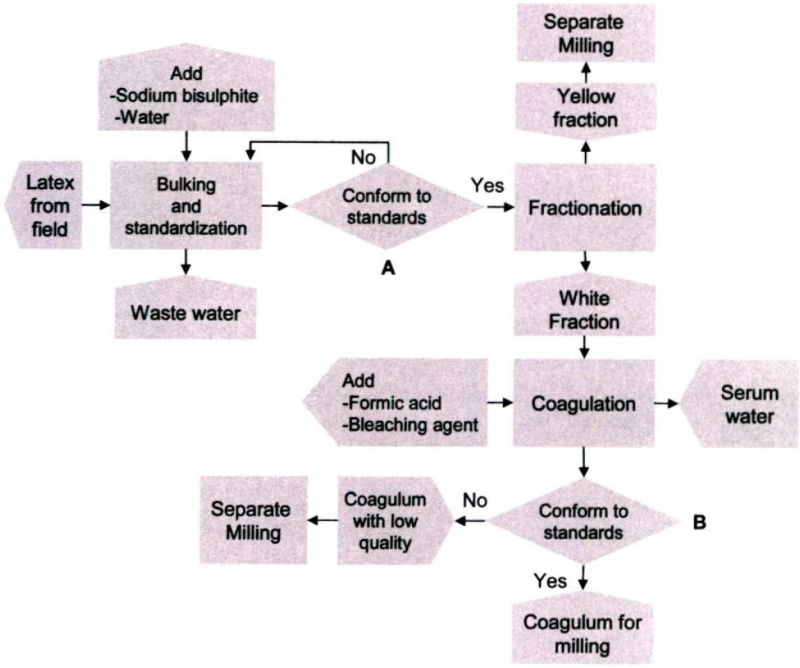


Fig. 13. Process map of latex crepe manufacturing process up to production of coagulum

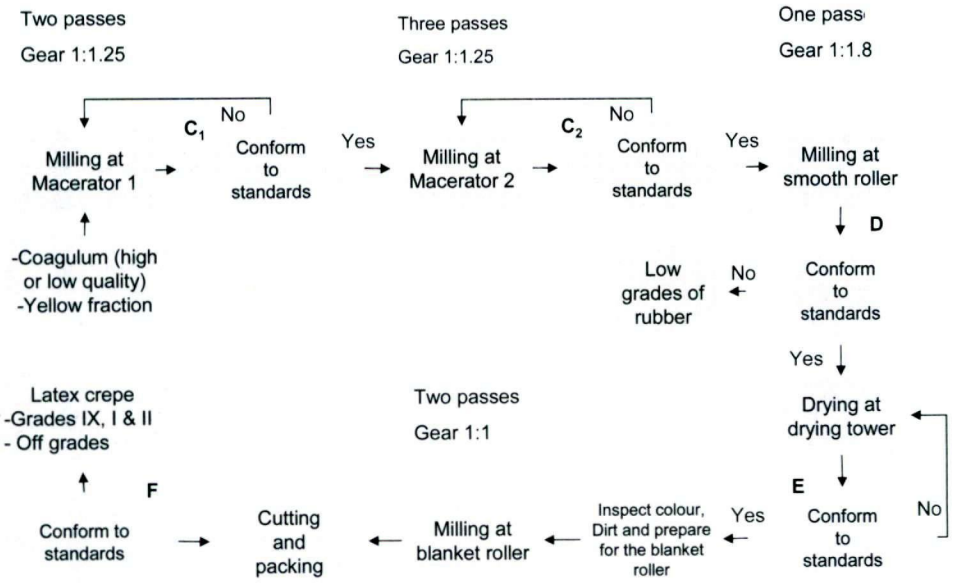


Fig.14. Process map of milling and subsequent operations of latex crepe manufacturing

Table 4. *Parameters which can be potentially used for control charts, their definitions, units of measurements and engineering limits*

Stage	Variable used in control charts	Definition	Indicator/unit of measurement	Engineering limits
A	- Water quality	- Water quality required to keep rubber without discoloration (Measurable indicators - pH, presence of metal ions and turbidity)	- pH (the rest to be defined)	5.8 – 8.0 (the rest to be defined) *
	- Amount of water added	- Amount of water required to bring DRC of field latex to a pre determined limit	- litres/100kg of rubber	sufficient amount of water to bring DRC up to 21.5%
	- Dose of sodium bisulphite	- Dose required to avoid enzymatic discoloration	- g /100kg of rubber	500 maximum
	- Fraction %/ % of off grades	- Fraction of field latex removed at the end of fractionation process	- %	<12

Stage	Variable used in control charts	Definition	Indicator/unit of measurement	Engineering limits
B	- Dose of acid	- Dose of acid required for effective coagulation	- ml / kg of rubber	3.5 – 4.5
	- Dose of bleaching agent	- Optimum dose needed to bleach carotenoid pigments effectively	- g /100kg of rubber	100 – 150
	- Time of coagulation	- Time taken to coagulate latex properly	- hours (hr)	24 maximum
	- size, shape & weight of coagulum	- Optimum size of a piece of coagulum fed into 1st macerator	- thickness, length & width in cm - weight in kg	thickness < 10 (the rest to be defined)*
C_1 & C_2	- Moisture content	- Optimum moisture content of laces at the end of milling with macerator 1 & 2	- % (w /w)	to be defined *
	- Thickness	- Optimum thickness achieved at the end of milling	- mm	to be defined *
D	- Thickness	- Optimum thickness achieved at the end of milling	- mm	to be defined *
	- Moisture content	- Optimum moisture content of lace at the end of milling with smooth roller	- % (w /w)	to be defined *
	- Weight	- Optimum weight at the end of milling	- g/ m^2	600-700
E	- Drying temperature	- Optimum temperature in drying tower, at which laces are dried without degradation and discolouration	- ^{0}C	34 -35 (warm air drying)
	- Drying period	- Optimum drying time, at which laces are dried without degradation and discolouration	- hours (hr)	24 x 3 maximum
	- Moisture content	- Optimum moisture content of laces at the end of drying process	- % (w /w)	< 0.5
F	- Packing standards	- Length, width, height and weight as required by the customer/ buyer	- length, width & height in cm - Weight in kg	54x72x35 (depend on buyer's requirement) 50

* Further investigations are needed for defining appropriate specification limits

Table 5. *Reliable control limits derived for different variables during phase 1 application of control chart*

Variable	I chart			MR chart		
	UCL	$\bar{x}$	LCL	UCL	$\bar{x}$	LCL
1. Dose of Sodium bisulphite (g/ 100kg of rubber)	520.6	494.2	467.8	32.4	9.9	0.0
2. Dose of formic acid (ml / kg of rubber)	4.8	4.5	4.2	0.4	0.1	0.0
3. Dose of bleaching agent (g/ 100kg of rubber)	129.8	121.9	114.1	9.7	2.9	0.0
4. Off -grades (%)	13.7	11.7	9.6	2.5	0.8	0.0

UCL- Upper confidence limit, $\bar{x}$ = Mean, LCL – Lower confidence limit

LIBRARY AND PUBLICATIONS

The Library and Publication Section continued with its regular services in collecting and disseminating information on natural rubber and related subject areas and processing and publishing of its regular publications.

We observed that there was a big demand for the RRISL publications, DVDs etc. with new research findings of the Institute, among the students of Government Schools, Agriculture Schools and Universities as well as the general public and the sale of publications increased significantly, especially due to the sale of newly published "Advisory Leaflets"

Agricultural Information Network (AGRINET) continued their services throughout the year as well, by providing assistance and guidance to member libraries in resource sharing activities.

LIBRARY AND PUBLICATIONS

S U Amarasinghe

DETAILED REVIEW

Staff

Mr S U Amarasinghe, Librarian and Publications Officer, Mrs R M Amaratunga, Library Assistant and Assistant Publications Officer, Mr P M Prema Jayantha, Clerk/Typist, Miss Kanchana Ranaweera, Casual Library Clerk (Colombo Office) and two Library Attendants were on duty throughout the year.

Meetings/Seminars

- The AGM of the Sri Lanka Library Association at Sri Lanka Foundation Institute on 25th June
- Three AGRINET Advisory Committee meetings and three AGRINET Librarian's meetings at CARP Office on 5th March, 7th July and 24th September
- SLISTINET meeting at NSF on 26th March

Resource development activities

Thirty seven new books were added to the library, bringing the total collection to 5602.The library subscribed to a limited number of journals due to financial constraints. More than thirty five journals were received on exchange basis.

Publications

The following publications were published during 2010.

- Annual Review - 2009
- Annual Report - 2009
- RRISL Journal, Vol.89 (2009)
- Frequently Asked Questions Book (English)

ILL service

Twenty five articles were sent to various Agricultural Libraries on their request and vise versa twenty articles were requested for RRISL users. Nearly five 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 2010 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

A total crop of 186,796 kg, has been harvested during this season. The actual crop harvested was 91% of the estimated crop. When comparing with the previous year crop, records a decrease of 0.95%. The crop harvested from rain guard area 24,055 kg which amount to 13% of total harvested crop.

The YPH for the year was 968 kg compared with the same period last season YPH has decreased by 09 kg.

The average intake per tapper recorded during the year was 8.3 kg from a tapping task of 275 trees. Highest intake per tapper of 12.2 kg was recorded from the 1990 clearing with a tapping task of 301 trees tapped on ½S d/3 tapping system.

The total number of normal, late, rainguard and no tapping days recorded during the year were 210, 21, 68 and 84 days respectively.

Total rain fall recorded for the year was 4,948.0 m.m. with 231 wet days. When compared with same period last year it is more by 1,408.2 m.m. and 15 wet days respectively.

The COP and NSA achieved for the year was Rs.182.09 and Rs.427.87 respectively, giving a profit margin of Rs.245.78 per kg and a total profit of Rs.45.9 million. Profit per hectare recorded for the year was RS.237,830.09.

Latex Crepe No.01X and RSS No.01 manufactured during the year were 82% and 95% respectively.

DARTONFIELD GROUP

J Perera

DETAILED REVIEW

Mr Jehan Perera, the Estate Superintendent, Mr K K P Gunawardena Acting Chief Clerk, Mr D S K Ranaweera Rubber Factory 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
Playground	1.00	-	-	1.00
Grand total	**74.29**	**184.35**	**73.24**	**331.88**

Rainfall

The annual rainfall recorded for the year was 4,613.6 m.m. with 185 wet days.

Table 2. *Annual rainfall and wet days of the group for last five years*

	2006	2007	2008	2009	2010
Rainfall (mm)	4,260.9	3,997.4	5,244.4	3,354.1	4,613.6
Wet days	204	187	228	192	185

Crop

A total crop for 186,796 kg have been harvested against the estimated crop of 205,980 kg which is a decrease of 19,184 kg (09%) (Table 3).

Table 3. *The crop and YPH (kg) Dartonfield group from 2006 to 2010*

Hect.	2006		2007		2008		2009		2010	
	187.48		195.10		192.95		193.04		193.04	
Division	**Crop**	**YPH**	**Crop**	**YPH**	**Crop**	**YPH**	**Crop**	**YPH**	**Crop**	**YPH**
Dartonfield	40,278	1,032	38,025	974	27,341	701	29,025	759	29,935	782
Gallewatte	156,863	1,133	163,228	1,179	132,900	960	138,017	997	135,780	981
N'kele	11,970	1,197	11,743	1,174	15,581	1,007	21,527	1,319	21,081	1,292
Group total	209,111	1,115	212,996	1,136	175,822	911	188,569	977	186,796	968
Group estimate	184,900	986	230,736	1,231	217,954	1,130	206,520	1,070	205,980	1,067

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 2006 to 2010*

	2006	2007	2008	2009	2010
Dartonfield	7.1	6.6	7.7	6.6	5.6
Gallewatte	9.9	9.4	9.6	9.5	9.2
Nivitigalakele	6.3	6.3	6.5	8.2	8.1
Group average	8.9	8.5	8.8	8.8	8.3

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*

	2006	2007	2008	2009	2010
Normal tapping	199	212	184	203	211
Late tapping	35	22	30	56	22
Double tapping	(27)	(44)	(05)	-	-
No tapping	77	76	120	106	87
Rainguard tapping	54	46	31	-	45

Total number of tapping days have increased over the previous year.

Rainguard

Total of 144.79 hectares were rainguarded during the year and an additional crop of 24,055 kg was harvested due to rainguard amounts to 13% of total harvested crop. Additional tapping days done due to rainguard during the year 73 and 63 days from D/F & G/W respectively. Profit generated due to rainguard Rs.6.7 million and profit per hectare Rs.46,674.57

Table 7. *Additional income generated by fixing rainguards (Rs./kg)*

	Dartonfield division	Gallewatta division	Total
Hectarage	34.89	109.90	144.79
No. of rainguard fitted	9353	31228	40581
Additional crop	5311	18744	24055
Rainguard cost per kg.	53.07	56.74	55.94
Tapping cost per kg.	64.88	64.88	64.88
C.O.M. Rs./kg	26.11	26.11	26.11
Total cost Rs./kg	144.06	147.73	146.93
N.S.A. Rs./kg	427.87	427.87	427.87
Additional profit Rs./kg	283.81	280.14	280.94
Additional profit from rainguard	1507314.91	5250944.16	6758011.70
Additional profit per hectare	43201.92	47779.29	46674.57

Total profit and profitability per hectare

The total profit and profit per hectare were Rs.45,910,720.88 and Rs.237,830.09 respectively for the year under review.

Table 8. *Comparative statement of the revenue profit per kg. and profit per hectare*

	Years				
	2006	**2007**	**2008**	**2009**	**2010**
Mature area (ha.)	187.48	187.48	192.95	193.04	193.04
Total profit (Rs.)	19,556,061.30	20,268,699.36	14,438,502.64	13,648,624.22	45,910,720.88
Profit per ha. (Rs.)	104,310.12	108,111.26	74,830.28	70,703.61	237,830.09

Cost of production and productivity

COP has increased over previous year.

Table 9. *Labour rates and break down of cost of production from 2006 to 2010 (Rs./Kg.)*

	2006	**2007**	**2008**	**2009**	**2010**
				Jan / Mar 320.00	447.75
1. Labour wages	285.50	320.00	320.00	Apr/Dec 447.75	
2. Cost of production	116.24	128.12	150.04	155.95	182.09
2.1 Tapping	35.35	41.38	47.60	52.27	64.88
2.2 Manufacture	19.20	22.56	21.41	21.02	26.11
2.3 General charges	47.47	50.47	58.78	68.74	74.47
2.4 M/area upkeep	14.22	13.71	22.25	13.92	16.63
3. N.S.A.	209.76	223.28	232.16	228.33	427.87
4. Profit per kg	93.52	95.16	82.12	72.38	245.78

Manufacture

Out of the latex crop of 170,271 kg harvested, 126,649 kg has been sent as No.1 which is 82%. Details are given in Table 10.

Table 10. *Summary of grades manufactured during the year*

Grade	**Quantity (kg.)**	**Percentage %**
Latex crepe No.1	126,649	82
Latex crepe No.2		
Latex crepe No.3	28,697	18
Total	**155,346**	**100**
Scrap crepe No. 1	11,958	72
Scrap crepe No.2	4,199	25
Scrap crepe No.3	368	03
Total	**16,525**	**100**
RSS No.1	14,225	95
RSS No.3	700	05
Total	**14,925**	**100**
Grand total	**186,796**	

KURUWITA SUB - STATION

A total crop of 101,836 kg has been harvested during the year recording an increase of 22% on previous year's crop. The actual yield per hectare (YPH) achieved was 1,455 kg and a yield per hectare of 1,523 kg was achieved from intercropped rubber area during the year. The average intake per tapper (IPT) of the estate was 8.9 kg and this is a increase of 0.7 kg when compared with the previous year.

The annual rainfall was 4,986.4 mm with 132 wet days as against 4,188.6 mm with 84 wet days during the last year. The average number of normal, late, rain interference, double and no tapping days were 323, 10, 03, 19 and 29 days respectively.

The cost of production and the net sale average for the year were Rs.129.79 and Rs.366.08 per kg respectively. The profit per kg was Rs.236.29 and profit made for the year was Rs.24,062,828.44. The total profit made inclusive of sundry income was Rs.25,292,736.50.

KURUWITA SUB STATION

S A R Samarasekera

DETAILED REVIEW

The Visiting Superintendent Mr S P Dissanayake, Deputy General Manager of Agalawatta Plantation over looked the activities of the Sub – station throughout the year.

Staff

Mr S A R Samarasekara Assistant Estate Superintendent, Mr D S Jayasinghe Clerk were on duty through out the year.

Mr J R C Jayalath resigned from the post of Asst. Field Officer with effect from 31.10.2010 and Mr N V U S V Kumara Junior Asst. Field Officer has been under interdiction since 11.11.2010 on disciplinary grounds.

The estate cadre stood as follows at the end of the year.

Intermediate staff	- 01
Assistant staff	- 01
Minor staff	- 04

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	14.32
Proposed Re – planting area	2.00
Nurseries	2.25
Tea area	1.45
Paddy	1.00
Buildings, Gardens & Road	9.34
Water tank	0.01
Unsuitable for planting	0.84
Total	**100.00**

Crop

A crop of 101,836 kg was harvested from an extent of 68.79 hectares during the year when compared with the actual of the previous year this is an increase of 18,285 kg.

The yield per hectare (YPH) of the estate has increased by 17% from that of the previous year. Also it was higher than the estimate of the year.

The yield per hectare (YPH) for the past five years is given in the Table 2.

Table 2. *Yield per hectare for the past five years*

YPH (kg)	Year				
	2006	2007	2008	2009	2010
Estimated	1,200.00	1,200.00	1,536.70	1,456.29	1,453.69
Actual	1,610.20	1,615.30	1,530.10	1,265.90	1480.38

The yield per hectare recorded for each month during the year is given in Table 3.

Table 3. *Yield per hectare recorded for each month during the year*

Month	YPH (kg)	Month	YPH (kg)
January	152.0	July	133.6
February	99.2	August	134.7
March	111.9	September	154.8
April	64.9	October	137.8
May	87.3	November	130.3
June	122.2	December	151.0

Tapper productivity

The average intake per tapper for the last 5 years of the estate are given in Table 4.

Table 4. *The average intake per tapper (IPT) (kg) for the last five years*

	Year				
	2006	2007	2008	2009	2010
Intake per tapper	9.4	8.6	8.4	8.2	8.9

The tapper productivity shows a slight increase of 0.7 kg over the previous year.

Tapping

There were 336 tapping days recorded during the year (Table 5) this was possible merely due to the use of rainguards.

Table 5. *The number of tapping days, average intake per tapper and Y.P.H. for the last five years*

	Year				
	2006	**2007**	**2008**	**2009**	**2010**
01. Total tapping days	**336**	**334**	**337**	**276**	**336**
1.1 Normal	306	315	310	208	323
1.2 Late	20	01	16	52	10
1.3 Rain interference	09	18	11	16	03
1.4 Rainguards	(122)	(109)	(106)	-	(111)
1.5 Double	(02)	(03)	(04)	(29)	(19)
02. No. tapping	30	31	29	89	29
03. Average intake per tapper	9.4	8.6	8.4	8.2	8.9
04. YPH	1,610.20	1,615.3	1,530.1	1,265.9	1,480.38

Tapping and production cost

The tapping and production cost of the estate has increased by 13% over the last year (Table 6).

Table 6. *A break down in total tapping cost for the last 05 years*

	Cost/kg (Rs.) Year				
	2006	**2007**	**2008**	**2009**	**2010**
Tapping	26.39	33.28	37.38	41.58	49.51
Double tapping	0.09	0.07	0.20	1.42	1.02
Over time on tapping	0.36	0.27	0.31	0.35	0.27
Over kilos	0.54	0.60	0.60	1.13	1.68
Extra pay to Kangany	0.02	0.02	0.01	0.02	0.01
Scrap pay	0.88	0.86	1.47	1.59	1.63
Incentive pay to Field staff	0.25	0.23	0.12	0.03	0.04
Transportation of scrap	-	-	0.18	-	-
Cash tapping	-	-	0.31	0.37	0.80
Stimulation	-	-	-	0.34	0.38
Tapping utensils	0.65	0.73	1.39	0.75	0.39
Latex transportation	-	-	-	0.48	0.26
Factory labour	0.46	1.62	3.52	3.47	2.74
Factory sundries	-	-	0.01	0.02	0.02
Total tapping cost (Rs.)	**29.64**	**37.68**	**45.50**	**51.55**	**58.75**

Rain fall

The annual rainfall recorded for the year was 4,986.4 mm with 132 wet days. The wet weather conditions distributed evenly throughout the year were unfavorable for harvesting of crop.

Table 7. *Annual rain fall figures and the number of wet days of the estate for the last five years*

	Year				
	2006	**2007**	**2008**	**2009**	**2010**
Rain fall in (mm)	4,100	3,365	4,624.1	4,188.6	4,986.4
Wet days	132	130	135	84	132

Rainguards

Due to the use of rainguards, an additional 111 tapping days were recorded in the year. This contributed to 30% of the total crop yielding an additional profit of Rs.8,394,436.71

The performance of the use of rainguards for the years 2006, 2007, 2008 and 2010 are given in Table 8. Fixing of rainguards was not carried out in the year 2009.

Table 8. *Additional income generated by use of rainguards (Rs. kg.)*

	Year			
	2006	**2007**	**2008**	**2010**
Hectarge (ha.)	33.66	50.31	59.63	67.29
No. of rainguards fitted	15,680	16,300	21,131.00	22,323
No. of kilos harvested	15,679	23,038	28,312	30,465
Cost per rainguard (Rs.)	19.08	21.63	31.04	43.38
Tapping cost (Rs./kg.)	28.53	35.33	40.58	58.75
N.A.S. (Rs./kg.)	165.82	202.41	228.25	366.08
Profit (Rs./kg.)	118.21	145.45	164.50	275.54
Additional profit from rainguards Rs.)	1,853,376.00	3,496,676.00	4,657,406.80	8,394,436.71
Additional profit per hectare (Rs.)	55,061.67	69,502.60	78,103.92	124,750.13
Additional tapping days	122	109	106	111

Total profit and profitability per hectare

The total profit and profit per hectare were Rs.24,062,828.44 and Rs.349,801.26 respectively for the year 2010.

Table 9. *Comparative statement of the mature extent, total profit and profit per hectare for the last five years*

	Year				
	2006	**2007**	**2008**	**2009**	**2010**
Mature extent (ha.)	48.61	53.31	64.63	68.79	68.79
Total profit (Rs.)	6,796,618.25	8,973,092.48	10,477,953.44	5,536,089.26	24,062,828.44
Profit per hectare (Rs.)	139,819.34	162,232.73	162,122.13	80,478.11	349,801.26

The total profit and profit per hectare were Rs.24,062,828.44 and 349,801.26 respectively for the year 2010. This is an increase of Rs.18,526,739.18 and Rs.269,323.15 respectively when compared with the last year.

Cost of production and profitability

The cost of production has increased by Rs.1.89 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				
	2006	**2007**	**2008**	**2009**	**2010**
Labour rate	285.50	320.00	320.00	405.00	405.00
Total COP	78.99	95.75	114.27	127.90	129.79
Tapping	29.64	37.68	45.50	51.55	58.75
General charges	37.09	45.11	47.59	55.98	56.00
Upkeep	12.26	12.96	21.18	20.37	15.04
N.S.A	165.82	202.41	228.25	194.16	366.08
Profit per kg.	86.83	106.66	113.98	66.26	236.29

The profit has increased by Rs.170.03 per kg when compared with the previous year.

Other crops

Tea

A crop of 11,767 kg was harvested during the year. The cost of production and the net sale average for the year were Rs.48.28 and Rs.56.81 per kg respectively.

Cinnamon

481 kg of cinnamon were sold during the year from Rubber/Cinnamon intercrop experimental area.

Banana

718.5 kg of banana were harvested during the year from rubber/banana intercrop experimental area.

Rubber plants

7,110 young budded plants were sold to the smallholders during the year.

Reward

The selected best tappers were rewarded during the year in order to motivate them.

Fertilizer application

Fertilizer application for immature fields were carried out as scheduled.

METEOROLOGICAL REPORT

This year was a comparatively wet one with a total rainfall of 4948 mm at Dartonfield. The rainfall pattern followed the usual bimodal pattern with below average rainfall values in March and October while the rest of the months recorded rainfall figures above average. The observed total number of rainy days of the year was 231, which is above its long term average of 220 days. The highest weekly rainfall of 510 mm was observed in the 20th standard week, which coincided with mid May. Further, a rainfall of more than 200 mm was recorded during the 16th, 38th, 40th, 47th and 49th standard weeks. There were seven rainfall events that exceeded the hazardous limits, viz 100 mm/day for landslides reported during the year under review. First and second rain spells commenced successfully by 13th March and 28th August, which were quite early. Rains have ceased by 20th July and 17th February, in 1st and 2nd rain spells, respectively. A dry spell of 24 days was recorded during the period from 17th February to 12th March.

The daily average temperature pattern was fairly steady with a mean annual temperature of 27.6^{0}C. The lowest mean minimum temperature of 21.8^{0}C was observed in January while the highest mean maximum temperature of 34.2^{0}C was observed in February. A total of 1744 sunshine hours was received at an average rate of 4.8 hr/day which was comparatively lower than the respective figures observed during the last year. Daily morning Relative Humidity (RH) at Dartonfield in 2009 was observed in the range, 69% to 98 %. More than 15 days exceeded 90% RH in the morning in months from May to July.

A total rainfall of 4,986.4 mm and 2,596.6 mm were recorded respectively in Kuruwita and Narampola Sub-stations of RRISL

Meteorological Report
Dartonfield Station

H M L K Herath

Comparatively, a wet weather was experienced during 2010. A total rainfall of 4,948 mm was recorded during this year, which was 1,408 mm increase compared to 2009 and 876 mm increase with respect to long term average. As indicated in Fig. 1 the rainfall distribution at Dartonfield during this year followed the usual bimodal pattern. Below average rainfall values were observed in March and October while the rest of the months recorded rainfall figures above average. The minimum monthly rainfall of 127.3 mm and the maximum monthly rainfall of 879.8 mm were recorded in March and May, respectively.

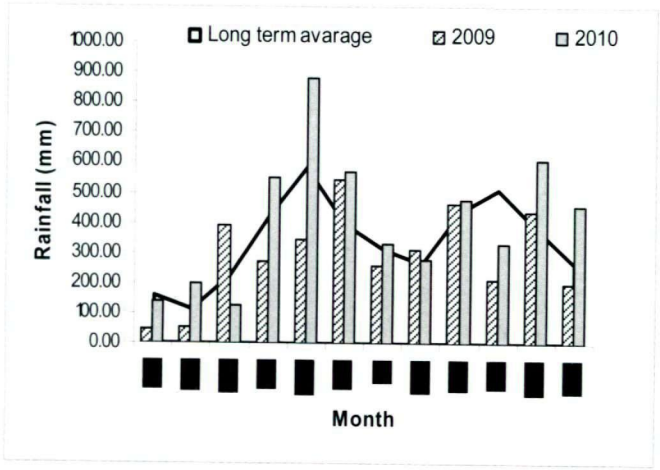


Fig.1. Monthly variation in rainfall

The distribution of weekly rainfall is illustrated in Fig. 2. Seven dry weeks (weeks having a total rainfall less than 10 mm) were observed during this year compared to eight weeks in 2010. The highest weekly rainfall of 510 mm was observed in the 20th standard week, which coincided with mid May. Further, a rainfall of more than 200 mm was recorded during the 16th, 38th, 40th, 47th and 49th

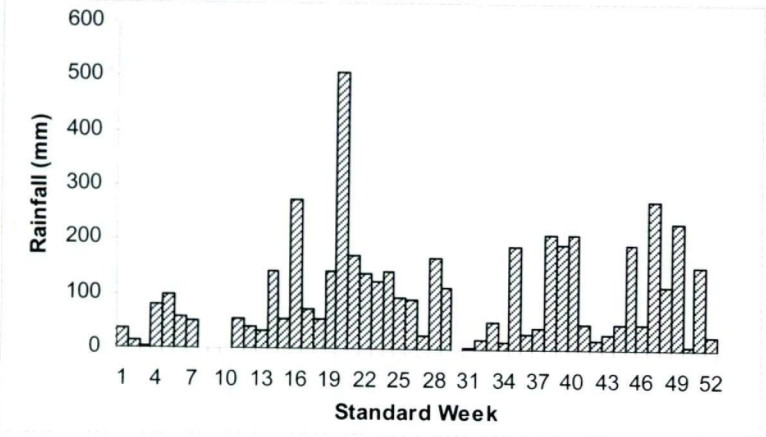


Fig. 2. Weekly variation in rainfall

standard weeks. There were only three such weeks with more than 200mm rainfall (including the week with the highest rainfall) observed in the previous year.

There were seven rainfall events that exceeded the hazardous limits for landslides (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 231, which is above its 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 24 days was recorded during the period from 17th February to 12th March. However, the rains received during this year were well distributed over time compared to the rainfall distribution of the last year.

Table 1. *Monthly variation of rainfall and rainy days in 2010*

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	140.3	(156)	11	(11)	5	5	1	75.7
February	201.6	(114)	9	(9)	2	5	2	79.8
March	127.3	(222)	14	(13)	7	7	-	112.4
April	549.7	(415)	23	(18)	5	16	2	82.8
May	879.8	(584)	25	(24)	3	16	6	77.5
June	568.9	(398)	26	(23)	5	18	3	61.6
July	330.1	(313)	19	(22)	6	12	1	80.2
August	276.1	(268)	16	(20)	4	10	2	60.0
September	475.6	(436)	22	(22)	3	16	3	64.9
October	331.1	(513)	22	(23)	5	16	1	67.8
November	612.0	(387)	25	(20)	4	17	4	57.9
December	455.5	(266)	19	(15)	4	12	3	64.2
Total	4948	(4160)	231	(220)	53	150	28	884.8

* A rainy day is defined as a day with a rainfall $\geq$ 0.3 mm

** Average values for 1980-2005 are shown in parentheses

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 were considered. For the year under review, first spell and the second spell of rains commenced successfully by 13th of March and 28th August, which were early starts compared to their 80% expected starts.

Rains have ceased generally by 14th August and 05th January for SW and NE rainy seasons, respectively. For the year under review, the cease of SW was 20th July while NE rains have ceased by the 17th of February.

Rainfall at RRISL Sub-stations

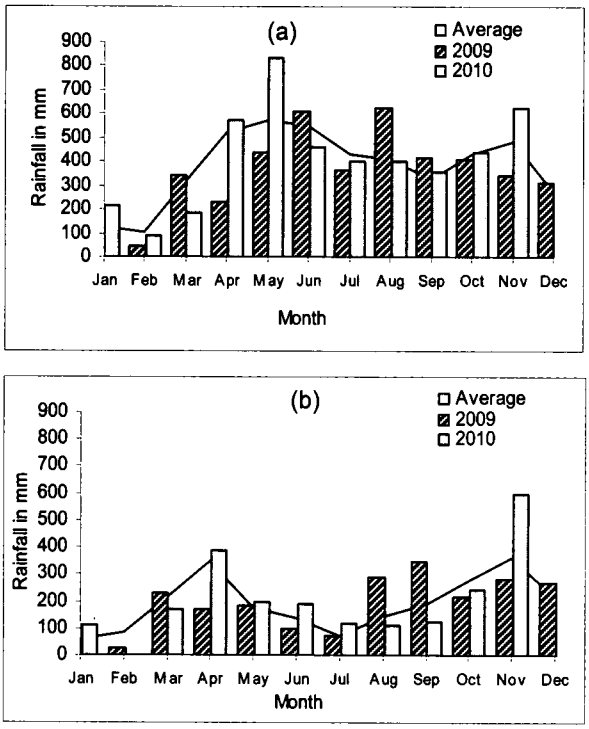


Fig. 3. Distribution of monthly rainfall in (a) Kuruwita and (b) Narampola

There are three substations maintained by RRISL in Kuruwita (WL_{1a}), Narampola (IL_{1a} bordering WL_{2b}) and Monaragala (IL_{1c}). A total rainfall of 4986.4 mm and 2596.6 mm were recorded respectively in Kuruwita and Narampola stations during 2010. The meteorological station at Moneragala is still under construction. 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 and Narampola were apparent during this year while it was not clearly visible at Kuruwita in year 2009. The highest monthly rainfall in Kuruwita was recorded during the first rain spell while in Narampola it occurred during the second rain spell.

Other meteorological parameters

Table 2 depicts the monthly values of some important meteorological observations together with averages from 1980 to 2005 at Dartonfield. Daily fluctuations of the minimum and maximum temperatures at Dartonfield are illustrated in Fig. 4. During the year under review, the minimum temperature dropped below 20^0C in 4 days in January and 2 days in February. More incidences with maximum temperature below 29^0C were observed during the latter half of the year.

The daily average temperature pattern was fairly steady with a mean annual temperature of 27.6^0C and standard deviation of 1.1 which could be a favourable condition for rubber plantations. The lowest mean minimum temperature of 21.8^0C was observed in January while the highest mean maximum temperature of 34.2^0C was observed in February. However, any signs of adverse conditions with respect to the temperature regime at Dartonfield were not reported during the year.

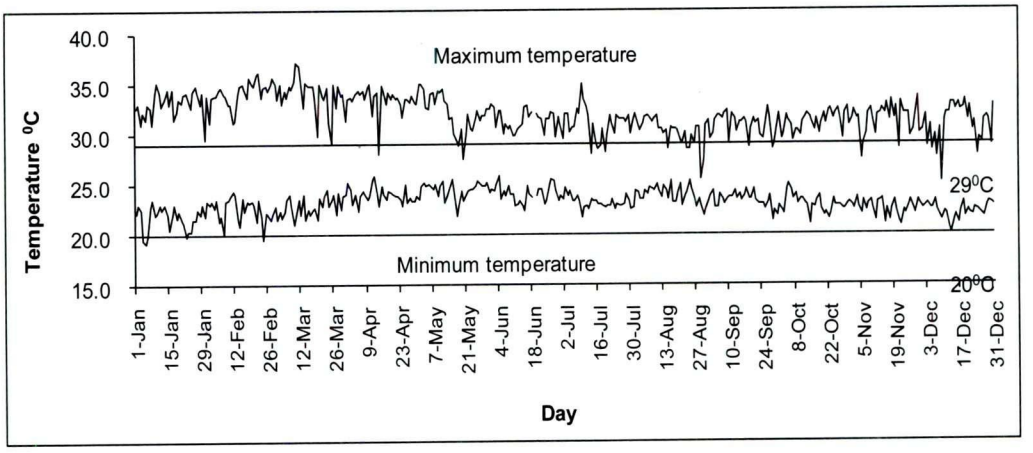


Fig. 4. Daily minimum, maximum and average temperature distributions

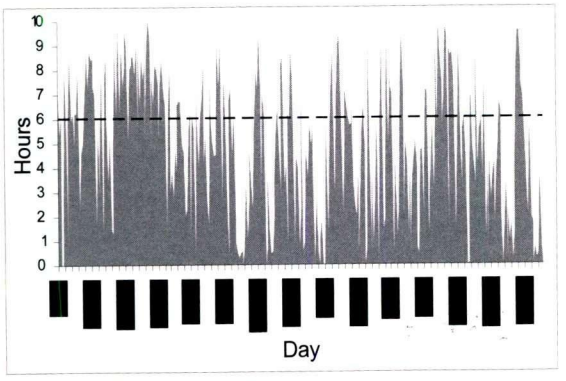


Fig. 5. Distribution of daily sunshine hours during 2010

The distribution of daily sunshine duration at Dartonfield in 2010 is illustrated in Fig. 5. A total of 1744 sunshine hours was received at an average rate of 4.8 hr/day which was comparatively lower than the respective figures observed during the last year. Out of this, a total of 710 hours of sunshine had been received at an average rate of 6.0 hr/day during the first four months in which the wintering of rubber trees is coincided. Compared to the optimum requirements for rubber (2000hr 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, during which the plantations are expected to be more productive.

Daily morning Relative humidity (RH) at Dartonfield in 2009 was observed in the range, 69% to 98%. More than 15 days exceeded 90% RH in the morning in months from May to July. This is a favorable condition for tapping. The mean annual RH recorded during the year was 82% (standard deviation = 7). Monthly values of soil temperatures at 4 different depths are given in Table 3.

Table 12. *Farmer training programmes conducted in the year 2010*

Region	AWP (Self)		AWP (Joint)		TSD (for tappers in model farmers)		TSD (General)		WRD		TTS	
	No. of programmes	No. of farmers benefitted	No. of programmes	No. of farmers benefitted	No. of programmes	No. of farmers benefitted	No. of programme	No. of farmers benefitted	No. of programme	No. of farmers benefitted	No. of programmes	No. of farmers benefitted
Col/Gampaha	4	174	11	438	01	20	04	76	2	52	0	0
Kegalle	8	409	12	580	1	18	10	194	0	0	3	53
Kaluatara	1	70	6	593	4	24	10	125	4	63	2	29
R'pura	4	251	4	230	0	0	9	119	1	86	0	0
Galle/Matara	6	226	0	0	5	26	1	11	0	0	0	0
Total	**23**	**1130**	**33**	**1841**	**11**	**88**	**34**	**525**	**7**	**201**	**5**	**82**

Total No. of Programmes 113 Total No. of Farmer benefited 3867

AWP (self) - General Awareness Programmes organized by individual REOo for selected rubber re-planters, model farm owners and medium scale rubber growers in the range.

AWP (joint) - General Awareness Programmes jointly conducted by group of REOo for selected re-planters, model farm owners and medium scale rubber growers in district levels.

TSD - Skill Development Programmes for semi skilled rubber tappers

TTS - Tapper Training Programmes to train and introduce new rubber tappers as a solution for the shortage of rubber tappers in the industry.

WRD - Training programmes to educate rubber smallholders on identification and control of White root disease.

Table 3. *Soil temperatures recorded at different depths at Dartonfield - 2010*

Month	08.30 hrs				15.30 hrs			
	5 cm	10cm	20cm	30cm	5 cm	10cm	20cm	30cm
January	26.5	26.5	27.5	28.3	33.0	31.7	29.9	28.9
February	27.7	27.7	28.5	29.2	35.1	33.4	31.7	30.0
March	29.6	28.7	29.8	30.6	38.2	36.1	33.6	31.6
April	28.8	27.8	28.6	29.2	33.4	32.6	30.9	29.9
May	28.4	27.7	28.3	28.9	33.2	32.1	30.6	29.6
June	28.1	27.4	28.1	28.7	33.3	32.0	30.4	29.3
July	27.3	26.8	27.5	28.2	32.4	31.2	29.7	29.0
August	27.7	27.3	27.8	28.6	32.3	31.3	30.1	29.2
September	28.0	27.0	27.4	28.0	31.9	30.8	29.5	28.8
October	28.2	27.1	27.6	28.2	31.9	31.0	29.8	28.9
November	27.5	26.6	27.0	27.7	30.3	29.9	28.9	28.4
December	26.1	25.6	26.2	27.0	29.6	29.2	28.3	27.7

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