

ANNUAL REVIEW 1992

RUBBER RESEARCH INSTITUTE OF SRI LANKA

THE RUBBER RESEARCH INSTITUTE OF SRI LANKA

ANNUAL REVIEW 1992



Cover :

Solid Tyres - Sri Lanka is the leading manufacturer in the world today

Photographs : Wimal Amaratunge

**The Rubber Research Institute
of Sri Lanka**

Annual Review – 1992

1st January 1992 to 31st December 1992

June 1993

**Headquarters & Laboratories
Dartonfield
Agalawatta**

**Colombo Office & Laboratories
Telawala Road
Ratmalana**



DR OSMUND STANLEY PERIES
(An Appreciation)

Born: 7th May 1927

Died: 11th December 1992

It is with deep regret that we record the death of Dr O S Peries, former Director of the Rubber Research Institute of Sri Lanka. Dr Ossie Peries had a sound and liberal education at St. Peter's College, Bambalapitiya. His school days were marked by scholastic achievements and sportsmanship. After leaving school he proceeded to the University of Melbourne. In 1954 saw him returning with a degree in Agriculture from Melbourne, to join the Rubber Research Institute as a Technical Assistant to the Director. Thus began his long and distinguished association with the RRI, which he was to ultimately head with distinction for 17 years from 1968 upto his retirement in 1985. During this period Dr Peries published over 100 papers – several in respected International Journals, won the Presidential Award for Scientific Achievement, the prestigious FAO Ceres medal for outstanding research contributions and a merit award from the Sri Lanka Plastics and Rubber Institute.

The giant strides that the RRI took under his exemplary stewardship, the international recognition it won and the pool of competent and dedicated scientists it spawned – will be undying testimony to his vision and total dedication.

Exceptional though he doubtless was, Dr Peries will long remain in our hearts and memories as a devout family man, a steadfast friend and above all a warm, caring, human being. We extend our deepest sympathies to members of his family.

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THE RUBBER RESEARCH INSTITUTE OF SRI LANKA

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Mr P I Peiris, Deputy Chairman, M/s Richard Peiris & Co Ltd
Mr M M A Naina Marikar, Planter (Smallholders' Representative)
Mr R Wijegunaratne, Working Director

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Mr G W S K de Silva, Rubber Controller
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Mr K D W Ratnayake, Chairman, SLSPC (up to 30.09.1992)
Mr Sarath Ranawaka, MP for Kalutara District
Mrs C S Kumarasinghe, Deputy Director (Budget Division), Ministry of Finance

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Mr M R C Peiris, Chairman, SLSPC
Mr Denzil Peiris, Representative of the JEDB
Mr Nihal Cooray, **Visiting** Superintendent, Kuruwita Sub-station (In attendance)
Dr L M K Tillekeratne, Director, RRI
Mr V M Katugaha, Estate Superintendent (In attendance)
Mr J A A S Ranasinghe, Secretary, RRB

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Mr M M A N Marikar, Board Member, RRB
Mr P I Peiris, Board Member, RRB
Mr G W S K de Silva, Rubber Controller, Board Member, RRB
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Dr N Yogaratnam, Deputy Director (Research) II, RRI
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Dr N E M Jayasekera, Head, Genetics & Plant Breeding Dept., RRI
Dr A Nugawela, Head, Plant Science Dept., RRI
Mr C K Jayasinghe, Head, Plant Pathology & Microbiology Dept., RRI
Dr (Mrs) L Samarappuli, Head, Soils & Plant Nutrition Dept., RRI
Dr (Mrs) K G K de Silva, Head, Polymer Chemistry Dept., RRI
Dr (Miss) N M V Kalyani, Head, Rubber Technology Dept., RRI
Dr W M G Seneviratne, Actg Head, Raw Rubber Process Development & Chemical
Engineering Dept., RRI
Mr A Dahanayake, Actg Director, ASD
Mr V M Katugaha, Estate Superintendent, Dartonfield Group, RRI
Mr L Karunanayake, Asst. Specifications Officer, RRI
Mr K Meegahawatte, Head, Development Division, ASD
Mr L Madawela, Director, Marketing, SLSPC
Mr M R C Peiris, Chairman, SLSPC V, Ratnapura (till June)
Mr S S R Rodrigo, Chairman, SLSPC III, Horana (till June)
Mr D D Jayasuriya, Chairman, SLSPC IV, Avissawella (till June)
Mr S N Gunaratne, Director, JEDB IV, Avissawella (till June)
Mr G Amarasinghe, Chairman, JEDB IV, Avissawella (till June)
Mr D H Giragama, Superintendent, Mahaoya Estate
Mr B M S Fernando, Superintendent, Yatawatte Estate
Mr A M Perera, Superintendent, Bibile Group, Bibile
Mr D E C Wijesinghe, Superintendent, Padukka Estate
Mr J Weragama, Superintendent, Pussella Estate

Scientific Committee - Technology & Marketing

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Mr P I Peiris, Deputy Chairman, Richard Peiris & Co Ltd

Dr L M K Tillekeratne, Director, RRI
Mr S W Karunaratne, Deputy Director (Research) I, RRI
Mr A Dahanayake, Actg Director, ASD
Dr (Mrs) K G K de Silva, Head, Polymer Chemistry Dept., RRI
Dr W M G Seneviratne, Actg Head, Raw Rubber Process Development & Chemical
Engineering Dept., RRI
Dr (Miss) N M V Kalyani, Head, Rubber Technology & Product Development Dept.,
RRI
Mr Desmond Fernando, Marketing Specialist, JEDB
Mr Lee Madawela, Marketing Specialist, SLSPC
Mr G W S K de Silva, Rubber Controller, RCD
Mr D E C Wijesinghe, Factory Advisor, SLSPC (till June)
Mr Lasantha Perera, Factory Advisor, JEDB (till June)
Mr Jim Amarasinghe, Marketing Specialist, JEDB (till June)

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Mr G P S U de Silva, Secretary, Ministry of Plantation Services
Mrs C S Kumarasinghe, Deputy Director (Budget Division), Ministry of Finance
Mr G W S K de Silva, Rubber Controller, RCD
Mr M M A Naina Marikar, Planter
Mr R Wijegunaratne, Working Director, RRB
Dr L M K Tillekeratne, Director, RRI (In attendance except from May - July 1992)
Mr S W Karunaratne, Actg Director, RRI (In attendance from May - July 1992)
Mr A Dahanayake, Actg Director, ASD (In attendance)
Mr J A A S Ranasinghe (Secretary)
Mr P R N Pandikorala, Chief Administrative Officer, RRI (In attendance from May
1992)
Mr G Fonseka, Accountant, RRI (In attendance)

Provident Fund Committee

Mr M M A Naina Marikar, Chairman
Dr L M K Tillekeratne, Director, RRI
Mr J A A S Ranasinghe, Secretary
Mr W C Dayaratne, Elected Committee Member
Mr Gamini Fonseka, Accountant, RRI (From 24.10.1992)

Extension Committee

Professor I Balasooriya, Chairman, RRB
Mr G W S K de Silva, Rubber Controller, RCD
Mr M M A Naina Marikar, Member, RRB
Dr L M K Tillekeratne, Director, RRI
Mr A Dahanayake, Actg Director, ASD
Mr S W Karunaratne, Deputy Director (Research) I, RRI
Dr N Yogaratnam, Deputy Director (Research) II, RRI
Mr L K Meegahawatte, Head, Development Division, ASD
Dr N E M Jayasekera, Head, Genetics & Plant Breeding Dept., RRI
Dr R C W M R A Nugawela, Head, Plant Science Dept., RRI
Mr A J L de Silva, Regional Advisory Officer (Colombo District)
Mr P Samaranyake, Regional Advisory Officer (Kalutara District)
Mr M C Samarasekera, Regional Advisory Officer (Galle & Matara Districts)
Mr D D Dassanayake, Regional Advisory Officer (Kegalle District)
Mr A H Kularatne, Regional Advisory Officer (Ratnapura District)

Board Office

Secretary to the Board	- Mr J A A S Ranasinghe
Secretary to the Chairman	- Mrs L J C Perera
Clerk/Typist	- Miss S N Munasinghe
Stenographer	- Mrs P Balasooriya

Lawyers

Attorney General
Attorney General's Department,
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P O Box 502
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Auditors

M/s Tissa Fernando & Co
Chartered Accountants
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Bankers

Bank of Ceylon
Corporate Branch
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Registered Office & Laboratories

Dartonfield, Agalawatta

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Colombo Office & Laboratories consist of

Rubber Research Board Office

Advisory Services Department

Polymer Chemistry Department

Raw Rubber & Chemical Analysis Department

Raw Rubber Process Development & Chemical Engineering Department

Rubber Technology & Development Department

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THE RUBBER RESEARCH INSTITUTE OF SRI LANKA

STAFF

(As at 31st December 1992)

<i>Chairman</i>	Professor I Balasooriya, BSc (Cey.), PhD (Liverpool), FI Biol (SL), FNAS (SL)
<i>Director</i>	L M K Tillekeratne, BSc(Cey.), MSc(Aston), PhD(Aston), FI Chem C, FPRI
<i>Deputy Director (Research) (I)</i>	S W Karunaratne, BSc (Cey.), MSc(Aston), FPRI, FI Chem C
<i>Deputy Director (Research) (II)</i>	N Yogaratnam, BSc Agric(Alld), PhD (Lond.)

RESEARCH DEPARTMENTS

Plant Science

<i>Head of Department</i>	R C W M R A Nugawela, BSc (SL), MSc (Lond.), PhD (Essex)
<i>Botanists</i>	Mrs G P W P P Seneviratne, BSc (SL), PhD (Bath) V H L Rodrigo, BSc Agric (SL), MSc (Essex)
<i>Assistant Botanists</i>	*Mrs M S Ranasinghe, BSc (SL) L S S Pathiratne, M I Biol., MPhil (SL)
<i>Experimental Officers</i>	R B Gunaratne L S Kariyawasam
<i>Senior Technical Officers</i>	K A G B Amaratunga R P Karunasena
<i>Senior Experimental Assistant</i>	S Wilbert

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Mrs C W Ranasinghe, BA (Cey.)
Mrs G A S Wijesekera
Mrs R K Samarasekera
U S Weerakoon
T U K Silva
M K P Perera
S M A Samarakoon, Dip. Agric
W D M N de Alwis
Miss G G M de Soysa, Dip. Agric
Mrs H D D E Jayawardena

Clerk/Typist

Genetics & Plant Breeding

Head of Department

N E M Jayasekera, BSc Agric (Cey.),
PhD (Birm.)

*Assistant Geneticist & Plant
Breeder*

D P S T G Attanayake, BSc Agric (SL),
PhD (Birm.)

Experimental Officer

K W Rупatunga

Senior Experimental Assistant

B M S G Peiris

A K M S Senaratne

Technical Officers

R A S K Ranatunga

I D M J Sarath Kumara

Miss K P Sunethra Nilmini

Plant Pathology & Microbiology

Head of Department

C K Jayasinghe, BSc (SL), MSc (SL),
MSc (Agric) (Aust.)

Assistant Plant Pathologists

A H R Jayaratne, BSc (SL),
MSc (SL), PhD (Sheffield)

*K E Jayasooriya, MSc (USSR)

Miss W P K Silva, BSc (SL),
MSc (SL)

Experimental Officers

L W Amaratunga

W A D D S Wettasinghe

Senior Technical Officer

Mrs P C Wettasinghe

Technical Officers

Miss B I Fernando, Dip. Agric.

Miss T H P S Fernando

Clerk/Typist

Mrs W S P Amarasekera

Soils & Plant Nutrition

Head of Department

Mrs M L A Samarappuli,
BSc Agric (SL), MSc (Calf.), PhD (SL)

Assistant Soils Chemists

D M A P Dissanayake, BSc Agric (SL),
PhD (Aberdeen)

P I Yapa, BSc Agric (SL)

**R S Dharmakeerthi, BSc Agric (SL)

Experimental Officers

A M A Perera

H D S P Perera, BSc (SL)

J G de Mel

Mrs R P Hettiarachchi, BSc (SL)

Senior Technical Officer

Mrs S D C K Maheepala

Technical Officers

Mrs M K Mahanama

S N Silva

P Karunadasa, BSc (SL)

A H U Mitrasena

A N Yakandawala

T B Dissanayake

M D R Gunasekera

Specification Assistant (Special Grade)

T M Ahamadeen

English Stenographer

Mrs K A D L Rupasinghe Perera

Biochemistry & Physiology

Assistant Biochemists

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Mrs P N de Silva, BSc (SL)

<i>Experimental Officer</i>	E B Fernando
<i>Technical Officers</i>	M D C Seneviratne
	Miss K V V S Kudaligama
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Polymer Chemistry

<i>Head of Department</i>	Mrs K G K de Silva, BSc (SL), MSc (SL), PhD (Aston)
<i>Rubber Chemist</i>	Mrs S A P P Gunatilleke, BSc (SL), PhD (Sussex)
<i>Assistant Rubber Chemist</i>	*S M C E Silva, BSc (SL)
<i>Experimental Officers</i>	H N K K Chandralal, BSc (SL), MSc (SL)
	Mrs D I R Denawaka
<i>Senior Technical Officers</i>	Mrs W C M Kuruppu
	S S Warnapura
<i>Technical Officers</i>	L P P Vitharana
	S L G Ranjith
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<i>Clerk/Stores Assistant</i>	Mrs L Rukmanie

Raw Rubber & Chemical Analysis

<i>Head of Department</i>	L M K Tillekeratne, BSc (Cey.), MSc (Aston), PhD (Aston), FI Chem C, FPRI
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<i>Assistant Rubber Chemist</i>	Miss J A G S G Gunawardena, BSc (SL), MSc (SL)
<i>Experimental Officer</i>	A S Dekumpitiya, NRP
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	Mrs L Wanigatunge
	Mrs H V K Gamage

Technical Officers

Mrs C S Lokuge

R S Wijesundera

Specification Assistants

G Wanigatunge

B Gunasiri

W W Nandasena

K R N Karunatileke

P L Perera

Clerk/Typist

Mrs I Wijesinghe

Rubber Technology & Development

Head of Department

Miss N M V Kalyani, BSc (SL),
PhD (Lond.)

Assistant Rubber Chemists

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Miss H M M de S Rajapakse, BSc (SL),
MSc (SL)

Mrs D G Edirisinghe, BSc (SL), MSc (SL)

Experimental Officers

D D Medagama

Mrs H S Weeraman

Technical Officers

Mrs S I Yapa

Mrs H K D C S Munasinghe

K M U Mitranande

D P Wettasinghe

Raw Rubber Process Development & Chemical Engineering

Acting Head of Department

W M G Seneviratne, BSc (SL),
PhD (Sussex)

Assistant Rubber Chemist

S Siriwardena, BSc (SL)

Experimental Officer

P H Sarath Kumara, DPRI

Technical Officers

Mrs W K C Nalinie

T A S Siriwardene

E C D Senanayake

Technical Officer
Clerk/Typist
Electronic Repair Unit

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Mrs S A Parnavithana

Instrument Technician

L G P Lelwela

Biometry Section

Assistant Biometrician
Senior Technical Officer

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Mrs Nandanie Wanigatunge

Director's Office
Adaptive Research Unit

Research Assistant/Agronomy
Assistant Development Officers

S M M Iqbal, BSc Agric (SL), MPhil (SL)

F P W Silva

P P Jayasinghe, LPRI

W C Dayaratne

K B A Karunasekera

Senior Technical Officer

E A T Senadeera

Specification Assistant (Special Grade)

W A S Wijesekera

Agricultural Economics Unit

Assistant Agricultural Economists

H Talgaswatte, BSc Agric (SL),
MCom (Lincoln)

P H M U Herath, BSc Agric (SL),
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I N Samarappuli, BSc Agric (SL),
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**Mrs S Amaratunge, BA (SL)

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<i>Library Assistant & Assistant Publications Officer</i>	Mrs D T Dantanarayana
<i>Clerk/Typist</i>	Mrs R M Amaratunge

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<i>Assistant Administrative Officer</i>	T H Wijesena
<i>Office Assistant</i>	J D Gunaratne
<i>Assistant Medical Practitioner</i>	K V de Silva
<i>Chief Clerk</i>	D U Kannangara
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	Miss M D P Gunasekera
	Mrs E W Dhammika
<i>Telephone Operator</i>	Mrs P Edirimanne

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<i>Assistant Internal Auditor</i>	Neil C de Silva
<i>Internal Audit Assistants</i>	S W S G Gunawardene
	D E C Warnakula

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G Mahanama

Transport Officer

B D Ponnampuruma

Electrical Foreman

W D Ratnasinghe

Mechanical Foreman

S D Gunawardene

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Assistant Accountant

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Accounting Assistant

W Kularatne

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Mrs K Jagoda, BA (Cey.)

Accounts Clerks (Special Grade)

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G A Kannangara

Accounts Clerks

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Miss S Irene

Mrs M Gunawardena

Mrs K Kapuge

K C Fernando

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Mrs R Handungoda

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D C P Pothmitiyage

Assistant Store Keepers

P D Somadasa
K D Sumanasena

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Chief Clerk

S A L Chandrawansa

Senior Assistant Clerk

K K P Gunawardena

Junior Assistant Clerks

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D S K Ranaweera

Rubber Factory Supervisor

W D D Senanayake

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A K D Hemapala

H M J Premalal

S K S de Silva (attending to Clerical Work)

Assistant Field Officer

J A Wimalasena

Field Supervisors

S R Vadivel

T Somaratne

N L D Reggie

Kuruwita Sub-Station

Visiting Superintendent

N M Cooray

Assistant Estate Superintendent

S A R Samarasekera

* On study leave overseas

** On study leave locally

THE RUBBER RESEARCH INSTITUTE OF SRI LANKA

DIRECTOR'S REVIEW

L M K Tillekeratne

During the year 1992, the total rubber production in the world was 14 million tonnes (t), out of which the natural rubber (NR) component was 5125 t. Out of the synthetic rubber component, 2937 t had been presented as solid Styrene Butadiene Rubber (SBR) and another 331 t of SBR had been presented in latex form.

As far as the NR production for 1991 is concerned, Sri Lanka has been pushed down to the 8th position among NR producing countries from the 6th position it enjoyed in the previous years. For the first time both Philippines and Nigeria have overtaken Sri Lanka in 1991, producing 201.5 t and 155 000 t respectively. Even Malaysia which has been maintaining the reputation as the leading rubber producing country in the world has been pushed down to the 3rd position by Thailand and Indonesia, recording production figures of 1 340 800 t and 1 284 000 t respectively.

The major reason for the declining of NR production in Sri Lanka had been the diversification of rubber land to other crops by the smallholders mainly because of poor price fetched by natural rubber. However, in areas where latex is being purchased for the manufacture of centrifuged latex the smallholders have been able to obtain reasonably higher prices, as compared to the prices paid by the crepe factories.

Also in this year Rubber Controller started a scheme of declaring minimum price paid for the latex based on the end product they manufacture out of their latex. Severe shortage of trained tappers is another problem facing the rubber industry in Sri Lanka. However, the RRI has provided conclusive evidence to show that one of the main causes for the low yields per hectare recorded by the state sector estates has been the increase in the incidence of tapping panel dryness caused by over exploitation. In spite of the recommendations of RRI, over exploitation of trees by excessive recovery tapping (over 6 days per month) and stimulation during dry wintering months were on the increase during the year under review.

Management of most of estates belonging to SLSPC and JEDB were privatized in July 1992 transferring the management of these to 22 local companies. Most of the rubber estates are coming under the control of 16 companies and are being presently managed by experienced planters who worked for the SLSPC and JEDB. Some estates have got the service of foreign experts mainly Indian and Malaysian to advise them.

There have been complaints that the new managing companies have suspended replanting activities in order to bring down the percentage of immature extents in estates to the recommended 18 - 20% level. RRI has been advising the managers on the precautions to be taken when doing so in order to avoid either a glut or a scarcity of rubber to the respective factories.

After the privatization of the management of the plantations rubber prices started improving and most of the rubber factories, mainly crepe factories which were running at a loss during the past few years started recording profits, since October 1992. With the expected removal of export duty on rubber, prices for all grades are expected to rise to Rs. 35 - 45 level in early 1993. But the 15 - 30% salary increase to plantation workers from January 1993 may affect the c.o.p. of all grades of rubber and will affect the profit margins. With the initiative of the Ceylon Planters' Association and the RRI many proposals are under way to improve the presentation and grading of latex crepe rubber to attract the correct end users and to obtain a still better price for latex crepe including sole crepe in the future. The RRI has been stressing the need for introducing a standardized method for the manufacture of latex crepe to make the properties of the end products such as solubility, mooney viscosity, PRI etc. uniform and present them in proper standard packages to make handling convenient and cheap. Such procedures would improve the possibility of regaining the demand and hence the premium price we enjoyed for crepe rubber in late 60's by attracting the correct end users.

During 1992, consumption of raw natural rubber in the country increased to a record level of 29 000 t. Towards the end of 1992, Sri Lanka was catering to 15% of the world demand for solid tyres. Even the manufacture of latex based gloves had increased considerably in 1992. With the installation of 2 more solid tyre factories and the expansion of other rubber based industries the domestic consumption of NR in Sri Lanka would increase to around 40% of the total production towards the end of this century.

In order to meet this extra demand and to increase earnings from raw rubber exports, Sri Lanka must increase her NR production considerably. New high yielding clones such as RRIC 100, RRIC 102 and RRIC 121 are becoming more and more popular among the smallholders. Under Adaptive Research Programmes, smallholders are encouraged to cultivate high yielding clones planted at a closer spacing to increase the stand per hectare to between 450 and 500, in order to increase productivity. Smallholders are also encouraged to interplant tea and other crops with rubber to generate an additional income for them, specially during the immature period of rubber. Rainguards introduced by the RRI are becoming more and more popular. Rainguard will not only prevent bark rot due to *Phytophthora* attacks, but also increase the yield by about 15%. It will also ensure daily work for the tappers

during rainy months. This should also reduce the scarcity of tappers by increasing their income.

Year 1992 has been a very good year for the export of rubber products from Sri Lanka. Earnings from rubber products exports in 1992 compared to the previous year has almost doubled.

Total foreign exchange earnings from the export of rubber products mainly rubber apparel and clothing, solid tyres, tubes and footwear has been Rs.2855 million in this year. There was also a sharp growth in the production of rubber apparel and clothings and in the manufacture of tyres, tubes and footwear. The main inducement for the growth of the rubber products industry in Sri Lanka has been the availability of NR at a low price, cheap and intelligent labour, geographical location of the country with faster market access, liberalizing economy and trade etc. However, if the export duty is removed the investors fear that the main attraction viz the low internal price of rubber, may disappear thereby making things difficult for them. It should also be emphasized that so far there has been no a single factory for the manufacture of pharmaceutical rubber appliances which makes use of our latex crepe rubber. Board of Investment (BOI), must take a special interest in this direction mainly to find a market for this grade of rubber which is selling far below the cost of production.

However, the main threat to all industries in South East Asia including Sri Lanka is the imposition of ISO 9000 (OR EN 29000) requirement in EEC countries and in the USA. Very soon, it will be virtually impossible for any manufacturers to supply to the European market with raw material or a finished product, as registration under the ISO 9000 series becomes obligatory after January 1994.

It is therefore essential for Sri Lanka too to start updating factory management and educate people to adopt ISO 9000 requirements before the end of 1993. Under ISO 9000, effective process control or management controls have to be taken at every step of finished products manufacture or raw material manufacture, so that entire 100% of the end products will be of the required high quality. But no quality guarantee is necessary at the final point on 10% or 20% samples drawn from the production lines.

Biology

Three new clones viz RRIC 130, RRIC 131 and RRIC 133 were included in group IV of the clone recommendation for public sector estates. Germplasm studies indicated that Wickham derivatives were superior in vigor. But there were few germplasm clones that performed better than some clones originating from Wickham

collection. This indicated the possibility of using germplasm clones as a new source of genetic material to improve vigor. Analysis of data collected from genotype-environment interaction studies showed that genotype expressed fully and stabilized themselves around 12 to 13 year after planting in the field suggesting that selection for vigor is most effective at this stage.

The budgrafting success in the young budding technique is not influenced by the type of bud patch used and by the growth stage of the top most whorl of the seedling. By using young budding as planting material, 100% field establishment success can be achieved.

Among the different low frequency tapping systems tested, 1/2S d/3 system with stimulation appears to be most promising. Nevertheless, the total dry rubber yield obtained from a plant is more in the conventional 1/2S d/2 system of tapping.

Use of rainguards, in wet regions, is expected to increase yield by about 15 and 26% over areas where recovery tapping is practiced and not practiced, respectively. Further with rainguards tapping will be more systematic with no recovery trapping, and as a result the trees will yield better and incidence of dryness will also be low.

The incidence of *Phytophthora* Leaf Fall and Bark Rot during South West monsoon season of 1992 was the highest recorded for the last decade. The main factors that contributed to this severe out break of *Phytophthora* disease were the unusual prolonged rainfall of S.W. Monsoons and low incidence of *Oidium* Leaf Fall due to dry weather experienced at the beginning of the year. Observations from a screening trial indicated that clones RRIC 130, RRIM 600, RRIC 110, RRIC 133 and RRIC 119 are highly susceptible to Bark Rot while clones such as BPM 24, RRIC 100, RRIC 102, RRIC 121 and RRIC 116 are resistant to this disease. *Hevea* clone PB 235 was found to be extremely susceptible to *Oidium hevea* whereas PB 260 and PR 255 showed resistance to this pathogen.

White Root disease caused by *Rigidoporus lignosus* continued to cause damage both in immature and mature rubber plantations. Black Root disease, a devastating root disease restricted to few estates in Kegalle, Kurunegala and Galle was detected for the first time at Hatherly Estate, Rakwana.

Root-knot nematode, *Meloidogyne incognita* (Kofoid & White ,1919) was detected from the roots of stunted *Hevea* seedlings in three seedling nurseries. This is the first record of nematodes on *Hevea* in Sri Lanka.

In studies in the field with immature *Hevea brasiliensis*, use of dead mulch of paddy straw around the base of the plants reduced the immature, unproductive period of *Hevea* by 12 months in comparison with the conventional practice of growing creeping leguminous covers such as *Pueraria phaseoloides* and *Desmodium ovalifolium* and by 18 months in comparison with allowing naturals (weeds) to grow in high rainfall areas with poor soil characteristics. In addition to early tapping, yield of latex was also higher during the early stages, increases in the region of 33% and

40% were obtained in comparison with creeping legumes and naturals respectively. The present value of the benefit achieved from mulching amounts to Rs. 27267/- per hectare of which Rs.11348/- is the savings on inputs (during early maturity) and the balance Rs.15919/- is due to extra yield.

Under moisture stress, situations increasing the level of potassium application improved the growth performance of young rubber plants. Among the important plant physiological characteristics, measurement of leaf diffusive resistance may serve as a useful parameter in screening clones for planting in areas marginal with regard to rainfall.

Laboratory investigations showed that Eppawela Rock Phosphate (ERP) required more time for its dissolution in soils than imported Rock Phosphate. Moreover, more than 60% of released P was fixed possibly due to high amounts of Fe and Al in rubber soils. Scanning electron microscopic studies showed that ERP dissolved only chemically and not biologically in the soil.

Adaptive Research Programmes started on smallholder fields in the Kalutara, Galle, Kegalle and Ratnapura regions in 1989, 1990 and 1991 were continued. More new programmes were also started in 1992. The objective of this programme is to evaluate and refine or modify if necessary, the technologies developed at the research stations and state owned plantations to fit better smallholder resource and risk situation and to meet their needs. Several programmes on clone evaluation, intercropping, soil moisture and conservation practices, tapping systems, use of yield stimulants and ranguards were in progress.

Intercropping and Multicropping in immature rubber land is becoming very popular and crops such as banana, passion fruit and pineapple are now recommended as intercrops during the immature period with the objective of providing an income in particular to the small holders during the long immature period. Multicropping of rubber lands with tea has now been recommended in commercial scale with a spacing of 12 m by 2.4 m which would provide approximately 70% of the recommended planting density of rubber and 75% of the recommended planting density of tea.

Chemistry and Technology

Depolymerized NR : Technical know how for the manufacture of depolymerized NR was sold to a local company. A dryer is being installed in the factory and commercial production is expected to start once the dryer is commissioned. Meanwhile promotional brochures have been printed and distributed among the likely buyers.

Tyre retreading : The latex based cement developed by the RRI to fix the tread on to the buffed tyre was evaluated in the field. The performance of the cement was very

satisfactory and a retreading company is now keen to acquire this technology. The drying rate of the water based latex cement was improved by the incorporation of special additives.

Precured retreading is catching up in Sri Lanka and several retreaders were assisted to acquire the precured retreading technology.

Latex bitumen emulsion in road construction : A large scale trial on the in situ preparation of latex/bitumen emulsion based on positex, a cationic latex prepared from NR latex, was successfully carried out and this was used to sand seal a 500m road stretch, 4m wide. This resulted in an improvement in the sand adhesion. Experiments are in progress to improve the storage stability of the latex bitumen emulsion.

Irradiating of NR Latex : Trace metal ions such as Cu and Mn play a significant role in controlling the clarity of irradiated latex films prepared from different clonal latex.

Treatment of effluent from rubber factories : RRI now recommends a treatment which involves both anaerobic and aerobic treatment. The treatment plant is basically a three unit system consisting of an anaerobic enclosed digestion, an aerobic treatment system and a sedimentation lagoon. A carrier matrix is used in the anaerobic digestion tank which has made it possible to reduce the size of the tank. The following methods have been developed in the aerobic treatment.

1. Effluent cascading technique.
2. Rotating coir belt contactor system.
3. Fine bubble aeration.

Aerobically treated effluent is finally discharged after sedimentation of the sludge in a lagoon for 1 to 2 days.

Analysis : A titrimetric method has been developed to determine the level of active mercaptan in the water soluble bleaching agent used to bleach the yellow colouring matter in field latex.

Raw rubber process Development and Chemical Engineering department continued to advise estates to improve the quality of their end product while helping to improve processing, minimizing electricity cost by means of power factor correction. The main role of this department was to advise estates to go for effluent treatment to minimize environmental pollution.

Raw Rubber and Chemical Analysis department continued to issue shipment certificates for TSR manufactured in Sri Lanka while providing factories with chemical analysis service for their raw materials.

STAFF

Overseas Visits

Dr A H R Jayaratne, Assistant Plant Pathologist resumed duties on 15th September after completing his post-graduate studies leading to PhD in Soil Microbiology at the University of Sheffield, U.K.

Mr H N K K Chandralal, Experimental Officer resumed duties on 16th November after undergoing a training programme under the Scientist's Exchange Programme at the Japan Atomic Energy Research Institute, Japan.

Mr K A G B Amaratunga, Senior Technical Officer resumed duties on 13th August after undergoing a training programme in Analytical Instrumentation at the International Centre for Analytical Technology, England, U.K.

Dr D P S T G Attanayake, Assistant Geneticist and Plant Breeder resumed duties on 04th December after completing his post-graduate studies leading to PhD in Genetics at the University of Birmingham, U.K.

Dr D M A P Dissanayake, Assistant Soils Chemist resumed duties on 03rd August after completing his post-graduate studies leading to PhD in soils chemistry at the University of Aberdeen, U.K.

Mr H Talgaswatte, Assistant Agricultural Economist, resumed duties on 25th August after post-graduate studies. He is scheduled to leave the country again on 30.03.1993 to continue his post-graduate studies for a period of nine (09) month up to 31.12.1993.

Mr M T Warnakula, Assistant Bio-chemist left for Australia on 17th February to continue his post-graduate studies leading to the PhD.

Mr L Karunanayake, Assistant Specifications Officer left for United Kingdom on 24th September for a period of eighteen (18) months to read for his MPhil degree at the University of North London, U.K.

Mr S M C E Silva, Assistant Rubber Chemist left for United Kingdom on 24th September for a Period of eighteen (18) months to read for his MPhil degree at the University of North London, U.K.

Mr K E Jayasooriya, Assistant Plant Pathologist left for United Kingdom for period of eighteen (18) months to read for his MPhil degree at the University of Edinburgh, U.K.

Miss M S Ranasinghe, Assistant Botanist left for Australia on 29th October to continue her post-graduate studies leading to the PhD.

Mr D P Weeraratne, Assistant Rubber Chemist continued his post-graduate studies at the University of Loughborough, U.K.

Mr C K Jayasinghe, Head of Plant Pathology and Microbiology Department visited India to attend the International Natural Rubber Conference during the period 05th to 08th February.

Dr N E M Jayasekera, Head of Genetics and Plant Breeding Department visited Thailand to attend a meeting on the Multilateral Clone Exchange Programme during the period 13th to 17th January. He also visited Malaysia, Indonesia and India during the period 22nd June to 04th July to participate in the ANRPC Plant Breeders' Field Mission and the 2nd Meeting of ANRPC Plant Breeders'.

Dr (Miss) N M V Kalyani, Head of Rubber Technology and Development Department visited Malaysia to attend a Workshop on Truck Tyre Retreading during the period 11th to 17th February. She also visited Germany to undergo a training on the use of Brabender Plasticorder during the period 20th to 26th June.

Dr R C W M R A Nugawela, Head of Plant Science Department visited India to attend a International Natural Rubber Conference during the period 05th to 08th February.

Dr (Mrs) Pushpa Gunatilleke, Rubber Chemist was in Singapore to undergo a training on the use of Shimadzu F.T.I.R. Spectrophotometer at the Shimadzu Application Laboratory, during the period 06th to 10th January.

Dr W M G Seneviratne, Acting Head of Raw Rubber Development and Chemical Engineering Department visited India to attend the International Natural Rubber Conference during the period 05th to 08th February. He also visited Malaysia to undergo a training programme on Effluent Treatment and Disposal Techniques Practiced by Malaysian Rubber Factories in Malaysia during the period 15th August to 05th September.

Dr (Mrs) M L A Samarappuli, Head of Soils & Plant Nutrition Department visited India to attend the International Natural Rubber Conference during the period 05th to 08th February. She also visited Malaysia to attend the International Conference on "Fertilizer usage in the Tropics" during the period 24th August to 01st September.

Dr L M K Tillekeratne, Director visited Burma for an assignment on no pay leave for a period of three (03) months commencing 24th May. He also attended the Annual Meeting of the International Rubber Research and Development Board held in Jakarta, Indonesia during the period 25th to 30th October.

Dr N Yogaratnam, Deputy Director (Research) (II) visited U.K. on a study programme and was attached to the Scottish Agricultural College, Aberdeen, U.K. for a period of four (04) weeks commencing 28th September. He also visited a few other research organizations in U.K. covering a further period of two (02) weeks from 26th October.

Local Training

Mr R S Dharmakeerthi, Assistant Soils Chemist is following a training course leading to the award of the MSc at the post-graduate Institute of Agriculture, Peradeniya for a period of one (01) year commencing 05th October.

Mrs S Amaratunga, Assistant Agricultural Economist is following a training course leading to the award of the MA at the University of Colombo for a period of one (01) year commencing 08th January.

VISITORS

Visitors to the Institute included:

Mr Abdul Majid, ANRPC, Kuala Lumpur
Mr J Bloak, FAO, Rome
Prof John A Milburn, University of New England, Australia
Mr Huns Bruins, BKH, Holland
Mr Charles A Fewsons, University of Gladgood, Scotland
Mr Phillip Chank, University of Melbourne, Australia
Mr Wolf Fanz Joset, BAD SODEN, SALM, Germany
Mr Chikara Kulirihara, CITI, Japan
Mr Takuhika Ohita, CITI, Japan
Mr Clave Stirling, University of Essex, U.K.
Mr Stina Voluer, Breda, Holland
Dr M J Lawrence, University of Birmingham, U.K.
Mr I M While, CAB International, U.K.
Mr J D Shtridge, CAB International, U.K.
Mr Ho Thiern Hua, Malaysia

GENETICS AND PLANT BREEDING

N E M Jayasekera

SUMMARY

Two new clones, RRIC 131 and RRIC 132 were included in group IV of the clone recommendation for public sector estates. Germplasm studies indicated that Wickham derivatives were superior in vigour. But there were few germplasm clones that performed better than some clones originating from Wickham collection. This indicated the possibility of using germplasm clones as a new source of genetic material to improve vigour. Analysis of data collected from genotype-environment interaction studies showed that genotypes expressed fully and stabilized themselves around 12 to 13 year after planting in the field suggesting that selection for vigour is most effective at this stage.

DETAILED REVIEW

Staff

Dr N E M Jayasekera, Head of the Department, Mr K B Karunasekera, Assistant Development Officer, Mr K W Rupatunge, Experimental Officer, Mr B M S G Peries, Senior Experimental Assistant, Mr A K M S Senarathna, Experimental Assistant, Messrs I D M J Sarath Kumara, R A S K Ranatunge and Miss Sunethra Nilmini, Technical Officers were on duty throughout the year.

Dr (Mrs) S C Dharmarathna, Geneticist and Plant Breeder vacated the post on 15th June 1992.

Dr D P S T G Attanayake returned to the island in December 1992 after completing his postgraduate studies at the school of Biological Sciences of the University of Birmingham, U K.

Meetings, Seminars, Workshops and Field Missions

Head of the Department attended the following seminars, meetings and field missions.

1. First meeting of Plant Breeders of the Association of Natural Rubber Producing Countries (ANRPC) held in Hat Yai, Thailand from 16th to 17th of January 1992.
2. Biotechnology meetings held at the Agrarian Research and Training Centre, Colombo.
3. ANRPC Plant Breeders' field mission to Malaysia, Indonesia, Sri Lanka and India and the 2nd Plant Breeders' meeting in India at the end of the field mission.
4. Seminar on Biotechnology for plant improvement, held at the British Council, Colombo.
5. Workshop on review of plant quarantine policies and regulations, held at BMICH, Colombo.
6. Seminar on Biological aspects of rubber cultivation, for managers of new plantation management companies, held at the training centre at Nivitigalakele sub-station.

Training

NDT students were trained.

Miss W N P Katuwawala, trainee typist, completed her six month training.

Visitors

Dr M J Lawrence, Senior Lecturer in Genetics, School of Biological Sciences of the University of Birmingham visited the Department.

Publications

Attanayake, D P S T G (1992) Molecular cloning, characterization and manipulation of the Rubber Elongation Factor gene from *Hevea brasiliensis*. PhD thesis submitted to the University of Birmingham, U.K.

Jayasekera, N E M, Karunasekera, K B and Ranatunge, R A S K (1992) Assessment of juvenile vigour of some IRRDB germplasm clones in Sri Lanka. Paper read at the IRRDB Plant Breeders' meeting held in Jakarta, Indonesia.

Reports

Jayasekera, N E M (1991) Annual Review of the Genetics and Plant Breeding Department.

GENERAL

New Clones

In accordance with goals and targets of 5 year corporate plan, two new clones, RRIC 131 and RRIC 133 were included in Group IV of the clone recommendation for public sector estates. Both clones are very vigorous and high yielding. RRIC 133 has a straight and smooth trunk which could be used as timber.

LABORATORY INVESTIGATIONS

Isozyme studies for clone identification GPB/ISO/91/2.

Earlier studies indicated that band resolutions in both esterases and acid phosphatase were insufficient to interpret the variation. Further investigations using discontinuous polyacrylamide gel electrophoresis were not possible as Dr (Mrs) S C Dharmaratna who was in charge of this project vacated her post.

FIELD EXPERIMENTS

Artificial crossing of proven foreign clones with proven local clones (GPB/BST/HPS/91/1).

The main objective was to produce new breeding populations for future selection by crossing proven local clones with proven foreign clones developed in other Asian rubber growing countries. During 1992 flowering season five foreign clones *viz* RRIM 712, PB 255, PR 255, PR 309 and BPM 24 were crossed with three local clones, RRIC 100, RRIC 121 and RRIC 102.

Foreign clones were used as male parents for which induction of flowers on

plants in multiplication nurseries was done by ring barking and bending of the stem.

Due to extreme dry weather conditions between January and April, a heavy drop of unopened female flowers was observed. Crosses made, number of pollinations per cross, number of seedling plants derived per cross are given in Table 1 (S C Dharmarathna, K P Sunethra Nilmini and K W Rupatunge).

Table 1. *Cross made, number of pollinations and plants derived per each cross.*

Cross	No. of pollinations	No. of plants
RRIC 100 x RRIM 712	1136	72
RRIC 100 x PB 255	1124	85
RRIC 100 x PR 255	504	94
RRIC 121 x PB 255	1235	57
RRIC 102 x PB 255	914	40
BPM 24 x RRIM 712	528	06
RRIC 100 x PR 309	504	36
RRIC 121 x PR 255	53	17
RRIC 102 x PR 309	672	02
RRIC 121 x PR 309	314	09
Total	6984	418

Breeding and Selection of New Clones (GPB/BST).

Evaluation of selection from 1974, 1975 and 1978 hand pollinated seedlings.

In the small scale trial on Moraliyoa estate (GPB/BST/HPS/74/1) some of the clones selected from 1974 Hand Pollinated (H.P.) seedlings are tested.

A girth measurement was recorded during 1992 and statistically analyzed. Significant differences existed between the clones. RRIC 121 recorded the highest girth of 91.15 cm while 74-166 with a mean girth of 82.50 cm was the second best clone. RRIM 600 and RRIC 100 (the other two control clones) occupied the 14th and 23rd positions respectively in the ranking of mean girth values.

Only 3 test tappings were possible in this trial due mainly to rain interference and therefore valid statistical analysis was not possible (N E M Jayasekera and R A S K Ranatunga).

In the small scale trial at Kuruwita sub-station (GPB/BST/HPS/74/3) 13 selections from 1974 H.P. seedling population are tested along with three control clones, RRIC 100, RRIC 121 and RRIM 600.

A girth measurement was recorded in 1992. Analysis of girth data indicated significant differences between clones. Duncan Multiple Test (DMT) revealed that the 16 clones could be arranged into 4 groups with overlapping between some groups. The two groups A and B had five clones. RRIC 121 recorded the highest mean girth of 75.02 cm followed by the H.P. selection 74-41. Clones included in group A and B and their means are given in Table 2. There was no overlapping between group B and the next group, C.

Table 2. *The two best groups according to DMT*

Grouping	Mean girth (cm)	Clone
A	75.02	RRIC 121
A	74.85	74-41
B A	70.83	74-135
B	69.67	74-12
B	67.98	74-198

LSD for 5% level 4.755

Yield data (13 test tappings) for 1992 were statistically analyzed. Highly significant differences existed between clones. DMT revealed that the highest yielding clone in this trial, RRIC 121, was the solitary clone in group A. Group B had 3 clones (Table 3) all of which were new selections. Interesting feature of the DMT to note is that RRIC 100 occupied the Group E which overlapped with other lower groups such as F, G and H. According to mean yields RRIC 100 was ranked 11th. First 4 groups (ABCDE) of DMT, the clones included in them and mean yields are given in Table 3.

Promising selections, 74-41, 74-135, 74-12 and 74-193 have been selected for large scale testing and are now in the multiplication stage (N E M Jayasekera and B M S G Peries).

Small scale trial on Yatadola estate (GPB/BST/HPS/74/2) is aimed at evaluating a part of the selection made from 1974 H.P. seedlings.

An annual girth measurement was recorded and statistically analyzed.

RRIC 121 which is one of the control clone, had the highest mean girth (73.559 cm) followed by 75-166. Mean girth values of 10 top ranking clones are given in Table 4.

Table 3. *The first 4 groupings of DMT and their clones and mean yields.*

Duncan Grouping	Mean yield (g/t)	Clone
A	86.69	RRIC 121
B	74.18	74-41
B	72.48	74-135
C B	63.67	74-12
C D	59.63	74-193
E D	50.69	74-180
E F	47.08	74-139
E F	44.26	RRIM 600
E F G	43.04	74-205
E F G H	38.49	74-162
E F G H	38.06	RRIC 100

LSD for 5% level 11.41

Yield data (7 test tappings) too was statistically analyzed. Analysis indicated highly significant differences between selections (clones). One of the control clones, RRIC 121 had the highest mean yield.

According to DMT, the group (A) with highest means had 5 clones including the two control clones RRIC 121 and RRIM 600. The five clones in this group (A) and their means are given in Table 5 (N E M Jayasekera and K W Rupertunge).

Table 4. *Mean girth values of ten top ranking clones.*

Clone	Mean girth (cm)
RRIC 121 (control)	73.55
75-166	68.72
75-181	68.33
75-202	68.00
75-175	65.13
75-173	64.46
75-200	64.00
75-218	63.97
75-207	62.72
RRIM 600 (control)	62.70

LSD for 5% level 8.74

Table 5. *Clones and their means in Group A which had highest mean according DMT grouping.*

Group	Mean yield (g/t)	Clone
A	40.11	RRIC 121
A	36.30	74-207
A	33.47	74-173
A	33.33	74-212
A	32.16	RRIM 600

LSD for 5% level 7.84

The small scale trial established on Clyde estate (GPB/BST/HPS/75/1) was designed to evaluate 25 new selections from 1975 H.P. seedlings. The highest vigour in terms of girth was exhibited by 75-143 with a mean of 81.66 cm. RRIC 121, the best out of the 3 control clones registered a mean girth of 70.53 cm. With respect to yield, RRIC 121 was the highest yielding clone in this trial.

Mean yield of the promising new selections are presented in Table 6 along with mean girth (N E M Jayasekera, I D M J Sarath Kumara and K B Karunasekera).

Table 6. *Mean girth and mean yield of promising new selections and the best control clone.*

Clone	Mean girth (cm)	Mean yield (g/t)
75-143	81.66	47.17
75-33	67.93	40.61
75-118	66.96	35.90
RRIC 121 (best control clone)	70.53	51.28

LSD 5% level for girth 5.94

LSD 5% level for yield 10.79

Three new selections 75-143, 75-33 and 75-118 which show very promising yield potential as well as high vigour are being multiplied in multiplication nurseries for large scale testing.

On Sorana estate (GPB/BST/HPS/75/2) 19 selections from 1975 H.P. seedlings population are tested in a small scale trial.

DMT indicated that there is no significant difference between the two highest yielding clones, RRIC 121 (a control clone) and 75-4 (a new selection). In the DMT grouping these two clones were grouped together in one group (A) without overlapping with the next group (Table 7).

With respect to girth RRIC 121 had the highest value (72.80 cm). High yielding new selection 75-4 ranked 5th with an average girth of 67.85 cm (N E M Jayasekera, K B Karunasekera and K W Rupertunga).

Table 7. DMT grouping of four best yielders in small scale trial on Sorana estate.

DMT Grouping	Mean Yield (g/t)	Clone
A	52.45	RRIC 121
A	47.96	75-4
B	35.41	RRIC 130
B	35.40	RRIC 100

LSD for 5% level 8.05

Few selections from each of 1974, 1975 and 1978 H.P. seedlings are evaluated on Paiyagala estate (GPB/BST/HPS/74,75,78/1). This is also a small scale trial and 16 new selections are planted along with 3 control clones, RRIC 121, RRIC 100 and RRIC 102. Highest mean girth was recorded by RRIC 121. Ten top ranking clones are given in Table 8.

Table 8. Mean girth values of 10 top ranking clones.

Clone	Mean girth (cm)
RRIC 121	56.23
78-33	55.25
75-55	55.25
75-268	55.20
RRIC 102	54.96
75-85	53.43
74-181	53.32
75-103	52.30
79-92	52.06
75-101	51.46

LSD for 5% level 4.99

Only 3 test tappings were possible in this trial. Therefore data were not subjected to a statistical analysis.

Evaluation of 1979 H.P. seedlings. (GPB/BST/HPS/79/2)

Nine H.P. seedlings families are evaluated in this trial. Analysis of variance indicated significant differences between families for both traits, girth and yield, under study. Mean girth and yield of nine families are given in Table 9 (N E M Jayasekera and K W Rupatunge)

Table 9. *Mean girth (cm) and yield (g/t/t) of 1979 H.P. seedling families.*

Family	Mean girth (cm)	Mean yield (g/t/t)
RRIC 103 x RRIM 623	71.80	40.67
RRIC 100 x RRIM 600	68.00	34.94
RRIC 103 x RRIC 101	66.00	37.70
RRIC 100 x RRIC 101	62.75	23.58
RRIC 101 x RRIC 600	58.65	25.38
RRIC 102 x RRIM 600	57.02	25.28
RRIC 103 x RRIM 600	56.00	23.46
RRIC 101 x RRIM 623	56.00	33.25
RRIC 102 x RRIM 623	52.60	19.40

LSD 5% level for girth 13.63

LSD 5% level for yield 18.18

Evaluation of 1981 H.P. seedlings. (GPB/BST/HPS/81/2)

Girth and yield data were analyzed. Their mean girth and yield are given in Table 10.

Table 10. Mean girth and yield of 1981 H.P. families.

Family	Mean girth (cm)	Mean yield (g/t)
RRIC 52 x IAN 45/710	77.00	39.38
RRIC 52 x PB 28/59	76.02	41.26
RRIC 102 x IAN 45/710	72.00	77.57
RRIC 102 x PB 28/59	67.12	45.44
PB 28/59 x IAN 45/710	65.91	42.31
PB 28/59 x RRIC 52	65.22	33.56
PB 28/59 x RRIC 121	62.40	41.90
PB 28/59 x RRIC 102	61.13	37.57

LSD 5% level for girth 15.13

LSD 5% level for yield 36.71

Under the breeding and selection project seven promising clones have been selected from 1974 and 1975 hand pollinated seedlings for large scale testing. Promising clones from 1979 and 1981 hand pollinated seedlings too will be selected for large scale planting.

Evaluation of germplasm clones (GPB/GP/85/2 at Kuruwita sub-station).

Five girth measurements recorded from 1988 to 1992, inclusive of both years, were used to work out the growth rates by regressing individual tree girth on to years taking years 1, 2, 3, 4 and 5 as independent variable.

Analysis of variance performed on growth rates of individual trees indicated highly significant differences between clones.

Significant differences between classes, when clones were classified according to their origin, indicated differences in growth rates of clones of different origins.

Duncan Multiple Range test carried out resulted in 17 groups with considerable overlapping. This made it extremely difficult to group them according to their vigour.

In group A, with a highest mean girth of 8.52 cm, all 3 clones with Wickham origin were included.

There were germplasm clones that had higher growth rates than some of the Wickham derivatives such as RRIC 102 and RRIC 600. RRIC 121 had the highest

mean (9.940 cm) followed by a germplasm clone MT-C-1-1 with a mean girth of 9.450 cm. This indicated that germplasm clones could be a good resource material to incorporate new genetic variability with respect to vigour (N E M Jayasekera, R A S K Ranatunge and K B Karunasekera).

Genotype - environment interaction studies (GPB/GE/75/1).

Field operations, collection of girth and yield data were, terminated during 1992. As envisaged in the 5 year corporate plan analysis of data is in progress.

Initial analysis of girth data indicated a fairly high environmental component soon after planting which decreased gradually and stabilized around 10.53 to 12.13% in the 12th to 13th year after planting (Table 11). In contrast to environmental effect genetic effect was lowest (13.68%) soon after planting but gradually increased up to 78.63% in the 12th year (Table 11).

This indicates that with respect to girth, the genotypes fully express themselves around 12th and 13th year and during early years of establishment they are influenced by environment. Results suggest that any selection for vigour should be delayed until the full expression of the genotypes. Genotype-environment interaction component (GxE) varied from 6.79 to 19.32 percent during this period (N E M Jayasekera, K B Karunasekera, K W Rупatunge and I D M J Sarath Kumara).

Testing of proven foreign clones received under SRRP II (GPB/FC/91/2).

Trials established under this project are progressing well.

Vacancies of the trial areas were filled during S.W. and N.E. monsoon seasons.

During *Oidium* season of 1992, clones in these trials were assessed for *Oidium* tolerance. In this evaluation 20 plants per site were observed and a score was given considering the number of *Oidium* lesions on the leaf, spread of the lesion and other characters. Mean score for each clone in each site is given separately in Table 12.

It was also observed that at Eladuwa PR 261 defoliated due to *Phytophthora* leaf disease. New flush of this clone was attacked by slugs. Collection of girth data was not possible as plants were still small for such a measurement (N E M Jayasekera, K W Rупatunge and B M S G Peries).

Table 11. *Genetic, Environment and Genotype-Environment interaction components expressed as a percentage of total variation.*

Year Pre Tapping	Genetic	Component	
		Environment	G x E
1976	13.68	66.98	19.32
1977	14.24	68.56	17.19
1978	16.52	66.41	17.06
1979	19.83	69.06	11.09
1980	31.08	57.71	11.20
1981	40.80	48.50	10.69
Post Tapping			
1982	41.22	49.98	8.78
1983	40.00	52.88	6.79
1984	47.25	42.13	10.61
1985	56.35	33.27	5.03
1986	64.74	25.63	9.63
1987	64.78	24.42	10.78
1988	75.70	13.10	11.10
1989	78.63	10.53	10.82
1990	75.00	8.60	12.52

Table 12. Mean Oidium score for each clone in each site during 1992 Oidium season.
The number in the brackets indicates the ranking within the site.

Clone	Site:	Salawa Estate	Eladuwa Estate	Kuruwita S.S.	Bentota Estate	Bibile Estate
	District:	K.V.	Kalutara	Ratnapura	Galle	Bibile
PB 235		16.75(1)	37.43(2)	4.44(1)	8.83(1)	13.88(1)
PB 217		15.07(2)	41.21(1)	-	-	-
RRIC 100		13.19(3)	34.88(5)	-	-	-
PR 261		11.55(4)	23.94(6)	3.03(3)	5.01(5)	1.66(5)
RRIM 712		8.59(5)	35.28(4)	3.50(2)	5.03(4)	1.60(7)
PR 255		5.43(6)	23.47(7)	0.41(7)	0.86(7)	4.36(2)
RRIC 110		5.16(7)	17.50(10)	-	-	-
RRIC 121		4.63(8)	35.51(3)	0.50(6)	7.38(2)	2.79(3)
BPM 24		3.65(9)	23.72(9)	2.69(4)	5.98(3)	1.88(4)
PB 260		3.27(10)	17.86(8)	0.80(5)	3.63(6)	1.64(6)

PLANT SCIENCE

A Nugawela

SUMMARY

The budgrafting success in the young budding technique is not influenced by the type of bud patch used and by the growth stage of the top most whorl of the seedling. It appears that budgrafting success may vary with the clone. In young buddings, leaving a long snag, improves the growth of the scion significantly. By using young budding as planting material, 100% field establishment success can be achieved. Further, a young budding and a two-whorled brown budding, reaches a comparable growth stage, about a year after establishment in the field.

Among the different low frequency tapping systems tested, 1/2S d/3 system with stimulation appears to be the most promising. Nevertheless, the total dry rubber yield obtained from a plant is more in the conventional 1/2S d/2 system of tapping. An economic analysis is being done considering the other beneficial aspects of low frequency tapping.

Opening of trees at lower girths results in significantly low yields. It appears that after one year of tapping, the girthing of trees opened at 18" is not significantly affected.

Use of rainguards, in wet regions, will increase yield by about 15 and 26% over areas where recovery tapping is practiced and not practiced, respectively. Further, with rainguards tapping will be more systematic i.e. no recovery tapping, and as a result the trees will yield better and incidence of dryness will be low.

Budwood nurseries in the plantation sector estates in Galle, Kalutara, Kegalle and Avissawella regions were inspected. More than 5000 budded stumps from 17 clones were issued to the plantation sector for establishing budwood nurseries.

DETAILED REVIEW

Staff

The Head of Department, Dr A Nugawela, Dr (Mrs) P Seneviratne, Mr V H L Rodrigo, Mr L S S Pathiratna, Assistant Botanists, Mr R B Gunaratna, Mr L S Kariyawasam, Experimental Officers, Mr R P Karunasena, Senior Technical Officer, Mr S Wilbert, Senior Experimental Assistant, Mrs C W Ranasinghe, Mrs G A S Wijesekera, Mr U S Weerakoon, Mr M K P Perera, Mr S M A Samarakoon, Mr T U K Silva, Miss G G M de Zoysa and Mr M de Alwis, Technical Officers, Mrs D E Jayawardena, Clerk/Typist were on duty throughout the year. Mrs R K Samarasekera, Technical Officer was on maternity leave from 2nd January 1992 to 8th June 1992.

Miss M S Ranasinghe left on the 01.11.1992 to University of New England, Australia to continue her postgraduate studies.

Mr K A G B Amaratunge, Senior Technical Officer, reported for work on the 13th August 1992 after completion of his training on instrumentation in the UK.

Dr (Mrs) P Seneviratne and Mr V H L Rodrigo were promoted to the post of Botanist with effect from 1st March and 24th September 1992 respectively.

Research Students

Mr P B Kodikara, undergraduate student from Ruhuna University completed his final year project on the "Effect of planting density on growth, yield and some related factors of *Hevea brasiliensis* (Muell Arg.) genotype RRIC 101" under the supervision of Mr L S S Pathiratna and Dr A Nugawela.

Mr K L Weeralal, undergraduate student from Ruhuna University completed his final year project on the "Effect of planting density on growth, yield and some related factors of *Hevea brasiliensis* (Muell. Arg.) genotype PB 86" under the supervision of Mr V H L Rodrigo and Dr A Nugawela.

Miss S P Withanage, undergraduate student from Ruhuna University completed her final year project on "Anther culture and Establishment of field grown shoot materials of *Hevea brasiliensis* under the supervision of Dr (Mrs) P Seneviratne.

Mr G V S Jayaratne, undergraduate student from Peradeniya University completed his final year project on "The effect of maturity of budwood on the early growth of *Hevea brasiliensis* budded stumps" under the supervision of Dr A Nugawela.

Visits

Department staff made advisory visits to State Plantations and Smallholdings. Further, regular visits were made to the experimental sites.

Meetings and Conferences

The Head of Department addressed at the following meetings/conferences on subjects indicated.

1. Field day for planting executives in the Ratnapura region – Exploitation.
2. Seminar on Biological aspects of rubber plantations for the new management companies – An analysis on yield decline in rubber plantations.
3. Planting executives of the RPK Plantations Ltd., – Planting to achieve high establishment rates and even stands.
4. Planters Association meeting at Tebuwana, Kalutara – Use of rainguards.

Training Programmes

The Department staff were involved with the following programmes:

1. Training of new Rubber Extension Officers.
2. Field day for Asst. Superintendents, Kegalle Region.
3. Nursery management for private commercial nursery owners.

Publications

Nugawela, A, Karunasena, R P and Wilbert, S (1992). The genotypic differences and the influence of environmental factors and management practices on the development of Tapping Panel Dryness. Proc. Intl. Rubb. Conf. Bangalore, India.

Nugawela, A, Balasubramaniam, S, Samarasekera, R K (1992). Diurnal variation in CO₂ assimilation rates and related parameters of *Artocarpus heterophylla* and *Mangifera indica*. Proc. of the Sri Lanka Asso. Adv. of Science, Colombo.

Reports

Nugawela, A (1991). Annual Review of the Plant Science Department.

LABORATORY INVESTIGATIONS

Tissue Culture

1. Somatic Embryogenesis

Anther Culture

Good callus growth was observed in all clones tested. Attempts to make the calli differentiate to give rise to embryoids were not successful.

Nucellar Tissues

Good callus growth was observed. Nevertheless, calli failed to differentiate.

2. Shoot Tip/ Nodal Culture

Seedling/Juvenile material

Micropropagation of juvenile origin *Hevea* was continued throughout the year. Shoot proliferation continued to show satisfactory results. Genetic differences of the seeds seems to affect the proliferation rate.

Experiments on substituting analar grade sucrose with ordinary sugar showed promising results.

The acclimatized plants growing in polybags are performing well and soon will be established in the field.

Clonal/Mature material

Only successful culture establishment was possible in the micropropagation of mature *Hevea*. Successive grafting on seedlings to rejuvenate mature material is continued. Three passages have been completed in the series of "successive grafting" of clonal *Hevea* and the material will be tested for juvenile characters after 2 more successive graftings. Further, a few mature trees were cut at the base to harvest stump sprouts in order to test for juvenile characteristics.

3. Embryo Culture

The embryos of immature seeds of hand pollination programmes were grown *in vitro* when they were about 3 months old. Embryos younger than this did not germinate on the media tested (P Seneviratne, G A S Wijesekara and G G M Zoysa).

Gas Exchange Studies

1. Early Selection of New Genotypes

The physiological yield determinants, i.e. light interception, conversion efficiency of the intercepted light and rate of loss of dry matter produced were estimated in 30 seedlings derived from the 1990 hand pollination programme of the Plant Breeding Department.

The seedlings were then ranked based on a selection index for potential yield at maturity, calculated using the estimated dry matter yield determinants (A Nugawela, R K Samarasekera and R P Karunasena).

2. The effect of maturity of the scion on the early growth of bare root budded stumps.

Stock seedlings of uniform size were grafted with clone RRIC 100. Bud patches for grafting were obtained from green budwood, brown budwood and brown budwood obtained from mature field plants.

At the maturity of the first leaf, the growth rates of bare root budded stumps were similar. The dry matter yield determinants, i.e. CO₂ assimilation rates, dark respiration rates and leaf area were also not significantly different in the different treatments (A Nugawela, G V S Jayaratne and R K Samarasekera).

FIELD EXPERIMENTS

Tapping

Interaction of clones and tapping systems (CT/77/3)

Five tapping systems are being tested on 13 genotypes to ascertain the most economic tapping system for clones tested.

The tapping systems 1/2S d/3 and 2x1/2S d/3 (↓↓) gave significantly high yields per tree per tapping (g/t). Nevertheless, the estimated total annual yield per tree per annum (kg/t/year) is high in 1/4S d/2 + E and 1/2S d/2 systems (Table 1).

Unfortunately, this trial had to be abandoned at the beginning of the second half of the year as the estate management did not provide the labour to conduct the trial. Girth measurements were not possible due to this reason (A Nugawela, L S S Pathiratna and C W Ranasinghe).

Table 1. *The mean yield per tree per tapping (g/t/t) and estimated total annual yield per tree per tapping (kg/t/year) of the different tapping systems.*

Tapping System	Yield	
	g/t/t	kg/t/year
1/2 S d/3	34.94 A	4.19
2 x 1/2 S d/3 (↓↓)	33.44 A	4.01
1/4 S d/2 + E*	30.19 B	5.43
1/2 S d/2	29.96 B	5.39
PT** d/2	17.97 C	3.24

(Means with the same letter are not significantly different).

E* 5% ET, Ba 0.8 (2.5) 4/y , PT** 5% ET, Ga 0.8% (2.5) m

Low frequency tapping systems and clones - Eladuwa (F/76/5)

Three tapping systems are being tested on three different genotypes, i.e. RRIC 100, RRIC 101 and PB 86. Low frequency tapping with stimulation continues to give significantly high yields per tree per tapping (g/t/t) in each clone tested (Table 2).

Table 2. *The mean yield (g/t/t) and estimated yield per tree per annum (kg/t/year) obtained from different tapping systems.*

Tapping System	Yield	
	g/t/t	Kg/t/year
1/2 S d/4 + E*	41.14 A	3.70
1/2 S d/3	28.86 B	3.46
1/2 S d/2	24.48 C	4.41

(Means with same letter are not significantly different)

E* 5% ET, Ba 0.8(2.5) 4/y

The estimated yield per tree per annum (kg/t/year) is high in the 1/2 S d/2 system (Table 2). The girthing of the plants are not significantly different though the tapping systems are different (A Nugawela, S Wilbert and T U K Silva).

Low Frequency Tapping

The objective of these trials is to find out whether it is more economical to exploit newly introduced clones with low frequency tapping with stimulation than the presently recommended 1/2S d/2 system. Low frequency tapping systems can have the advantages of low tapping costs and longer tapping cycles.

RRIC 100, 1981 Replanting - Gallewatta (LFT/88/1)

The conventional 1/2S d/2 tapping system and other low frequency tapping systems with stimulation have given similar dry rubber yields per tree per tapping (g/t/t). 1/4S d/2 system with stimulation continues to give the lowest yields (Table 3). The estimated total annual yield per tree (kg/t/year) based on the theoretical maximum possible days of tapping per year is high in the conventional 1/2S d/2 system. Both the girth and girth increment are significantly low in trees tapped on 1/2S d/2 system which gives the highest total dry rubber yield per annum (Table 3).

Table 3. *Dry rubber yields and growth measurements of RRIC 100 trees tapped on different tapping systems.*

Tapping system	Yield		Growth	
	g/t/t	kg/t/year	Girth (cm)	Girth increment (cm)
1/2S d/2	31.77 A	5.72	69.1 B	3.3 AB
1/2S d/3 + E*	32.14 A	3.86	71.2 AB	4.4 A
1/2S d/4 + E*	29.17 A	2.63	71.1 AB	3.2 B
1/4S d/2 + E*	20.13 B	3.62	74.2 A	4.5 A

(Means with same letter are not significantly different)

E* 2.5%ET, Ba 0.8(2.5) 4/y.

RRIC 121, 1985 Replanting - Kiriwanaketiya (LFT/91/1)

1/2S d/3 system with stimulation gives a significantly high dry rubber yield, per tree per tapping (g/t/t), than other systems tested. Anyhow, the estimated total annual yield, based on the theoretical maximum possible days of tapping per year, is highest in the conventional 1/2S d/2 system (Table 4).

The girth increment during the year 1992 is lowest in the trees tapped on 1/2S d/3 + E system, the treatment which gives the highest dry rubber yield per tree per tapping (Table 4).

Table 4. *The dry rubber yields and girth increments of clone RRIC 121 tapped on different tapping systems.*

Tapping system	Yield		Girth Increment (cm)
	g/t/t	kg/t/year	
1/2S d/2	29.56 B	5.32	5.73 A
1/2S d/3	28.95 B	3.47	5.65 A
1/2S d/3 + E*	35.79 A	4.30	4.88 B
1/2S d/4 + E*	29.59 B	2.66	5.25 A

(Means with same letter are not significantly different)

E* 2.5% ET Ba 0.8(2.5) 4/y

(A Nugawela, S Wilbert and T U K Silva).

Girth at Opening

The objective of this study is to find out the possibility of reducing the immature period by commencing tapping at lower girths than the presently recommended 50 cm or above.

1. RRIC 100, 1985 Replanting, Dalkeith (TG/91/1)
2. RRIC 100, 1985 Replanting, Kiriwanaketiya (TG/91/3)
3. RRIC 100, 1985 Replanting, Eladuwa (TG/91/4)

In each of the above clearings, a tapping block was selected. Trees belonging to the following girth classes were identified in each tapping block and were tapped. Tapping is done at 67% intensity and a test tapping was carried out each month of the year.

- T₁ 40-44.9 cm
- T₂ 45-49.9 cm
- T₃ 50-54.9 cm
- T₄ 55 cm and above

4. RRIC 121, 1984 Replanting, Perth (TG/91/2)

Three adjacent tapping blocks were selected from the above clearing and a trial similar to above was conducted. Tapping was done at 67% intensity and a test tapping was carried out each month of the year.

The mean dry rubber yield per tree per tapping (g/t/t) and the girth increment for different treatments in both clones are summarized in Table 5.

Table 5. *Mean dry rubber yield per tree per tapping (g/t/t) and the mean girth increment (cm) of RRIC 100 and RRIC 121 trees opened at different girths.*

Girth Class (cm)	Yield (g/t/t)		Girth Increment (cm)	
	RRIC 100	RRIC 121	RRIC 100	RRIC 121
40-44.9	15.4 C	16.1 C	4.9 A	4.0 C
45-49.9	18.9 C	21.6 B	4.4 A	5.1 B
50-54.9	23.9 B	25.3 B	4.2 A	5.4 B
55 and above	31.6 A	32.2 A	4.6 A	6.9 A

(means with same letter are not significantly different)

In genotype RRIC 100, trees opened at 45-49.9 cm give significantly lower yields than trees opened at 50-54.9 cm. In genotype RRIC 121, though the difference is not significant, it is considerable, i.e. 4 g/t/t.

There is no significant difference in the girth increment when opened at 45-49.9 cm or 50-54.9 cm in both clones.

Height of Opening (TH)

The objective of these trials were to study the possibility of increasing the height of opening with the use of Jebong knife. This will give more time for bark renewal.

RRIC 100, 1985 Replanting - Dalkeith (TH/91/1)

RRIC 100, 1985 Replanting - Kiriwanaketiya (TH/91/2)

Three adjacent tapping blocks tapped by the same tapper, were selected from each of the above clearings. In each tapping block, the treatments mentioned in Table 6 were introduced randomly. Tapping was done at 67% intensity. Information on yield, bark consumption rate and girthing are summarized in Table 6.

In both trials the rate of bark consumption is significantly high when tapped using the Jebong knife. It is ca.20% more than the bark consumption from Push knife. In trial TH/91/2 it appears that intakes are high when Jebong knife is used. However, there is no evidence for this from the other trial and when data of both trials are pooled. (A Nugawela, S Wilbert and T U K Silva)

Table 6. *Mean yields (Y,g/t/t), rate of bark consumption (BCR, cm/y) and girth increments (GI,cm/y) on trees opened at 60" using Jebong knife and at 48" using Push knife.*

Treatment	TH/91/1			TH/91/2		
	Y	BCR	GI	Y	BCR	GI
60",Jebong knife	31.0 A	18.8 A	5.7 A	27.8 AB	16.0 A	4.9 B
60", Jebong and Push knife at 48"	32.1 A	18.8 A	6.2 A	29.5 A	16.0 A	5.7 A
48",Push knife	31.6 A	15.0 B	6.1 A	25.5 B	13.9 B	5.3 AB

(Means with same letter are not significantly different)

Economics of the Use of Rainguards

In our plantations, yield losses due to the interference of rain on tapping is generally minimized by resorting to recovery tapping. About 15% increase in yield could be achieved by recovery tapping. Use of rainguards results in a 26-30% increase in yield, i.e. 11-15% increase over recovery tapped areas.

Recovery tapping results in continuous tapping of a tree. As a consequence the trees will be under stress and the incidence of tapping panel dryness increases. With the use of rainguards, tapping can be done strictly at the recommended frequency with minimal stress to the plant. Therefore, incidence of dryness could be reduced.

The net return by investing on rainguards depends on ;

- a) the extent of rain interference
- b) yield potential of trees
- c) the cost of production and net sale averages of rubber and
- d) the cost of fixing rainguards.

Considering the above variables an economic analysis on the use of rainguards was done for the Kalutara region. The profit margin (Rs/tree/annum) to be expected from trees with different yield potentials (for Kalutara region) are given in Table 7 .

Further, use of rainguards will increase,

1. national rubber production
2. employment opportunities
3. income to wage earner

(A Nugawela and R P Karunasena).

Table 7. *Economic analysis on the use of rainguards for trees with different yield potentials in the Kalutara region*

Yield potential (g/t)	Yield Increase RG(kg/tree/yr)	Additional Income (Rs)(@Rs. 40/kg)	Additional Expenditure				Profit margin Rs/tree/yr
			RG	Tapping	COM	Total	
30	0.47	18.80	7.00	4.22	3.29	15.57	4.29
40	0.63	25.20	7.00	4.22	4.41	15.63	8.57
50	0.78	31.20	7.00	4.22	5.46	16.68	14.52

Planting material and techniques

Young budding

Increasing the size of the polybag did not significantly affect the growth of either the seedling or the scion. Leaving a long snag significantly improves the growth of scion.

The grafting success is not influenced by the type of bud patch, i.e. axillary or scale. Nevertheless, it appears that grafting success depends on the clone. The grafting success was significantly high in clone RRIC 121 when compared to that of clone RRIC 100. The growth stage of the top leaf whorl, i.e. immature or mature, of the seedling did not influence the grafting success (P Seneviratne, A Nugawela and A M A Samarakoon).

Planting techniques

The objective of these experiments is to compare the performance i.e. establishment rate and early growth of different planting techniques in different agroclimatic conditions where rubber is grown in Sri Lanka.

Padukka (PT/91/1)

The establishment success and early growth rate of following planting material (clone RRIC 121) are being tested in this experiment (Table 8). Planting was done according to a randomized block design during S.W. 1991 at Padukka S.P., i.e. a plantation in the wet region.

Table 8. *The different types of planting material tested and their mean establishment success and girth (cm).*

Planting material	Establishment success (%)	Girth (cm)
Two whorled young buddings	100	11.8 A
Two whorled brown buddings	100	12.3 A
Bare root brown buddings	88	9.8 C
Bare root green buddings	96	10.5 B

(Means with same letter are not significantly different)

The establishment success of two whorled young buddings and brown buddings were 100 percent. The establishment success of bare root brown buddings is unusually low and may be due to poor quality of the planting material used.

The growth rate of two whorled young buddings and brown buddings, after a period of about one year is comparable and much superior to bare root brown and green budded stumps.

Mohamedi (PT/92/1)

The following planting material are being tested in this trial (Table 9). The green budded bare root and polybag plants were raised from the seedling nurseries established in the previous year, i.e. August and September 1991. Planting was done during S.W. 1992 according to randomized block design.

Table 9. *The different type of planting material used and their establishment success(%) and early growth rates, i.e. stem height (cm) and diameter (mm).*

Planting Material	Establishment success (%)	Stem height (cm)	Stem diameter (mm)
1. Bare root green buddings	93	41.3 C	7.8 D
2. Bare root brown buddings	99	38.9 C	8.4 D
3. Green budding polybags	94	52.4 BC	9.9 C
4. Young buddings	100	62.3 B	11.6 C
5. Brown budding polybags	98	89.5 A	14.8 A

(Means with same letter are not significantly different)

The establishment success is relatively low in both green budded bare root and polybag plants. The establishment success of young buddings is 100%. That of brown budded bare root plants and polybag plants are also good and comparable to young buddings.

After 6 months from field establishment, the growth of brown budded polybag plants and young buddings, are superior to all other planting materials being tested (A Nugawela and S M A Samarakoon).

Pallegama (PT/93/1)

A trial similar to that at Mohamedi (PT/92/1) is planned to be established at Pallegama Estate, i.e. a plantation in a relatively dry region. Nurseries are established to obtain the required planting material (A Nugawela and K A G B Amaratunge).

Planting density

The objective of these trials is to examine the possibility of increasing the planting density of rubber to increase productivity per unit area of land.

Millawa, 1977 Replantation - CD/77/1

Clones RRIC 101, RRIC 103 and PB 86 were established in 1977 at six spacings and densities, on a 3 x 6 factorial experiment with three replicates (Table 10). Each plot accommodates 64-156 plants depending on the density.

Table 10. *The plant spacing and density*

Spacing (m)	Density (trees/ha)
2.5 x 10	400
2.5 x 7.5	533
2.5 x 6	666
2.5 x 5	800
3.87(Triangular)	771
3.54(Triangular)	920

In clones RRIC 101 and RRIC 103 a significant reduction in growth, with increasing planting density, is reported (Annual Review 1984). Tapping was commenced in January 1984. The clone RRIC 103 was uprooted in 1988 due to the outbreak of *Corynespora* leaf disease. In the other two clones tapping and the management practices continued as recommended.

A detail study on the growth, yield and parameters related to yield were made during 1992. In clone PB 86, within the density range being tested, i.e. 400-920 trees/ha, the dry rubber yield in grammes per tree per tapping declined at a rate of 0.015. Nevertheless, the dry rubber yield per hectare increased at a rate of 5.2 grammes per tapping with the increase in planting density. The clone RRIC 101 also behaved similarly.

The girth of the plant and the thickness of virgin and renewed bark, parameters closely related to yield, declined with the increase in planting density. Anyhow, increasing planting density appears to have no significant effect on the number of latex vessel rings in the renewed and virgin bark (A Nugawela, V H L Rodrigo, L S S Pathiratna, P B Kodikara and J K L Weeralal).

Kuruwita 1992 Replanting - PD/92/1

Three clones, i.e. RRIC 100, RRIC 110 and RRIC 121, were established at 4 densities on a split plot design comprising of 4 blocks. Planting density was taken as the main plot and clones as the sub-plot, as shown below.

Main Plots (size = 0.3ha.)

Density(trees/ha) Spacing (m)

1. 500 2.5 x 8
2. 600 2.5 x 6.6
3. 700 2.5 x 5.7
4. 800 2.5 x 5

Sub Plots (Size = 0.1ha.)

Clones

1. RRIC 100
2. RRIC 110
3. RRIC 121

(V H L Rodrigo, A Nugawela, L S Kariyawasam in collaboration with Genetics & Plant Breeding Department).

Nursery Inspection Unit

Inspections

Seventy two private commercial nurseries were inspected and reports were submitted to the Rubber Control Department for the issue of permits.

Budwood nurseries in the Plantation Sector Estates in Galle, Kalutara, Kegalle and Avissawella regions were inspected to check the authenticity of clones and to provide advice on the upkeep.

Budded Stumps for Multiplication Nurseries

For the above purpose, 4795 bare root budded stumps were distributed to the Plantations Sector as follows.

Clone	Region				
	Avissawella	Galle	Kalutara	Kegalle	Ratnapura
PB 217	-	225	65	500	150
PB 235	85	225	75	250	110
PB 255	30	225	85	75	10

Clone	Avissawella	Galle	Kalutara	Kegalle	Ratnapura
PB 260	30	225	130	100	-
PR 255	-	225	85	75	-
PR 305	-	225	25	100	85
BPM 24	-	-	25	75	-
RRIC 105	25	225	50	250	235
RRIM 712	-	180	70	80	135
PR 261	-	-	-	40	-

For the purpose of establishing private commercial budwood nurseries 530 bare root budded stumps were distributed as follows:

Clone	No. Plants Issued
RRIC 100	365
RRIC 102	155
RRIC 121	10
PB 86	-

Training Programmes

For the Private Commercial Nursery Owners, four training programmes were conducted at the Training Center, Nivitigalakele together with the Advisory Services Department.

Five training programmes on green budding and young budding were conducted for employees in the Plantation Sector in the Avissawella, Kalutara, Kegalle and Galle regions (A Nugawela, R B Gunaratne, U S Weerakoon and M de Alwis).

Intercropping

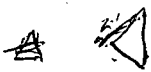
Spatial Arrangements

The light penetration through the canopy declines with the growth of the rubber plant. Therefore, intercropping is possible only during the initial years of the rubber crop. The objective of these trials is to find out alternate planting systems that will provide more light and for a longer period of the rubber crop to facilitate intercropping.

Usk Valley, 1992 Replanting - IC/S/92/1

Four non-traditional spatial arrangements for rubber are tested together with the traditional system recommended for intercropping, i.e. 2.4m x 8.1 m. All spatial arrangements being tested gives the recommended planting density, i.e. 500 trees/hectare. Banana a recommended intercrop is planted in the different systems to find out the performance of the intercrop with the maturity of rubber. The systems being tested are described below.

System/Treatment	Crops	Spacing
1	Rubber	2.4 m x 8.1 m
	Banana	A single row in the rubber inter row at 3.6 m intervals
2	Rubber	A double row with 2.4 m x 2.4 m triangular spacing. The distance between 2 double rows is 14.1 m
	Banana	Three rows at 3.6 m x 3.6 m triangular spacing between 2 double rows of rubber.
3	Rubber	A three row system, at 2.4 m x 2.4 m triangular spacing. The distance between 2 three row systems of rubber is 20.1 m.
	Banana	Five rows at 3.6 m x 3.6 m triangular spacing between 2 three row systems of rubber.
4	Rubber	Three plant triangular cluster system spaced 2.4 m within the cluster and 7.5 m among clusters.



	Banana	Three plant triangular cluster system spaced 3.6 m within the cluster and placed at the center of 3 clusters of rubber.
5	Rubber	Four plant square cluster system spaced 2.4 m within the cluster and 8.8 m among clusters.
	Banana	Four plant square cluster system spaced 3.6 m within the cluster and placed at the center of 4 clusters of rubber.

Planting was done according to a randomized complete block design, with 3 blocks, during S.W. 1992 (V H L Rodrigo and L S Kariyawasam).

Perth, 1992 Replanting - IC/S/92/2

The aim of this experiment is to study the advantage of planting rubber in east west oriented rows as it is expected that such a system would provide more sunlight for the intercrops under rubber for a longer period than in the normal contour plantings.

The experimental design is randomized blocks with four replicates. The treatments being tested in this experiment are as follows. The rubber clone here is RRIC 121.

Treatments

1. Row planting (RP) Rubber only.
2. RP - Grass (*Brachiaria brizantha*)
3. RP - Coffee
4. RP - Cinnamon
5. Contour planting (CP) - Rubber only
6. CP - Grass
7. CP - Coffee
8. CP - Cinnamon (L S S Pathiratne and M K P Perera).

Intercropping systems

Rubber and Timber

With urbanization the area under forest cover declines, whilst the demand for timber increases. Nevertheless, reforestation is limited due to the lack of land. In this study the feasibility of growing timber crops with rubber is investigated.

Usk Valley, 1992 Replanting - IC/RT/92/1

Ambatenna, 1992 Replanting - IC/RT/92/2

Four timber species, i.e. teak, mahogani, halmilla and havarinuga were planted in two types of spatial arrangements of rubber giving the recommended density of, i.e. 500 trees/ha. Four species of timber crops are sub plots of the main plots, i.e. two types of spatial arrangements for rubber.

Spatial arrangements are,

1. Traditional system recommended for intercropping - 2.4 m x 8.1 m
2. A double row with 2.4 m x 2.4 m triangular spacing. The distance between 2 double rows is 14.1m.

Planting of timber is restricted to a single row in a rubber inter-row in the traditional spatial arrangement, recommended for rubber for intercropping. In the double row system of planting rubber, 3 timber rows are planted at 4.5 m X 4.5 m triangular spacing in between two double rows of rubber. The rubber timber system is also compared with two high density systems of rubber sole crop included in the same experimental design (V H L Rodrigo and L S Kariyawasam).

Rubber and Sugarcane

Growing rubber is becoming popular in Monaragala and Bibile districts. However, the extended immature period in these districts due to the relatively dry weather, is a burden on the rubber growers. The climatic conditions are correct and a very good market exists for sugarcane in this region. Therefore, studies were initiated to identify suitable systems of growing sugarcane, as an intercrop, to obtain an economic return during the immature period of rubber.

The study is conducted in smallholdings in the region. Planting of rubber and sugarcane were undertaken during NE 1992. In each holding selected, the following treatments are being tested.

Treatment	Crops	Distance
1	Rubber only	2.4 x 8.1 m
2	Sugarcane only	1.2 m between rows
3	Rubber	2.4 x 8.1 m
	Sugarcane	5 rows, 1.2 m apart in a rubber inter-row. Distance between a rubber and sugarcane row is 1.65 m
4	Rubber	2.4 x 8.1 m
	Sugarcane	4 rows, 1.2 m apart in a rubber inter-row. The distance between a rubber and a sugarcane row is 2.25 m

In treatments 2,3 and 4, four sugarcane varieties, i.e. SL 8306, SL 7103, CO 775 and H 382915 are being tested in a split plot design. The experiment is replicated in 4 smallholdings, i.e. 2 at Moneragala and 2 at Bibile (A Nugawela, V H L Rodrigo in collaboration with the Sugar Research Institute, Uda Walawe and the Advisory Services Department of the Rubber Research Board. This project is being funded by the Council for Agricultural Research Policy).

Rubber and Coffee/Pepper Padukka - IC/87/1

The experimental details are given in the Annual Review of 1987. Treatment differences in girth and girth increment are given below. The differences are not significant.

Treatment	Mean girth (cm)	Girth increment (mm)
1	46.4	11.2
2	46.9	11.7
3	43.9	10.2
4	49.1	12.6
5	49.6	12.1
6	45.0	12.3

(V H L Rodrigo and L S Kariyawasam)

Rubber and Grass/Legume Neuchatle - IC/GL/91/1

Harvesting of grasses was commenced in May 1992. A 40 day cutting cycle for grasses was employed.

The dry matter (DM) production of *Panicum maximum* var Guinea B (PM) was found to be significantly higher than that of *Brachiaria brizantha* (BB) (Table 11). The growth of tree legumes was very poor and was harvested only once during this period. Ipil Ipil in *Brachiaria brizantha* (BB) plots failed to grow possibly due to severe competition. The growth of rubber trees were not significantly affected by treatment differences at this stage (Table 11).

Rubber and Cocoa/Cinnamom Dartonfield - IC/CC/91/2

The *Gliricidia* stakes planted in this experiment as shade trees, did not grow fast enough and was replaced by banana. The planting of the two intercrops was completed during May/June. (L S S Pathiratna and M K P Perera)

Intercropping Systems - Demonstration Plot Dartonfield - IC/DP/91/1

A demonstration plot consisting of following intercropping systems were established during N.E. 1991.

1. Rubber x Banana x Cocoa
2. Rubber x Coffee x Winged bean and *Gliricidia*
3. Rubber x Passionfruit x Pineapple
4. Rubber x Banana x Pepper and *Gliricidia*
5. Rubber x Banana x Papaw

6. Rubber x Grass x Tree Legumes

7. Rubber x Vegetables

Banana, Passionfruit and Pineapple came into bearing and 628, 85 and 58 Kg were harvested, respectively. 25 m² size plots of Kankun and Mukunuwanna yielded 225 and 115 Kg respectively (V H L Rodrigo, L S S Pathiratna, L S Kariyawasam and M K P Perera).

Table 11. *The dry matter production of grasses, legumes and growth of rubber.*

Treatments	Mean Dry Matter Yield(kg/ha)		Mean girth of rubber (cm)
	Grasses	Tree Legumes*	
Rubber Only	-	-	13.5
Rubber+PM	11307	-	13.8
Rubber+BB	6656	-	13.8
Rubber+Gliricidia	-	10.2	13.0
Rubber+Ipil Ipil	-	50.0	12.6
Rubber+PM+Gliricidia	10748	16.7	13.6
Rubber+PM+Ipil Ipil	12472	15.0	13.5
Rubber+BB+Gliricidia	5723	13.4	13.6
Rubber+BB+Ipil Ipil	6738	0	13.1

*Excluding the stems

(L S S Pathiratna and M K P Perera).

PLANT PATHOLOGY AND MICROBIOLOGY

C K Jayasinghe

SUMMARY

The incidence of *Phytophthora* Leaf Fall and Bark Rot during South West monsoon season of 1992 was the highest recorded for the last decade. The main factors that contributed to this severe out break of *Phytophthora* disease were the unusual prolonged rainfall of S.W. monsoon and low incidence of *Oidium* Leaf Fall due to dry weather experienced at the beginning of the year. An interim circular was sent to rubber growers predicting this situation and necessary advice was provided to all affected plantations. Results of a survey conducted during this season revealed that new clones viz: RRIC 130 and RRIC 131 are highly susceptible as RRIM 600 and PB 86 to Bark Rot. Even though the leaf fall is severe on RRIC 121 as in PB 86, the Bark Rot incidence was negligible. Furthermore, observations of a screening trial indicated that clones RRIC 130, RRIM 600, RRIC 110, RRIC 133, and RRII 119 are highly susceptible to Bark Rot while clones such as BPM 24, RRIC 100, RRIC 102, RRIC 121, and RRIC 116 are resistant to this disease.

The incidence of *Corynespora* Leaf Fall was mild and no new clones were reported to be affected in the field.

Hevea clone PB 235 was found to be extremely susceptible to *Oidium hevea* whereas PB 260 and PR 255 showed resistance to pathogen.

Thanatephorus cucumeris, a fungal pathogen first reported in 1991 in seed germination beds, was found to spread to a seedling nursery in November 1992. Necessary steps were taken immediately to eradicate the disease using 0.025% ai monceren. Moist heat was also proved to be very effective as a prophylactic measure in management of the disease in seed germination beds.

A document was prepared on South American Leaf Blight predicting the possible introduction to Sri Lanka and likelihood behaviour in rubber growing areas. White Root disease caused by *Rigidoporus lignosus* continued to cause damage both in immature and mature rubber plantations. Black Root disease, devastating root disease restricted to few estates in Kegalle, Kurunegala, and Galle was detected for the first time at Hatherly Estate, Rakwana.

Root-knot nematode, *Meloidogyne incognita* (Kofoid & White, 1919) was detected from the roots of stunted *Hevea* seedlings in three seedling nurseries of different rubber growing areas. This is the first record of nematodes on *Hevea* in Sri Lanka.

Necessary advice on the management of *Hevea* diseases was provided to estates on their request and to smallholders on the request of Rubber Advisory Service Department and Rubber Control Department.

DETAILED REVIEW

Staff

The Head of the Department, Mr C K Jayasinghe and Miss W P K Silva, Assistant Plant Pathologist continued to work in the Department. Dr R Jayaratne, Assistant Plant Pathologist returned to Sri Lanka on 15th September 1992 after successfully completing post-graduate training (PhD) at the University of Sheffield, U.K. Mr K E Jayasuriya, Assistant Plant Pathologist left for post-graduate studies to the University of Edinburgh, U.K. on the 1st November 1992.

The Experimental Officers Messrs. W Amaratunga, D S Wettasinghe and E B Fernando and Senior Technical Officer Mrs J L P C Wettasinghe were on duty throughout the year. The Technical Officers Misses B I Fernando & T H P S Fernando and Mrs P Amarasekera, Clerk/Typist continued to work in the Department. Mr C K Jayasinghe attended the International Natural Rubber Conference in Bangalore, India from 5th to 8th February 1992. He presented a paper entitled "Management of Collar rot of *Hevea* seedlings - A new record on *Hevea* in Sri Lanka" during this conference.

Visits

Advisory	94
Experimental	302
Miscellaneous	135
Total	531

Meetings

Mr C K Jayasinghe served as a member of Pesticide Formulary Committee.

Training

Mr C K Jayasinghe, Dr R Jayaratne, Mr K E Jayasuriya and Miss W P K Silva were involved in training Superintendents, Assistant Superintendents, Rubber Extension Officers and NDT Trainees.

Publications

- Jayasinghe, C K. The natural occurrence of *Thanatephorus cucumeris* leaf spot on *Hevea brasiliensis* in Sri Lanka. (sent for publication in Plant Pathology)
- Jayasinghe, C K, Wettasinghe, D S. Out breaks and new records - Root-knot-nematodes on *Hevea brasiliensis*. (sent for publication in FAO Plant Protection Bulletin)
- Jayasinghe, C K, Warnapura, S S and Fernando, B I. Sclerotium collar rot of *Hevea* seedlings and the management of the disease (sent for publication in Indian Journal of Natural Rubber Research).
- Jayasinghe, C K. South American Leaf Blight - Likelihood behaviour in Sri Lanka and Strategies in management (accepted for publication in Bulletin of the Rubber Research Institute)
- Jayasinghe, C K. Annual Review of the Plant Pathology and Microbiology Department 1991.
- Silva, W P K & Liyanage, N I S. Possible occurrence of different strains of *Corynespora cassiicola* and screening for disease resistance (Presented at the 48th Annual Sessions of SLAAS 1992)
- Jayarathne, A H R. Some aspects of biology of vesicular-arbuscular mycorrhiza with special reference to the external mycelial phase. PhD Thesis, University of Sheffield, U.K. 1992

GENERAL

The incidence of *Oidium* Leaf Fall was mild throughout the rubber growing districts during the 1992 refoliation season. However, repeated defoliations were noticed at higher elevations where susceptible clones succumbed to heavy attacks. The

weather conditions at the time of refoliation were dry and did not favour the establishment and propagation of the causal agent at lower elevations.

The incidence of *Phytophthora* Leaf Fall and Bark Rot during the S.W. monsoon season of 1992 was the highest recorded for the last decade. The main factors that contributed to this severe outbreak of *Phytophthora* diseases were the unusual prolonged rainfall of S.W. monsoon and low incidence of *Oidium* due to dry weather experienced at the beginning of the year. The most affected areas were Avissawella, Kalutara and Galle. Even though this situation was predicted early and interim circular was sent to all estate managing companies requesting them to be vigilant, a considerable number of plantations ended up with Bark Rot symptoms. All the affected plantations were visited and necessary advice was given on request.

The incidence of the *Corynespora* Leaf Fall disease was mild and no new clones were reported to be affected in the field. However, there were several requests throughout the year asking us to assist in identifying and controlling the disease. *Thanatephorus cucumeris*, a fungal pathogen discovered in seed germination beds during the year 1991, spread to a seedling nursery in November 1992. Necessary steps were taken immediately to manage the disease.

White Root Disease caused by *Rigidoporus lignosus* continued to cause damage both in immature and mature rubber plantations. Black Root disease, a devastating root disease restricted to few estates in Kegalle, Kurunegala and Galle was detected for the first time at Hatherly Estate, Rakwana (towards Embilipitiya area) in January 1992.

A document was prepared on South American Leaf Blight (SALB) predicting the possible introduction to Sri Lanka and likelihood behaviour in the rubber growing areas. The management strategies in SALB are also discussed in this paper. Five advisory circulars were revised during first quarter giving latest recommendations on management of diseases caused by *Phytophthora* spp., White Root disease, SALB, *Corynespora* Leaf Fall disease and nursery diseases.

LABORATORY AND FIELD INVESTIGATIONS

Chemical Control of Economically Important Diseases of *Hevea* (CC/89/1)

(A) New fungicides for control of Bark Rot

New formulations of two fungicides viz. dithane M 45 and sandofan M which were found to be potential fungicides to control *Phytophthora* spp. in vitro were screened at Nivithigalakele Estate. These studies were performed using virgin panels of the clone PB 86 and experiments were designed to find both prophylactic as well

as the curative effects of the chemicals. The recommended fungicides brunolinum plantarium and sandofan paste were also used as controls.

The results of the experiments conducted to evaluate the curative effect of fungicides varied markedly probably due to the natural control of the disease. In the case of prophylactic treatment, sandofan M performed best indicating that sandofan M at a concentration of 0.8% ai can prevent the disease incidence (C K Jayasinghe and E B Fernando).

(B) Screening of fungicides against *Rigidoporus lignosus*

Although 2% penta chloro phenol (PCP) was recommended as a collar protectant in controlling White Root disease in 1991, further observations were made during the year 1992. The results of these observations reaffirmed the effectivity of 2% PCP in the management of White Root disease, the most devastating root disease of *Hevea* in Sri Lanka. Furthermore, experiments were designed with two new concentrations. viz. 4% and 8% of PCP (C K Jayasinghe, K E Jayasuriya and T H P S Fernando).

A series of new experiments with bayleton and bayfidan, two fungicides which did not perform well during previous trials were initiated again in the 4th quarter to evaluate the effectiveness against *R. lignosus*. Studies with 10% phenol in a bituminous base are also in progress (R Jayaratne, C K Jayasinghe & J L P C Wettasinghe).

(c) Screening of fungicides against *Thanatephorus cucumeris*

Eight fungicides were screened in vitro using poisoned food technique to find an effective fungicide to control *Thanatephorus cucumeris*, a newly recorded *Hevea* pathogen. The chemicals used in this study were cobox, anthracol, dithane M 45, benlate, captan, bayleton, bayfidan and folicur. The results of the experiment showed that all the chemicals were significantly superior to control in checking the growth of the fungus (Table 1). Four fungicides viz. bayfidan, benlate, folicur and monceren proved to be the best chemicals as they checked the growth of the pathogen at a concentration of 0.01% ai. However, cobox and bayleton also behaved as effective fungicides at a concentration of 0.04% ai (Table 1).

With regard to pot trials, two fungicides namely monceren (0.025% ai) and benlate (0.015% ai) were superior to all other fungicides in controlling the pathogen. However, traditional burning of the soil prior to sowing performed as the best in the management of *T. cucumeris* in the germination beds (Table 2) (C K Jayasinghe, E B Fernando & I Fernando).

Table 1. *Effect of test fungicides on growth of T. cucumeris*

Treatment	Colony growth at different concentrations		
	0.01% ai	0.02% ai	0.04% ai
Pencycuron (Monceren)	- a	- a	- a
Tebuconazole (Folicur)	- a	- a	- a
Benomyl (Benlate)	- a	- a	- a
Triadimenol (Bayfidan)	- a	- a	- a
Captan (Captan)	8.0 b	10.0 b	- a
Triadimefon (Bayleton)	13.5 c	8.7 b	- a
Mancozeb (Dithane M 45)	26.1 d	19.9 c	10.6 b
Propineb (Anthracol)	52.6 e	36.5 d	19.0
Copper (Cobox)	80.0 f	71.0 e	- a
Control	80.0 f	80.0 f	80.0 d

Means with the same letter are not significantly different at 0.05 level according to DMRT.

Table 2. *Survival percentage of Hevea seedlings in the pot trial using five fungicides and burning of soil as treatments.*

Treatment	Post-emergence survival percent
Burning	100.0 (1.571) a
Pencycuron (Monceren)	93.7 (1.262) b
Benomyl (Benlate)	85.4 (1.107) b
Tebuconazole (Folicur)	62.5 (0.676) c
Mancozeb (Dithane M 45)	41.7 (0.431) cd
Copper (cobox)	25.0 (0.254) d
Control	18.7 (0.197) d

Transformed values are given in parenthesis.

Means with the same letter are not significantly different at 0.05 level according to DMRT.

Biology of Common Pathogens of *Hevea* (BCP/90/1)

A. Variation in different isolates of *Corynespora cassiicola*

Studies were continued on the (a) reaction of the different *Hevea* clones towards the toxin produced by *C. cassiicola* and (b) susceptibility of *Hevea* clones to different isolates of *C. cassiicola* using techniques modified in our laboratory during the year 1991. A further study was carried out to find the sensitivity of 17 isolates towards the selected fungicides. This study indicated that the fungicide dithane M 45 could be used for further studies as a marked variation in the sensitivity of the isolates towards dithane M 45 was exhibited. The other chemicals used in this study were benlate and cobox (C K Jayasinghe, W P K Silva, J L P C Wettasinghe and T H P S Fernando).

Micro-organisms and Pests Associated with Rubber Plantations (MP/89/1)

New records/uncommon pathogens of *Hevea* (MP/89/1B)

(a) Our attention was drawn to the abnormal seedlings which showed growth retardation and stunting in seedling nurseries during this year. Results of the experiments conducted to find the causative agent of this abnormality, revealed that

these seedlings were infested with root-knot nematodes. Pear shaped females were dissected from the galled tissue of roots. The nematode was identified as *Meloidogyne incognita* (Kofoid & White, 1919 Chitwood 1949) with the kind assistance of C.A.B. International Institute of Parasitology (C I P No 42/92).

This is the first record of nematodes on *Hevea* in Sri Lanka. However, occurrence of root-knot nematodes on *Hevea* has been reported from other rubber growing countries namely Malaysia (1965), India (1975) Vitenam (1985) and Brazil 1989 previously. Finally a survey was conducted and observations made revealed that several seedling nurseries viz Padukka Estate, Nivitigalakele Estate and Doloswela Estate in different rubber growing areas were affected with root-knot nematodes *Meloidogyne incognita* (C K Jayasinghe and D S Wettasinghe).

(b) It was brought to our notice that plants in a seedling nursery at Sudagala, Kuruwita was heavily affected with White Root disease caused by *Rigidoporus lignosus*. On the examination of the roots of the affected plants it was revealed that the causative agent was not *R. lignosus* but an unknown fungus. There were no disease symptoms on roots, collar or canopy. The soil of the nursery was found to be covered with leaf litter and coconut roots which were also heavily infected with the same fungus. Hence it was suspected as a saprophytic fungus and sent to CAB, U.K. for authentication (C K Jayasinghe and J L P C Wettasinghe).

(c) A cankerous growth was detected at the collar region of young buddings at Nakiyadeniya Estate, Galle. The affected plant defoliated and were subjected to die back within few weeks. The affected area was swollen with cracks. Further necrotic lesions were detected when the trunk was splited longitudinally. The pathogen was isolated and authenticated as *Nattrassia mangiferae* (H. Sydow & Sydow) B. Sutton & Dyko. with the kind assistance of C.A.B. International Mycological Institute (IMI No.352075). Experiments are in progress to prove Koch's postulates (C K Jayasinghe and W P K Silva).

(d) Spore suspensions of *Cochliobolus eragrostidis*, a fungus isolated from clone LCB 1320 were sprayed on to *Hevea* seedlings with the view of proving Koch's postulates. Typical symptoms of the disease were not produced on the foliage, most probably due to the dry weather that prevailed during the experimental period. Experiment will be repeated during the year 1993 (C K Jayasinghe & J L P C Wettasinghe).

Screening of Clones of Rubber for Leaf and Panel Diseases (SC/89/1)

I. Establishment of new clones for the utilization in future clonal evaluation programmes.

Arrangements were made to fertilize the plants and fill the vacancies of previously established clones at our thirteen nurseries located at Kalutara, Kelany Valley, Galle and Ratnapura regions.

II. Screening of *Hevea* clones against Bark Rot caused by *Phytophthora meadii*.

Twenty three clones were screened at four localities namely Padukka Estate, Nakiyadeniya Estate, Rilhena Estate and Madeniya Estate against Bark Rot caused by *Phytophthora* sp. during South West monsoon period. Plants of the different clones were artificially inoculated with a standard spore suspension of *P. meadii* and the resulting lesions were measured after 4 weeks.

These studies indicated that the clones namely RRIC 130, RRIM 600, RRIC 133 and RRIM 119 are highly susceptible to Bark Rot whereas clones such as BPM 24, RRIC 100, RRIC 102, RRIC 121 and RRIC 116 are resistant to the same disease (Table 3) (C K Jayasinghe and D S Wettasinghe).

III *Phytophthora* epidemic in rubber plantations from May to September

A survey was launched from May to September to detect the field susceptibility of recommended *Hevea* clones to *Phytophthora* infections as abnormal leaf fall and bark rot reached epidemic proportions during the S.W. Monsoon period of the year 1992.

The results of the survey revealed that the new clones namely RRIC 130 and RRIC 131 are highly susceptible as in the case of RRIM 600 & PB 86 to Bark Rot. Even though the leaf fall was severe on RRIC 121 as in PB 86, the Bark Rot incidence was negligible. The clones, RRIC 100, RRIC 102 and RRIC 110 showed a mild attack of *Phytophthora*. However, an intensive research programme is now in progress to screen all new *Hevea* clones (C K Jayasinghe and D S Wettasinghe).

IV Screening of foreign clones received under multi lateral exchange programme against *Oidium heveae*

Seven foreign clones viz. PB 217, PB 260, PB 235, PR 255, PR 261, BPM 24 and RRIM 712 and three local clones viz. RRIC 100, RRIC 110 and RRIC 121 were screened against *Oidium heveae*. These experiments were conducted at seven

Table 3. *Susceptibility of different clones to Bark Rot at four different localities*

Clone	Lesion area (cm) at different sites			
	Padukka	Nakiyadeniya	Rilhena	Madeniya
RRIC 130	12.8 b	10.56 bcd	13.71 a	20.38 a
RRIC 110	14.80 a	9.93 bcde	9.58 bc	18.78 abc
RRIM 600	12.30 b	7.80 efghi	7.74 edefg	-
RRIC 119	11.70 bc	13.69 a	10.93 b	20.19 a
RRII 105	11.38 bcd	7.69 efghi	-	-
RRIC 133	9.92 cde	13.74 a	10.93 b	18.14 abcd
RRIC 101	9.89 cde	9.09 cdefg	11.02 b	17.63 abcde
RRIC 109	9.28 def	9.74 bcde	7.53 cdefg	10.91 ghi
RRIC 114	9.11 efg	9.50 bcdef	8.92 bcde	16.96 abcde
RRIC 112	9.07 efg	-	13.46 a	19.17 ab
PB 86	8.92 efg	10.47 bcd	11.49 ab	15.24 cde
HP 74-193	8.87 efg	9.43 bcdefg	8.14 cdefg	11.61 fghi
RRIC 102	8.80 efg	7.07 fghi	8.23 cdefg	7.89 i
HP 74-181	8.69 efg	10.84 bc	9.45 bcd	13.98 efg
RRIC 132	8.57 efg	8.38 cdefgh	9.51 bcd	17.32 abcde
RRIM 712	8.56 efg	8.90 bcdefg	-	12.11 fgh
RRIC 120	8.46 efg	9.70 bcde	7.73 cddefg	16.25 bcde
PB 28/59	8.42 efg	7.03 fghi	7.51 cdefg	-
RRIC 113	8.16 efg	-	7.21 cdefg	11.39 fghi
RRIC 115	7.93 efg	9.52 bcdef	8.81 bcdef	14.84 def
RRIC 117	7.91 efg	11.70 ab	9.45 bcd	16.68 abcde
RRIM 717	7.87 efg	6.41 hi	7.89 cdefg	11.84 fgh
RRIC 111	7.73 efg	-	8.87 bcde	11.16 fghi
PB 260	7.71 efg	8.24 defghi	-	-
RRIC 116	7.59 efg	9.21 cdefg	5.82 g	10.81 ghi
RRIC 121	7.29 fg	7.70 efghi	6.12 fg	14.89 cdef
RRIC 100	7.01 fg	6.98 ghi	8.81 bcdef	9.48 hi
PB 235	6.97 fg	8.54 cdefgh	-	-
BPM 24	6.71 g	7.01 fghi	6.35 efg	8.63 hi
HP 74-194	-	7.11 fghi	-	-
PB 213	-	5.87 i	-	-
HP 74-213	-	-	6.79 defg	-

Means with the same letter are not significantly different at 0.05% level according to DMRT.

localities namely Bibile Estate, Atale Estate, Salawa Estate, Bentota Estate, Yatawatta Estate, Kuruwita Estate and Eladuwa Estate. Even though the reaction of clones at different sites varied markedly results of statistical analysis revealed that the clone PB 235 is extremely susceptible to *Oidium hevea* whereas clones PB 260 and PR 255 were highly resistant to this pathogen. The discrepancy of the observations in different sites would have occurred due to the different maturity stages of leaves at the time of *Oidium* infection (C K Jayasinghe and D S Wettasinghe in collaboration with N E M Jayasekera).

Miscellaneous

1. Utilization of bare patches caused by *Rigidiporus lignosus*

Seven plants species of the genera *Alastonia*, *Albizzia*, *Tephrosia*, *Calliandra* and cinnamon were inoculated with the fungus *Rigidiporus lignosus*, causative agent of White Root disease in pots as an initial step of the above project. Even though all hosts were infected only *Tephrosia* showed above ground symptoms. On the light of this situation a field trial was initiated at Dartonfield Estate using the same species. This experiment is in progress (W P K Silva and C K Jayasinghe).

2. Operation on eradication of *Corynespora* Leaf Fall disease in smallholdings

Reissuing of certificates to smallholders by RRI staff to obtain relief payments was terminated in the end of 1991. However, around 30 requests were made by the smallholders directly or through the Rubber Control Department to get their clearings inspected (C K Jayasinghe, K E Jayasuriya, D S Wettasinghe and B Fernando).

3. *Corynespora* Leaf Fall survey in State Plantations

Even though this programme was terminated in the year 1987 several new requests have been made during this year. Necessary advice was given and certificates were issued to uproot the affected clearings (C K Jayasinghe, D S Wettasinghe and E B Fernando).

4. Black Root disease incidence in *Hevea* plantations

Black Root disease caused by *Xylaria thwaitesii* is a deadly root disease of rubber, restricted to dry regions of rubber growing areas.

During this study, three estates namely Hathbawa, Golinda and Parambe where Black Root disease was recorded previously were reinspected to find the present

situation on the disease incidence. It was revealed that clearings in Parambe Estate and Golinda Estate are free from infections. However, four clearings in Hathbawa Estate were found to be affected with Black Root disease. Immediate action was taken to treat 27 plants in 1980 clearing at Mt. Prospect division with Penta Chloro Phenol, an alternative fungicide for PCNB. This exercise was launched mainly to educate the estate staff in the management of the Black Root disease.

Further, Black Root disease was detected for the first time in Rakwana at Lenark Div. Field No.8/1970 R.P. of Hatherly Estate in January 1992. Note: The weather conditions at Lenark Div. are similar to Kurunegala/Kegalle regions) (C K Jayasinghe, K E Jayasuriya, W P K Silva and D S Wettasinghe).

SOILS AND PLANT NUTRITION

Lalani Samarappuli

SUMMARY

Research on improvement of soil fertility, increasing efficiency of nutrient uptake, economizing on fertilizer use, improved methods of soil, water and nutrient conservation and weed control have been the main objectives of this Department.

In studies in the field with immature *Hevea brasiliensis* use of dead mulch of paddy straw around the base of the plants reduced the immature, unproductive period of *Hevea* by 12 month in comparison with the conventional growing of creeping leguminous covers such as *Pueraria phaseoloides* and *Desmodium ovalifolium* and by 18 months in comparison with allowing naturals (weeds) to grow, in high rainfall areas with poor soil characteristics. In addition to early tapping, yield of latex was also higher during the early stages, increases in the region of 33% and 40% were obtained in comparison with creeping legumes and naturals respectively. The present value of the benefit achieved from mulching amounts to Rs.27267/= per hectare of which Rs.11348/= is the savings on inputs (early maturity) and the balance Rs. 15919/= is due to extra yield. Mulching also improved the physico-chemical characteristics and water storage capacity of the soils and the nutritional status of the plants.

Under moisture stress situations increasing the level of potassium application improved the growth performance of young rubber plants. Among the important plant physiological characteristics, measurement of leaf diffusive resistance may serve as a useful parameter in screening clones for planting in marginal areas.

Laboratory investigations showed that Eppawela Rock Phosphate (ERP) required more time for its dissolution in soils than imported Rock Phosphate. But more than 60% of released P was fixed possibly due to high amounts of Fe and Al in rubber soils. Scanning electron microscopic studies showed that ERP was dissolved only chemically and not biologically in the soil.

It appears possible that application of sulphate of ammonia, triple super phosphate, muriate of potash and kieserite as conventional mixtures could be effectively used for young buddings and this would be cheaper than the current recommendations. Soil and Foliar Survey Programme continued to be popular among new management companies in providing fertilizer recommendations for mature rubber.

DETAILED REVIEW

Staff

The Head of the Department, Dr (Mrs) Lalani Samarappuli was on duty throughout the year. She was awarded the PhD degree of the University of Peradeniya, for her Thesis on "Effect of some soil management practices and moisture regimes on the performance of *Hevea*". Dr D M A P Dissanayake, Assistant Soils Chemist returned on 3rd August, after obtaining a PhD from the University of Aberdeen, Scotland. He was promoted to Senior Staff Grade II with effect from 3rd August. Mr P I Yapa continued to work as Assistant Soils Chemist. Mr S Dharmakeerthi, Assistant Soils Chemist commenced his post graduate studies leading to a MSc Degree in Soil Science at the Post Graduate Institute of Agriculture, University of Peradeniya.

The Experimental Officers Messrs A M A Perera, H D S P Perera, G de Mel and Mrs Rasika Hettiarachchi were on duty throughout the year.

Senior Technical Officer Mrs C Maheepala, Technical Officers Messrs S N Silva, P Karunadasa, U Mitrasena, T B Dissanayake, A Yakandawela, R Gunasekera, Mrs M K Mahanama, the Specification Assistant T M Ahamadeen and the English Stenographer Mrs Lakshmi Perera were on duty.

Miss S Jayasekera Technical Officer resigned from the Rubber Research Institute in May.

Research Students

Two Research students from the Faculty of Agriculture, University of Peradeniya worked on the following projects, in partial fulfillment of the requirements of the specialization course in soil science under the supervision of Dr (Mrs) Lalani Samarappuli and Dr D M A P Dissanayake respectively.

- Ratnayake, A R M N : Some aspects of soil moisture status in rubber soils.
- Soyza, Jayasena : Behavior of rock phosphates in rubber soils. A laboratory investigation.

Temporary Workers

Miss Thushara Peries and Miss Daivi Senaratne continued to work as temporary Technical Assistants in CIDA funded programme until 31st of March. Miss Chandani Jayalath resigned to rejoin as a temporary Technical Assistant in the CARP Programme.

Visits

Lalani Samarappuli attended the International Natural Rubber Conference held in Bangalore, India in February and presented a paper entitled "Some aspects of moisture stress in *Hevea brasiliensis* grown under Sri Lankan conditions".

She also attended the International Conference on Fertilizer Usage in the Tropics held in Malaysia in August and presented a paper entitled "Effects of potassium and moisture stress on the performance of young *Hevea brasiliensis*". She also visited the Rubber Research Institute of Malaysia (RRIM) during her stay in Malaysia.

The Departmental staff paid advisory visits to plantations and smallholdings and routine visits to experimental areas where necessary.

Meetings

Seminars, Meetings and Workshops

Lalani Samarappuli addressed the following seminars:

Weed Science Society Seminar at Gannoruwa Peradeniya in February on "Weed Management in Rubber Plantations"

Grantees Seminar of the CIDA Funded Potassium Fertilizer Research Project at Tangerine Beach Hotel, Kalutara in May, on "Some Aspects of Soil Moisture Stress in *Hevea brasiliensis* grown under Sri Lankan conditions"

Seminar on the Biological Aspects of Rubber Plantations Conducted by the RRI Scientists to the Personnel of the New Management Companies on "Soil Conservation and Fertilizer Recommendations". D M A P Dissanayake also participated in this seminar.

Agalawatta Sub - district Planters' Association Annual Meeting on "Soil Management". D M A P Dissanayake also gave a talk on "Nutrient Deficiencies in Rubber".

Lalani Samarappuli attended the following seminars and meetings

National seminar on "Fertilizer use in Agricultural Development" during 28th and 29th October at PGRC, Gannoruwa, Peradeniya.

Central Scientific Committee Meeting of the RRI.

Exploratory Meeting of the working group on fertilizer mixtures of the Sri Lanka Standards Institution

D M A P Dissanayake attended a workshop on "Scope, Priorities and Funding of Research" organized by NRESA.

P I Yapa and S Dharmakeerthi participated a workshop on "N-15 Fertilizers" organized by Atomic Energy Authority and University of Colombo.

Training Programmes

Lalani Samarappuli and D M A P Dissanayake were involved in the following training Programmes:

Rubber Extension Officers of the Advisory Services Department

Assistant Superintendents of Watawala Plantations Ltd.

Assistant Superintendents of Kegalle Plantations Ltd.

Publications

Dharmakeerthi, S and Yogaratnam, N (1992) Cheaper Fertilizer Mixture for *Hevea* plants raised by young budding technique. *Proceedings of the 48th Annual Session of the SLAAS*, December 1992.

Dissanayake, D M A P (1992). Plant and soil factors influencing the availability of phosphorus from natural phosphate sources. PhD thesis submitted to the University of Aberdeen, Scotland.

Samarappuli, L (1992). Effects of some soil management practices and moisture regimes on the performance of *Hevea*. PhD thesis submitted to the University of Peradeniya.

Samarappuli, L (1992). Weed management in rubber plantations. *Proceedings Weed Science Society of Sri Lanka* (In press)

Samarappuli, L (1992). Some agronomic aspects in overcoming moisture stress in *Hevea brasiliensis*. *Indian Journal of Natural Rubber Research* Vol. V and VI (In press)

Samarappuli, L (1992). Fertilizers to Rubber RRISL Advisory Circular No. 1992/01.

Samarappuli, L (1992). Ground covers and Cover Management, RRISL Advisory Circular No. 1992/11.

Samarappuli, L (1992). Soil Conservation RRISL Advisory Circular No. 1992/10

Samarappuli, L and Kannangara, K N (1992). Influence of different soil management practices on soil physical properties and their effect on growth of immature rubber. *Proceedings of the 48th Annual Session of the SLAAS, 1992, 14.*

Samarappuli, L and Yogaratnam, N (1992). Some aspects of soil moisture stress in *Hevea brasiliensis* grown under Sri Lankan conditions. *Proceedings of the Grantees Seminar CIDA Fertilizer Research Programme, May 1992.*

Samarappuli, L, Karunadasa, P and Mitrasena, U (1992). Effects of potassium and moisture stress on the performance of young *Hevea brasiliensis*. *Proceedings of the Malaysian Soil Science Society 1992 (In press).*

LABORATORY INVESTIGATIONS

Phosphate Nutrition

i. Dissolution of rock phosphates in rubber soils

A laboratory incubation study was carried out for 3 months to evaluate the factors governing the dissolution of rock phosphates. The effect of factors such as soil pH, P status, Ca content and time was evaluated on this aspect using top soils (0–15 cm) of *Boralu* series. The role of rubber factory effluent on P availability from ERP was also studied. Different amounts of ERP and IRP were thoroughly mixed with top soils (0–15 cm) of *Boralu* series to give 1.2g of P/2000g of soil. Factory effluent was added daily at the rate of 100ml per pot only up to 7 days of incubation. Treatments were replicated thrice and pots were kept in a glass house, according to randomized block design. Sub soil samples were drawn weekly.

Results showed that IRP has released significantly more P ($P < 0.05$) than ERP. But, application of effluent to ERP treated soils did not have any effect at the early stages. However, it was observed that effluent enhanced ($P < 0.05$) the dissolution of ERP with increased time suggesting that more time is required for the dissolution processes of ERP (Table 1).

Table 1. *Effect of different treatments on acetic- acid extractable P (mg/kg)*

Treatment	Time (weeks)				
	1	2	3	4	5
No P fertilizers	233.0 ^C	4.0 ^C	2.3 ^C	10.0 ^C	4.7 ^C
IRP	341.00 ^A	408.3 ^A	473.7 ^A	414.3 ^A	405.0 ^A
ERP	290.00 ^B	333.0 ^B	350.0 ^B	341.7 ^B	341.7 ^B
ERP + Effluent	328.7A ^B	345.7 ^B	399.0 ^B	381.7 ^A	384.0 ^A
Effluent only	14.7 ^C	14.0 ^C	8.3 ^C	14.3 ^C	5.6 ^C

(A Dissanayake, Jayasena Soyza, T Dissanayake, C Maheepala, R Gunasekera and C Jayalath).

ii. P fixation in rubber soils

An experiment was planned to quantify the P fixation capacities of different rubber soils. Soils were collected to represent all the rubber growing areas. Phosphate buffering capacity and equilibrium phosphate concentrations will be assessed for different soils by fitting P adsorption - desorption curves. Interrelationships of Fe, Al, clay and organic matter contents of soils with P fixing capacity will also be evaluated (A Dissanayake, A M A Perera, T Dissanayake, C Maheepala and C Jayalath).

FIELD INVESTIGATIONS

Soil-Plant-Water relation studies

i. Use of live and dead mulch on soil and moisture conservation

Effects of mulching on moisture stress, mineral composition, growth and latex production of *Hevea* were studied in experiments SM/82/5, SM/83/1 and SM/88/1.

Girthing had been much higher with mulching which resulted in the reduction of the immature unproductive period by 18 and 12 months in comparison with naturals and the conventional practice of growing creeping legumes respectively (Table 2).

Table 2. *Effect of different soil management practices on girth and tappability of rubber plants*

Treatment	Girth (cm)	Tappability (%)
Naturals	40.0 ^a	13.17 ^a
Legumes	44.5 ^b	25.58 ^b
Mulch	50.0 ^c	66.85 ^c

In addition to early tapping, yield of latex was also higher during the early stages, increases in the region of 33% and 40% were obtained in comparison with creeping legumes and naturals respectively. The present value of the benefit achieved from mulching amounts to Rs.27267/= per hectare of which Rs.11348/= is the savings on inputs (early maturity) and the balance of Rs.15919/= is due to extra yield (Table 3).

Table 3. *Increase in yield and income in response to mulching (up to 10th year of planting)*

Year of planting	Yield (Kg/ha/yr)		Yield increase due to mulching	Benefit due to extra yield	Present value of benefit
	Mulching	Legumes			
Year 6	325	Nil	325	8125	4116
Year 7	760	285	475	11875	5371
Year 8	953	675	278	6950	2807
Year 9	1035	907	128	3200	1154
Year 10	1235	928	397	7675	2471
				Total	15919

Rs. 25 per kg
Discount at 12% interest

Mulching also improved the physical and chemical characteristics of the soils (Table 4 and 5).

Table 4. *Effect of soil management practices on some physical characteristics of the soil*

Treatment	Soil moisture storage capacity (cm)	Bulk density (g/cm ³)	Porosity (%)	Penetrometer resistance (kg/cm ²)	Mean weight diameter (mm)
Naturals	21.7 ^a	1.27 ^a	51 ^a	10.31 ^a	32.41 ^a
Legumes	23.3 ^b	1.08 ^b	58 ^b	8.57 ^b	40.41 ^c
Mulch	27.6 ^c	1.02 ^c	61 ^c	8.61 ^b	37.65 ^b

Table 5. *Effect of soil management practices on some chemical characteristics of the soil*

Treatment	N(%)	P(ppm)	K (cmol/kg)	Mg (cmol/kg)	Organic C(%)	CEC (cmol/kg)
Naturals	0.165 ^a	9.3 ^a	0.090 ^a	0.1260 ^a	1.100 ^a	3.9 ^a
Legumes	0.179 ^a	11.5 ^b	0.094 ^a	0.1480 ^a	1.105 ^a	5.3 ^b
Mulch	0.145 ^b	18.5 ^b	0.113 ^b	0.2153 ^b	1.415 ^b	5.5 ^b

The above benefits clearly show that very significant financial and economic benefits could be achieved with the mulching technique, which will eventually increase the net returns due to higher yields and would also cut-down the C.O.P. due to early maturity. It should also be noted that in addition to the above quantified parameters, there are number of unquantifiable benefits that have to be taken into account in long run analysis which will further enhance the overall profit maximization process of the mulching technique (L Samarappuli, R Hettiarachchi, P Karunadasa and U Mitrasena).

ii. Fertilizer practices for overcoming moisture stress

Investigation on soil moisture and potassium (SM/88/4) indicated that under moisture stress situations increasing the level of potassium application, improved the growth performance of young rubber plants (Fig.1). This higher level of potassium might result in increased water use efficiency under stressed condition through significant reduction in transpirational loss of water by rubber (L Samarappuli, R Hettiarachchi, P Karunadasa and U Mitrasena).

iii. Identification of physiological parameters. (SM/88/5)

It appears in general that the water status of the clone RRIC 102 is better compared to other clones tested viz. PB 86, RRIC 100, RRIC 110 and RRIC 121, which also would enhance growth of the plants. The performance of young RRIC 102 plants may be improved as a result of the better plant water status. On the other hand the relative water content was also highest in clone RRIC 102 compared to other clones (Table 6).

Table 6. *Effects of different clones on leaf water potential (LWP) and relative water content (RWC)*

Clone	LWP (-MPa)	RWC (%)
RRIC 102	0.98a	90.19a
RRIC 100	1.05ab	87.91ab
RRIC 121	1.08bc	87.26ab
PB 86	1.12bc	86.44b
RRIC 110	1.15c	84.90b

Moreover leaf diffusive resistance measured indicated that clone RRIC 102 had the highest leaf diffusive resistance (Fig.2). Therefore among the important plant physiological characteristics, measurement of leaf diffusive resistance may serve as a useful parameter in screening clones for planting in marginal areas (L Samarappuli, R Hettiarachchi, P Karunadasa and U Mitrasena).

iv. Use of leguminous trees (SM/92/1)

This experiment was started to study the use of leguminous trees as hedges and their effects on soil and moisture conservation and on the mineral composition and growth of *Hevea* plants (L Samarappuli, U Mitrasena and P Karunadasa).

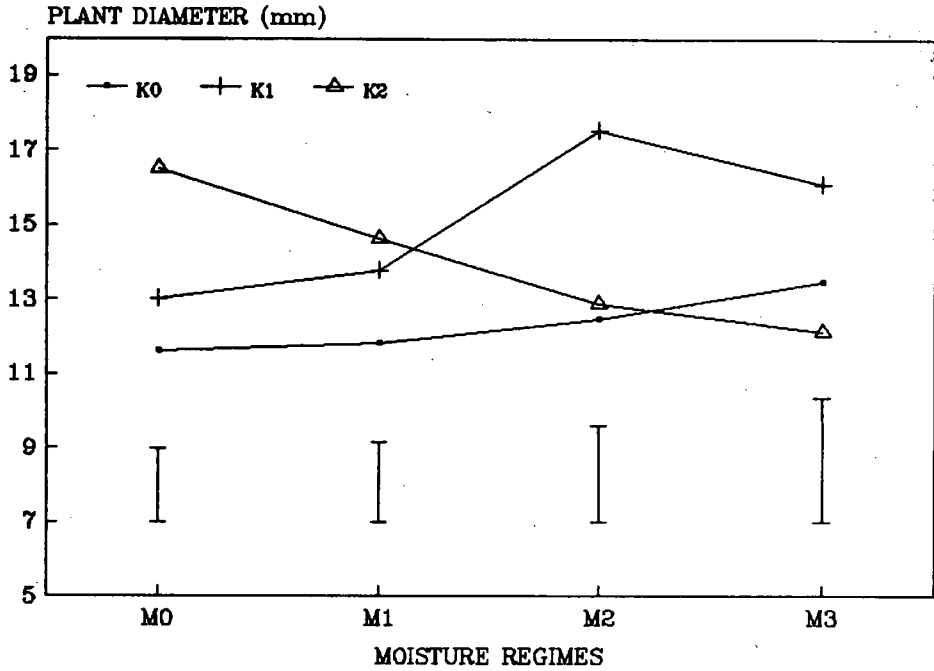


Fig. 1 Effect of different soil moisture regimes and K levels on plant diameter

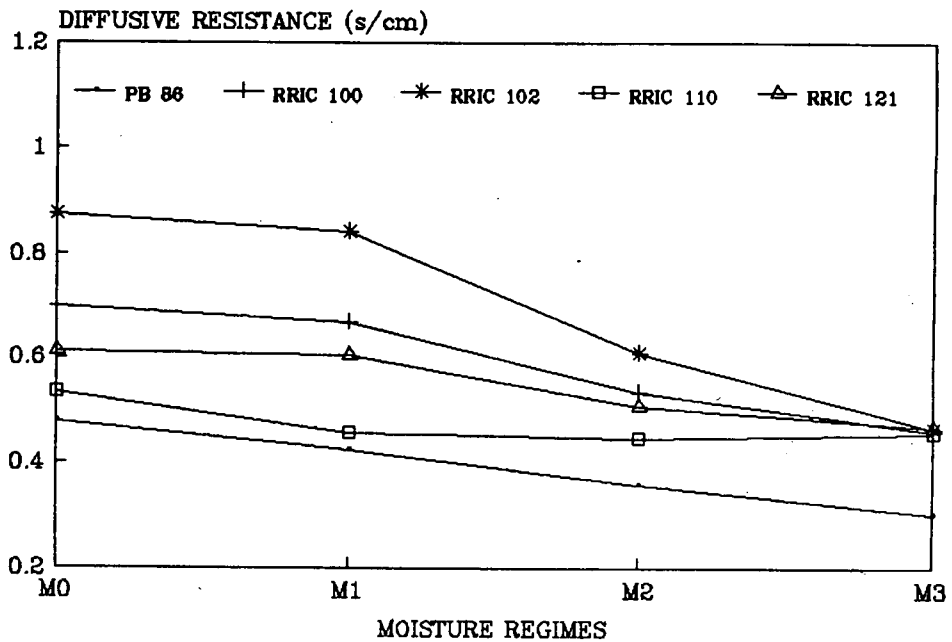


Fig. 2 Effect of different clones and moisture regimes on diffusive resistance

v. Organic manures

The use of organic manures in immature *Hevea* plantations is being studied at Elston estate Puwakpitiya (OM/86/1), Paiyagala estate (OM/86/2) and Hewagama estate (OM/88/1). Initial results obtained show an improved girthing of trees that received organic manure supplement (Table 7).

Table 7. *Effect of different fertilizer practices on girth of rubber*

Treatment	Girth(cm)
Inorganic fertilizer 1/2 normal rate	33.82
Inorganic fertilizer 1/2 normal rate + organic manure	40.06
Inorganic fertilizer normal rate	39.12
Inorganic fertilizer normal rate + organic manure	40.74

(N Yogaratnam and Geethal de Mel)

Phosphate Nutrition

A. Nursery plants

Two experiments were started (N/92/P/1 and N/92/P/2) at Ambetenna and Dartonfield estates in September 1992 to evaluate the effectiveness of Eppawela rock phosphate.

Treatments were as follows:

- T₁ - No P fertilizer
- T₂ - Imported rock phosphate
- T₃ - Eppawela rock phosphate

- T₄ - Eppawela rock phosphate + Effluent
 T₅ - Eppawela rock phosphate + Sulphate of ammonia
 T₆ - Effluent only

Studies on the possibility of using ERP alone and its effectiveness with sulphate of ammonia and rubber factory effluent were in progress.

Treatments did not show any effect on plant growth measured as stem diameter at the end of 3 months (data not presented).

At the age of 6 months the plants will be green budded. Soil chemical and biological parameters will be assessed at the end of the experiment, in addition to plant chemical analysis (A Dissanayake, T Dissanayake, R Gunasekera and Peter Perera).

B. Immature rubber

i. Effect of different sources and levels of P

Experiment started at Eladuwa estate to study the effect of different sources and levels of phosphate on the performance of clone PB 86 was continued. Soil and leaf samples were collected for analysis and girth measurements were made. The effect of ERP was similar to that of IRP and TSP on plant girthing (Table 8).

Table 8. *Effect of different sources of P on plant girth (cm)*

Source	Age (yrs)				
	1	2	3	4	5
IRP	2.92 ^A	4.74 ^A	25.27 ^A	33.29 ^A	38.72 ^A
ERP	2.95 ^A	4.69 ^A	24.76 ^A	32.17 ^A	37.16^A
TSP	2.87 ^A	4.81 ^A	25.94 ^A	33.49 ^A	37.72 ^A

(Means with the same letters are not significantly different at 5% level)

No significant differences were observed in plant girth between the recommended level (L1) and zero level (L₀) of P during the period of 5 years. But plants responded significantly ($P < 0.05$) to phosphate when the level was increased from zero to double the recommended level (L2).

Application of more phosphorous increased girthing during the latter stages of immaturity although both the normal and the double the recommended levels behaved in a similar way during the early period of plant growth (Table 9).

Table 9. *Effect of different levels of P on plant girth (cm)*

P level	Age (yrs)				
	1	2	3	4	5
L0 (No P fertilizer)	2.93 ^A	4.59 ^B	24.43 ^B	31.56 ^B	36.87 ^B
L1 (rec. level)	2.84 ^A	4.71A ^B	24.90 ^B	32.93A ^B	37.00 ^B
L2 (doub. rec. level)	2.98 ^A	4.94 ^A	26.62 ^A	34.45 ^A	39.73 ^A

(Means with the same letters are not significantly different at 5% level)

ii. Ability of different clones to utilize ERP

Arrangements have already been made to establish new experiments in different rubber growing areas to study the effects of ERP on the performances of RRIC clones such as 100, 110 and 121 (A Dissanayake, T Dissanayake, C K. Maheepala, R Gunasekera, Peter Perera and C Jayalath).

iii. Possibility of using both imported and locally available rock phosphates during the immature period

Arrangements have been made to evaluate IRP and ERP together as sources for P. During the early period plants will be fertilized with IRP and in the latter stages of immaturity with the ERP. Soil and leaf analysis will be done every year in addition to assessing growth parameters (A Dissanayake, T Dissanayake, C Maheepala and C Jayalath).

C. Mature rubber

i. Effect of different sources and levels of P

Field experiment started in 1976 on Boralu series of rubber growing soils was continued. Two levels of ERP and a rock phosphate fertilizer imported from Egypt (IRP) were tested in comparison with no P fertilizer treatment.

Application of rock phosphate fertilizers did not show any effect on the phosphorus content of the tree. The leaf P contents were fairly high even in plants that did not receive any phosphate and they were in medium to very high level range of threshold values established for rubber in Sri Lanka (Table 10).

Table 10. *Effect of rock phosphate fertilizers on leaf P content%*

P source	Leaf P%
Nil	0.255
IRP - Level 1	0.287
IRP - Level 2	0.290
ERP - Level 1	0.278
ERP - Level 2	0.278

Generally, the yield were higher during the period of December, February, thereafter it decreased (Fig.3). However, the yield of dry rubber was not influenced by added rock phosphate as no significant difference was observed between plants that received no phosphate fertilizers and those that received rock phosphate fertilizers.

Application of sparingly soluble rock phosphate to these mature rubber plants for several years would have helped in building up phosphate reserves in the soil. (A Dissanayake, T Dissanayake, R Gunasekera, C Maheepala and Geethal de Mel).

ii. Residual effect of added rock phosphate fertilizers

The above experiment has been converted to study the residual effect of phosphate reserves on the performance of rubber tree. Application of P fertilizers has

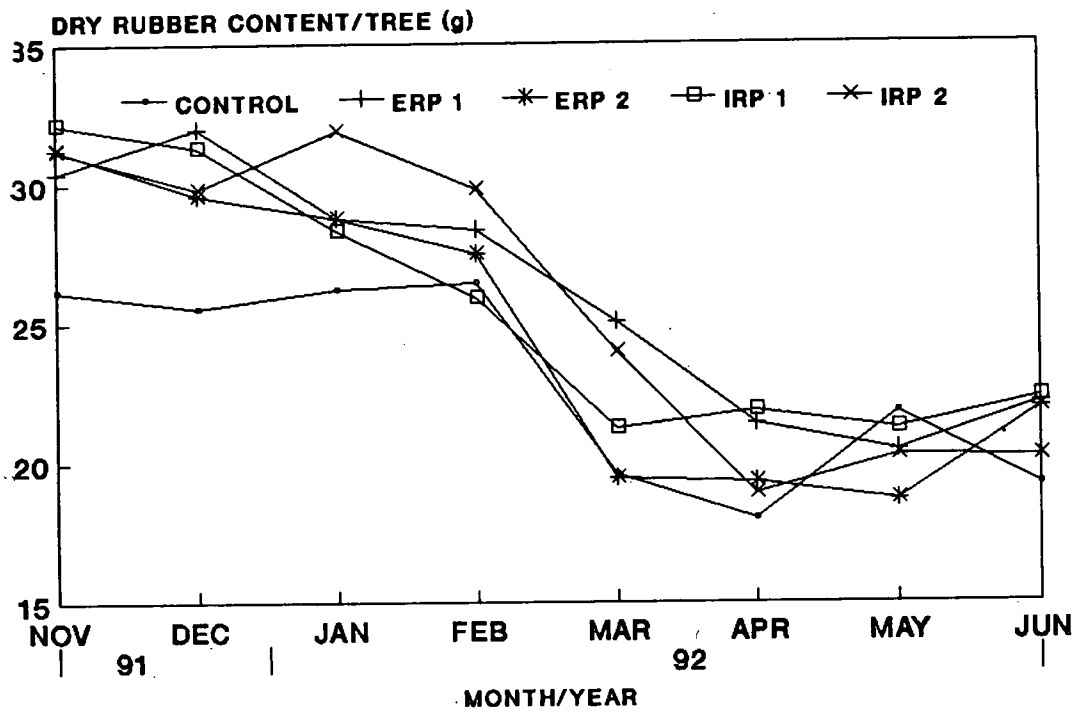


Fig. 3 Effect of rock phosphates on average monthly dry rubber content of the tree

been stopped from May 1992. The yield assessments will be made monthly in addition to analysis of both leaf and soil samples (A Dissanayake, T Dissanayake, R Gunasekera, C Maheepala, Peter Perera and C Jayalath).

iii. Evaluation of clonal differences in Rock Phosphate utilization

A field experiment was started which consisted with 4 replicates in Sorana, Perth and clyde estates to study the clonal differences in rock phosphate utilization. The recommendations for phosphate made by foliar analysis will be comparatively assessed with different rates of ERP on the performances of clones such as RRIC 100, 102,121 and 131. Yield, soil and leaf assessments will be carried out at different stages of the experiment (A Dissanayake, T Dissanayake, R Gunasekera, C Maheepala, C Jayalath and Peter Perera).

D. New approaches to increase the availability of P from ERP

i. Composting technique

An experiment was planned to use organic manures such as poultry litter, cow dung, rice straw, green parts of *Pueraria*, *Glyricidia* and waste materials from the rubber factory; effluent, in enhancing dissolution of ERP. These materials will be composted with ERP in two different ways. A 4'x4'x3' pit and a similar size wooden frame will be used for composting the materials. After different time periods, materials will be remixed thoroughly and sub samples will be analyzed for "available P" and microbial activities. The end product of composting will be evaluated as a fertilizer for nursery plants in comparison with both IRP, ERP and different ERP/effluent combinations (A Dissanayake, T Dissanayake, Peter Perera, C K Maheepala, C Jayalath and R Gunasekera).

ii. Mixing with coir dust

Preliminary arrangements were made to study the possibility of mixing ERP with coir dust to make "coir dust bricks" were investigated. Pieces of "ERP/Coir dust bricks" will be placed at different depths of polybags planted with rubber plants, and its efficiency will be assessed in comparison with ERP and IRP (A Dissanayake, T Dissanayake C Maheepala and C Jayalath).

iii. Mulching with rice-straw

Miriswatte Estate and Dorset Division of Clyde Estate were selected to study the effect of mulching on dissolution of ERP. Availability of P from ERP to immature rubber plants (clone RRIC 121) will be tested with and without rice-straw around the base of rubber trees. Growth measurements and chemical analysis of leaves of the plants will be carried out in addition to soil chemical and biological assessments yearly (A Dissanayake, L Samarappuli, T Dissanayake and C Maheepala).

iv Suitability of ERP to cover crops during immaturity

A Glasshouse pot experiment was planned to investigate the suitability of ERP to different cover crop species such as *Pureria* and *Desmodium*. ERP and a ERP+IRP mixture will be compared with IRP and no P fertilizer treatments. Experiment will be continued for 6-9 months and soil, plant analysis will be carried out at the end of the experiment (A Dissanayake, T Dissanayake, C Maheepala and R Gunasekera).

E. Mineralogy of rubber growing soils

This experiment was planned to evaluate the mineralogical characteristics of rubber growing soils. Initial work has commenced in collaboration with the Mineralogy Division of the CISIR, Colombo. One inch soil map of all the rubber growing districts were obtained from the Survey Department to demarcate the locations to be sampled. Different types of minerals present in different soil fractions will be examined by x-ray diffractometry in addition to chemical analysis for both macro and micro elements. Relationship between mineralogy and elements present in soils will be evaluated in relation to present fertilizer recommendation programme of the RRISL (A Dissanayake, A M A Perera, T Dissanayake, C Maheepala and C Jayalath).

Evaluation of fertilizer mixtures for young budding (YB/91/1)

This study was started to identify suitable fertilizer programmes which would be more economical than the current recommendation for young budding. Following treatments were allocated to single plant plots in randomized complete block treatment.

- T1 - Control (Nil fertilizer + watering)
- T2 - Control (Nil fertilizer + without watering)
- T3 - Sulphate of ammonia, muriate of potash and kieserite(Conventional mixture) + rock phosphate as a basal dressing + watering.
- T4 - Current recommendation for polybags (urea based) + watering
- T5 - Current recommendation for polybags (sulphate of ammonia) based + watering
- T6 - Current recommendation for young budding + watering
- T7 - CIC foliar application (Wuxal) + watering
- T8 - Mackwoods foliar application (Nitrophoska) + watering
- T9 - Sulphate of ammonia, tripple super phosphate, muriate of potash and kieserite (conventional mixture) + watering
- T10 - Latex effluent + watering

Treatment 6 and 9 have performed better, both in girthing and in success of budding compared to other treatments (Table 11). Considering the budding success cost of fertilizer to raise 1000 healthy plants in a nursery up to transplanting was calculated (Table 11).

Table 11. *Effect of different fertilizer treatments on budding success and cost of fertilizers*

Treatment	Budding success (%)	Cost of fertilizers (Rs)
1	-	-
2	36.8	-
3	57.9	743
4	-	-
5	42.7	-
6	70.4	536
7	55.5	618
8	50.0	740
9	73.3	470
10	40.6	-

It shows that the application of sulphate of ammonia, triple super phosphate, muriate of potash and kieserite in the form of conventional mixture is the cheapest compared to other treatments. But this mixture should be evaluated further for the method and frequency of application (S Dharmakeerthi, L Samarappuli and S N Silva in collaboration with N Yogaratnam).

Fertilizer requirements of new clones (F/91/1 and F/91/2)

These two experiments were started to study the fertilizer requirement of RRIC 110, RRIC 121, RRIM 712, 74-193 and PB 260. These high yielding and vigorously growing clones may differ in their nutrient requirements. Therefore following treatments were allocated to each plot and a pre treatment soil analysis was done.

Treatments

- T1 - No fertilizer
- T2 - 1/2 the current recommendation
- T3 - Current recommendation
- T4 - 1 1/2 times the current recommendation

Girth measurements, leaf and soil nutrient status will be done annually (S Dharmakeerthi, L Samarappuli and S N Silva in collaboration with N Yogaratnam).

Economics of fertilizer use in mature rubber

Economics of fertilizer utilization by mature rubber is being investigated in an experiment at Clyde estate, Dorset Division. Following treatments were allocated to each plot in a randomized complete block design with five replicates.

- T1 - No fertilizer from the first year of panel C
- T2 - No fertilizer from the second year of panel C
- T3 - No fertilizer from the third year of panel C
- T4 - No fertilizer from the fourth year of panel C
- T5 - Fertilizing throughout the panel C.

Yield data obtained are being analyzed. It is too early to make any

conclusions from this study (P I Yapa, L Samarappuli and S N Silva in collaboration with N Yogaratnam).

Extension trials on fertilizer use

Use of fertilizer in plantations is being investigated in the Avissawella region. Fertilizer treatments consist of no fertilizer control (T1), fertilizer on the basis of soil and foliar survey (T2) and conventional fertilizer mixture (T3). Yield data obtained is given below (Table 12).

Table 12. *Effect of different fertilizer treatments on yield of mature rubber*

Treatment	Year			Mean	Relative Yield(%)
	1989	1990	1991		
T1 (Control)	572.4	597.2	618.0	595.9	100
T2 (Leaf analysis)	528.4	567.4	580.6	558.8	94
T3 (Conventional mixture)	522.2	548.8	573.0	548.0	92

The results obtained from these experiments suggest that even fertilizers recommended on the basis of the soil and foliar survey programme are more than what is required by the plants under the conditions of these experiments (L Samarappuli and H D S P Perera in collaboration with N Yogaratnam).

Soil and Foliar Survey

The foliar survey programme for 1992 commenced in July and about 1000 hectares were covered this year. Computerized fertilizer programmes for the next 3 years (1993, 1994 and 1995) based on this survey were sent to all the estates (L Samarappuli, P I Yapa, A M A Perera, M Mahanama, A Yakandawela and T M Ahamadeen).

Chemical Analysis

Routine chemical analysis of soil, leaf latex and fertilizer samples collected for experimental and advisory purposes were carried out. Samples from other Departments and Organizations were also analyzed (P I Yapa, A M A Perera, R Hetttiarachchi and M Mahanama).

Adaptive Research Programme

Experiments were started to compare the effectiveness of growing bush/tree legumes with the current practice of growing creeping legumes on soil and moisture conservation in smallholdings in Kalutara and Kegalle Districts. Experimental details and results are discussed in the Review of the Adaptive Research Unit (L Samarappuli, F P W Silva, W C Dayaratne and A T Senadeera).

Use of poultry manure as a substitute for inorganic fertilizers in immature and mature rubber smallholdings is also being studied under Adaptive Research Programme (L Samarappuli and F P W Silva).

BIOCHEMISTRY AND PHYSIOLOGY

Neelamanie de Silva

SUMMARY

A modified rubber waste treatment system was tested at Dartonfield, Agalawatta as an experimental model with the intention of reducing the pollutant levels to acceptable standards.

Possibility of using rubber factory effluent as a fertilizer for mature rubber trees is being investigated at Culloden estate, Neboda.

Trials were continued to study the incidence of tapping panel dryness in relation to soil/plant nutritional status of mature rubber.

DETAILED REVIEW

Staff

Mr M T Warnakula Assistant Biochemist who was continuing his postgraduate research work until February 1992, left for Australia again. Mrs Neelamanie de Silva Assistant Biochemist, Mr M D C Seneviratna Technical Officer, Miss S Kudaligama Technical Officer, Mr P D J Rodrigo Specification Assistant, Mr D Ramawickrama Laboratory Attendant were on duty throughout the year.

LABORATORY AND FIELD EXPERIMENTS

Effluent Treatment

Research scale model installed at Dartonfield was used to study the feasibility of biological processes in the treatment of rubber factory effluent. Series of trials were continued by changing experimental variables. These trials were designed to obtain data to stipulate the design criteria of the system for large scale implementation. Analytical tests for the biologically treated serum were continued (M

T Warnakula, M D C Seneviratne, S Kudaligama, P D J Rodrigo, D Ramawickrama).

Effluent Utilization

Effect of rubber factory effluent as a fertilizer with special reference to N, P and K are being investigated at Culloden estate, Neboda. Effluent application was done according to the experimental design. Latex yield per tree and dry rubber content of latex were recorded at fortnightly intervals. N, P, K, Mg and Ca contents of soil and leaf samples were determined (Neelamanie de Silva, N Yogaratnam, M D C Seneviratne, P D J Rodrigo).

Tapping Panel Dryness (Brown Bast)

New high yielding clones of rubber have now been planted in most of the estates in Sri Lanka and the incidence of Brown Bast has also spread. Therefore, it has become urgent and important to prevent the occurrence of this disorder. An experiment was started at Eladuwa estate to study the incidence of tapping panel dryness in relation to soil/plant nutritional status of mature rubber.

Design - Completely randomized design

Clone - RRIC 100
120 brown bast affected trees were selected (tapped on "B" panel).
20 healthy trees in the same location were also selected for comparison purposes.

Treatments -

- T1 - No fertilizer application (control)
- T2 - 800g of appropriate N, P, K mixture/plant/year
+ 150g of Kieserite
- T3 - 1200g of appropriate N, P, K mixture/plant/year
+ 150g of Kieserite
- T4 - 1600g of appropriate N, P, K mixture/plant/year
+ 150g of Kieserite
- T5 - 2400g of appropriate N, P, K mixture/plant/year
+ 150g of Kieserite

The following assessments were made.

- Leaf analysis for N,P,K,Mg and Ca
- Dry Rubber Content of latex
- Latex, bark and leaf analysis for Proline, Proteins, Sugars and Sugar alcohols.
- Density of active latex vessels in the bark.

(Neelamanie de Silva, A Nugawela, M D C Seneviratne, S Kudaligama, D Ramawickrama).

Centrifuge Unit

The centrifuge unit functioned under Bio Chemistry Department and was involved in production of centrifuge latex for specification, Rubber Technology, Raw Rubber Development and Polymer Chemistry Departments.

RUBBER TECHNOLOGY AND DEVELOPMENT

N M V Kalyani

SUMMARY

Some latex formulations of better storage stability suitable for heat sensitization of irradiated latex by Zinc/amine system were developed.

A detailed investigation on the effects of clonal and soil characteristics upon technological properties of irradiated latex was initiated. Preliminary results suggest that trace metals such as Cu and Mn vary with the nature of clone and that these metal ions play a significant role in controlling the clarity of irradiated latex film.

Another large scale trial on the preparation of latex/bitumen emulsion was performed at Road Construction and Development Company (Pvt) Ltd.

A factory scale trial conducted to evaluate the performance of the new latex-based cement has produced very promising results.

A comparative study on the efficiency of some anionic and non - ionic stabilisers upon the stability of NR latex was performed. Attempts were made to compare the efficiency of Vulcastab LW as a stabilizer with that of a new commercially available stabilizer known as Wettem.

Some latex formulations suitable for coating of artificial fruits used for decorative purposes were developed to meet a request made by Magpek Exports Ltd.

Attempts were made to develop a quick and easy method to synthesize Epoxidised Natural Rubber (ENR) with various levels of epoxidation.

Several formulations have been tried out to prepare a foam of high dimensional stability.

The factory scale trial on the performance of brown crepe rubber grades in tyre retread compounds was completed. The results gathered were used to prepare a comprehensive report to prove the unsuitability of poor quality rubber in retread compounds. This report was circulated amongst all the retreaders in Sri Lanka.

A considerable amount of assistance was extended to leading retreaders in acquiring the precured retreading technology, a technology which is gaining rapid popularity amongst the tyre retreaders.

A quick and economical method for extending natural rubber with rubber seed oil at the latex stage was developed.

A study was initiated to investigate the effects of method of manufacture of RSS upon the physical properties of RSS based vulcanisates. The method of dilution used in the manufacture of RSS was found to influence the vulcanisate properties markedly.

A new study on the mastication behaviour of crepe rubber using Brabender Plasticorder has been initiated.

A preliminary study on the use of Thin Layer Chromatography (TLC) in analysis of rubber chemicals has been completed.

The department acquired a new equipment called Brabender Plasticorder during the year. Processing behaviour of 225 samples belonging to research officers of the Colombo office was studied using the machine.

DETAILED REVIEW

Staff

Dr (Miss) N M V Kalyani was on duty throughout the year. Mr B P Weeraratne, Assistant Rubber Chemist, continued his studies at the University of Loughborough, U K. Assistant Rubber Chemists, Mrs D G Edirisinghe and Miss H M M de S Rajapakse were on duty throughout the year. Mr D D Medagama, Experimental Officer, was on duty throughout the year. Technical Officers, Mr K M U Mithrananda, Mrs Sriyani I Yapa and Mrs Chintha S Munasinghe were on duty throughout the year. Technical Officer, Mr D P Wettasinghe resumed duties in the Department, after completing his Diploma in Chemical Engineering at the University of Moratuwa. Technical Officer, Miss Nisha Edirisooriya resigned from duties of the Institute with effect from 31st April 1992 to continue her studies at the University of Colombo.

Mrs Chintha S Munasinghe and Mrs Sriyani I Yapa, Technical Officers successfully completed the Diploma in Rubber Technology conducted by PRI, Colombo.

Visits

Dr N M V Kalyani participated in a UNIDO sponsored workshop on "Truck tyre retreads" held in Malaysia. Dr N M V Kalyani presented a paper on "Tyre Retreading Industry in Sri Lanka" at the workshop. An opportunity was given to visit Rubber Research Institute of Malaysia, Autoways (Malaysia) and Lee Rubber Factory, Kuala Lumpur, during the tour.

Dr N M V Kalyani visited the Brabender Application Laboratory in Duisburg, Germany to participate in a training on the use of Brabender Plasticorder.

Publications

Kalyani, N M V "Tyre Retreading Industry in Sri Lanka", Proceedings of the workshop on "Truck tyre retreads" Kuala Lumpur, Malaysia, 11 - 13 February 1992 (to be published).

Kalyani, N M V, Gunawardena, A, "Evaluation of performance of flat bark crepe, scrap crepe and RSS in tyre retread compounds," a paper submitted for publication in the *J. Rubb. Res. Inst. Sri Lanka*.

Meetings:

Dr N M V Kalyani participated in 4 sectorial committee meetings on "Rubber and Rubber Products" held at Sri Lanka Standards Institution.

Dr N M V Kalyani participated in 3 meetings of "Industrial Panel for manufactured Rubber Goods" held at the Ministry of Rural Industrial Development and Tourism.

Dr N M V Kalyani Participated at the Annual General Meeting of the Plastics and Rubber Institute, held at the Taj Samudra Hotel.

Dr N M V Kalyani participated in 2 committee meetings of the RVNRL group

Dr N M V Kalyani and Miss H Madhupani M de S Rajapakse attended the progress control meetings of the Road Development Authority to discuss the Latex/bitumen project.

Dr N M V Kalyani participated at the 6th Central Scientific Committee Meeting held at SLAAS.

Dr N M V Kalyani served as a lecturer for the Diploma Course in Rubber Technology organised by the Plastics and Rubber Institute.

Dr N M V Kalyani served as a lecturer for the Diploma course in Plantation

Management for factory officers organised by the National Institute of Plantation Management.

The Research Officers of the Department participated in a seminar on the use of FTIR spectroscopy held at the Mount Lavinia Hotel organised by Analytica Ltd.

The Research Officers of the Department participated in a seminar on the use of Brabender Plasticorder held at Ramada Hotel organised by the Analytical Instruments Ltd.

Dr N M V Kalyani participated in a seminar on "ISO 9000" held at the Institute of Engineers.

Dr N M V Kalyani participated in a seminar on "Rubber Manufacture and Related Post Harvest Operations" held at Savsiripaya, Colombo organised by the Rubber Research Institute.

Training

Rubber Technology and Development Department organised a two day course on "Rubber Products Manufacture" for about 30 people from Matara region who were keen to start rubber based industries.

LABORATORY INVESTIGATIONS

Latex Technology

1. Radiation Pre vulcanisation of NR latex

a. Irradiated latex in heat sensitive dipping applications

Suitable latex formulations of better storage stability for heat sensitization of irradiated latex by zinc/amine system were developed. Effects of variables such as former temperature, maturation period and concentration of added ZnO upon the heat sensitivity of these latex compounds were also looked into. All the variables tested were found to influence the degree of heat sensitivity of latex and the influence of

ZnO was found to be quite prominent. The results of this study were analyzed in detail and a comprehensive report was submitted to the Plastics and Rubber Institute as the project was carried out to meet a partial requirement of the Diploma in Rubber Technology of Mrs Sriyani I Yapa (N M V Kalyani, Sriyani I Yapa and Nisha Edirisooriya).

b. Effects of clonal and soil characteristics upon technological properties of irradiated latex

The Japanese experts in the field were keen to assess the consistency of the quality of special latex developed for radiation prevulcanisation by the research team of the committee for radiation vulcanization of natural rubber latex of Sri Lanka. Hence a study was initiated to investigate the influence of clonal and soil characteristics upon the technological properties of irradiated natural rubber latex. Two batches of special latex were prepared using latex from two different clones normally PB 86 and RRIC 100 at the Vincit Estate, Waharaka. Both batches were irradiated at TRCRE in Japan and were subjected to technological evaluations. It was observed that there is a noticeable difference in the technological properties of the latex films depending on the clone. The concentration of trace metals such as Cu and Mn were found to vary with the nature of the clone and it appears that those trace metals play a vital role in controlling the clarity of the irradiated latex film. However, further investigations are needed to establish these facts (N M V Kalyani, L Karunanayake, Sriyanthi Weeraman, H Narangoda (MSc Research student, Univ. Of Sri Jayawardenepura) and Chintha S Munasinghe).

2. Latex bitumen emulsions in road construction

A large scale plant trial on the in-situ preparation of one bowser of latex/bitumen emulsion was successfully performed at the Road Construction and Development (Pvt) Ltd., using a special type of cationic field latex. The resultant latex/bitumen blend was used by the Road Development Authority for sand sealing of a road stretch of about 500m length and approximately 2000m in surface area on the Mirihana/Ratmalana Road. It has been observed that the sand adhesion properties of the modified emulsions have been improved to a greater extent. However, the storage stability of the latex/bitumen blend was found to be quite poor. A separation of latex at the bottom of the mixture was observed. This factor is being corrected by altering the density of the special positex (N M V Kalyani, Madhupani M de S Rajapakse, Sriyani I Yapa, Chintha S Munasinghe and D P Wettasinghe).

3. Latex based cement with improved drying characteristics to be used in tyre retreading industry

The performance of the novel latex based cement developed last year was evaluated at the Associated Motor Ways Ltd. Two light truck tyres were used for this evaluation and both tyres passed the final inspection test after building. They were tested on the road after fixing to a company vehicle and no signs of tread separation or tread life were observed during the complete life of the tread. The company has indicated their willingness to acquire this technology to their production line if a large scale trial becomes successful (N M V Kalyani, L Karunanayake and Sriyanthi Weeraman).

4. Effects of some anionic and cationic stabilisers upon stability characteristics of NR latex.

A considerable amount of work has been done in the past on the influence of various types of stabilisers upon the stability of NR latex. Recently it has been demonstrated that locally available materials such as castor oil soaps can be used to increase the stability of NR latex. Based on this information some experiments were carried out to observe the efficiency of castor oil soap as a stabilizer and compare its efficiency with well known stabilisers such as ammonium laurate. Attempts were also made to compare the efficiency of vulcastab LW as a stabilizer with that of wettem, i.e. a new non - ionic stabilizer available in the market (N M V Kalyani and Chintha S Munasinghe).

5. NR latex based coatings for artificial fruits

Magpek Exports Ltd., requested for a suitable latex compound which can be used for coatings of artificial fruits used in decorative purposes. Several suitable latex formulations used in straight, coagulant and heat sensitive dipping methods were developed. Techniques of reducing the moisture content of the coatings of the finished products were also extended (N M V Kalyani, Dilhara G Edirisinghe and D P Wettasinghe).

6. Epoxidised natural rubber

It is well known that epoxidised NR vulcanisates do possess some commercially important characteristics such as low gas permeability, high oil resistance and high wet skid resistance. Attempts were made to synthesize ENR with different epoxidation levels by using various experimental conditions. The resultant

samples were analyzed for their relative levels of epoxidation using FTIR spectroscopy. The suitability of epoxidised samples in tyre retread compounds is being investigated (N M V Kalyani, H Madhupani M de S Rajapakse, Chintha S Munasinghe, D P Wettasinghe and Sriyani I Yapa).

7. Foam rubber

Several formulations have been tried out to prepare a foam with high dimensional stability. Most of the published formulations were found to give unsatisfactory results. A foam formulation which shows only a slight collapse upon heating was developed. Further work is in progress to improve the stability of the foam to the maximum (N M V Kalyani, Dilhara G Edirisinghe and Sriyani I Yapa).

Dry Rubber Technology

1. Evaluation of performance of poor quality rubber in tyre retread compounds

The factory scale trial on the evaluation of performance of poor quality rubber in tyre retread compounds was successfully completed. The results gathered were used to prepare a comprehensive report to prove the unsuitability of poor quality grades of raw rubber for tyre retread compounds. Copies of the report were circulated among all the retreaders in Sri Lanka. Some retreaders have already introduced our suggestions into their production lines (N M V Kalyani, Anoma Gunawardene).

2. Oil extended NR in tyre retreading

Further work was carried out on the use of rubber seed oil in the place of usual rubber processing oils to produce low cost compounds with better physical properties. Evaluation of physical properties of a tyre tread compound made using rubber seed oil showed an improvement in some physical properties. A very efficient quick method for incorporating oil into the rubber at the latex stage was developed. The new method has been found to be very economical and the stability of the oil incorporated latex has been found to be very satisfactory (N M V Kalyani, Dilhara G Edirisinghe, D D Medagama, K M U Mithrananda and D P Wettasinghe).

3. Effects of method of manufacture of RSS upon the physical properties of vulcanizates

It has been observed that the tensile properties of RSS based vulcanizates vary, depending on the method of RSS manufacture. In order to investigate this observation in depth a project was initiated with the assistance of a RSS manufacturer. A range of RSS sheets prepared according to various dilution conditions were used in this study. It was observed that the method of dilution has a marked influence upon the vulcanizate properties such as tensile strength, % elongation at break, hardness, resilience and compression set. Vulcanization characteristics of the compounds were studied using Monsanto Rheometer and the Brabender Plasticorder (N M V Kalyani, Dilhara G Edirisinghe, L Karunanayake, D P Wettasinghe and D D Medagama).

4. Mastication behaviour of crepe rubber

An investigation has been initiated to study the mastication behaviour of crepe rubber by using the Brabender Plasticorder. For this study, four crepe rubber samples prepared on for different days at the Dartonfield Estate were used. Within the four crepe rubber samples the consistency in the breakdown behaviour was quite good. Further work is being done on the mastication behaviour of crepe rubbers collected from different estates (S W Karunaratne, N M V Kalyani, Dilhara G Edirisinghe and D P Wettasinghe).

5. Thin layer chromatography (TLC) for analysis of rubber chemicals

Thin layer chromatography is one of the most popular and widely used techniques in separating and identifying chemical mixtures. Hence initial steps were taken in employing this technique in the field of rubber technology in measuring the purity of rubber chemicals as well as in identifying surface blooms of rubber based compounds and products. R/F values for a selected number of rubber chemicals were determined.

Iodine vapour and iodine solutions were used to visualize the separated spots. The method is being refined to identify surface blooms of rubber compounds and products (N M V Kalyani, Madhupani M Rajapakse, Dilhara G Edirisinghe, Anoma Gunawardena and Chintha S Munasinghe).

Industrial Extension

The following industries requested the services of the Department for product development and testing during the year under review.

Ratnayake Rubber Industries	-	Testing of solvents, cushion gum compounds
RRIATSCO (Pvt.) Ltd.,	-	Development and testing of tread compounds and cushion gum compounds for precured retreading
	-	Advice on improvements in compound processing and vulcanizing and tyre building and vulcanizing conditions.
Associated Motorways Ltd.,	-	Testing of tread compounds
JLS Company (Pvt.) Ltd.,	-	Testing of compounds
Road Grip	-	Testing of chemicals
Magpek Exports Ltd.,	-	Development of latex compounds suitable for coating artificial fruits
Kandy Tyre Rebuilders	-	Advice an reorganization of the retreading factory, compound processing, quality improvements, etc.,
Road Development Authority	-	Testing of latex/bitumen emulsions
Sarvodaya Economic Enterprises Development Services	-	Development of rubber seals of low water absorption characteristics
Richard Peiris & Co., Ltd.	-	Bloom analysis of rubber compounds
Plymouth Industries	-	Bloom analysis of rubber products
Grandslam Bridge Club	-	Rubber based spares for bridge tables
Sri Lanka Standards Institution	-	Testing of radiator hoses for adhesion strength and ageing characteristics

POLYMER CHEMISTRY

K G Karnika de Silva

SUMMARY

A detailed document was prepared on the innovation of depolymerized natural rubber and tender procedures were followed in offering the technical know how and other details of the manufacture of depolymerized natural rubber to Associated Speciality Rubbers (Pvt) Ltd, a local company on a royalty payment basis. Promotional brochures have been printed and distributed among the likely buyers. A new dryer will be installed at the factory to commence production of depolymerized rubber.

Expolaration of avenues for the use of depolymerized rubber in the adhesives industry has been continued. The use of depolymerized rubber as a base for primer for water proofing application and as the raw material in ebonite manufacture have been successful.

Commercial scale production of latex collecting cups and coagulating pans has been continued. The demand for coagulating pans is very high and it is intended to increase the production during 1993. The orders for these items can be placed either directly with the RRI or through the Regional Extension Officers of the ASD.

Several commercial scale batches of SP 10,20 and 40 rubbers were prepared during the year. Samples have been distributed among the foreign buyers by Associated Specialty Rubbers, for market promotions.

A study has been commenced to see the effect of various chemicals and different temperatures on latex stability. This study is important since some low ammonia preservative systems used at present contain toxic chemicals and takes about 21 days to achieve good mechanical stability.

Samples of latex were collected from Dalkeith Estate to study the reasons for the problems of frequent precoagulation of field latex supplied for centrifugation. A report was submitted on the observations made on the preservative systems and collection pattern. Some recommendations were made to improve the quality of latex to prevent precoagulation of latex. All for Chemistry & Technology Departments were involved in this study.

The first large scale trial on making cyclised rubber(CR) from natural rubber latex was carried out at Chemanex Ltd. Further trials on semi-commercial batches have been conducted in a reactor assembled in the laboratory to improve the solubility of CR. Discussions were held with Lankem Lanka Ltd and Masons Mixtures Ltd for commercialization of CR. A few trials were done in collaboration with the Road Development Authority to test CR based road marking paints.

Experiments on preparation of Epoxidised Natural Rubber(ENR) in the latex form carried out in the laboratory have been successful. However, these reactions have to be repeated to ensure the reproducibility. Dipped Products Ltd has shown an interest in this product.

Positex was used in several applications and samples were given to TRI and Magnum Garments Ltd, to test the suitability on relevant applications. A study has been started with the collaboration of University of Moratuwa to explore the possibilities of using positex with concrete to improve the water permeability including other physical properties such as shock and crack resistance and crushability.

A study on the effect of clonal characteristics and maturation of latex on gel content was carried out. It has been observed that the maturation of latex has a marked effect on the gel content.

A suitable antioxidant and co-sensitizer have been developed for radiation vulcanized NR latex systems in collaboration with Japanese Scientists.

Suitable formulations based on natural rubber latex were developed for screen printing bases, metal and fabric coating, carpet backing, wall paints and shoe cleaning liquid. Industrialists have shown keen interest on these products and research on improving the quality according to their requirement are being done in the laboratories.

Industrial trials were conducted in the laboratory to manufacture chlorinated rubber by a new method.

Several latex samples were prevulcanized with peroxide systems and tested for their physical properties. This will be important since the TMTD containing systems have now been considered as toxic systems in many applications.

Utilization of vulcanized and partially vulcanized waste material eg. used rubber slippers and cuttings were tried out in the laboratories in collaboration with Bata Shoe Co.

Research on the development of formulation for load bearing pads out of Low Nitrogen NR(LNNR) were carried out on a request by the Water Resources and Drainage Board. These pads will be required to lay underground heavy pipes on concrete.

Staff

Dr K G Karnika de Silva, Head Polymer Chemistry Department and Dr Pushpa Goonetilleke, Rubber Chemist were on duty throughout the year.

Mr S M C E Silva, Assistant Rubber Chemist left for UK in September 1992 for his post graduate studies on a grant offered by the Agriculture Research Project.

Mr H N K K Chandralal, Experimental Officer returned to the country in December after completing a one year training programme on Radiation Chemistry of NR latex in Japan.

Mrs Indra Denawaka, Experimental Officer and Mr S S Warnapura, Senior Technical Officer were on duty throughout the year.

Mrs Chitra Kuruppu, Senior Technical Officer successfully completed the Diploma of the Plastics and Rubber Institute. She was selected to undergo a training abroad under SRRP II grant scheme.

Messrs S L G Ranjith and L P Vitharana were on duty throughout the year.

Mrs Lakshmi Dissanayake, Technical Officer resigned and joined IFS Kandy with effect from March 1992.

Mrs Renuka Wijyaratne, Typist/Clerk was on duty throughout the year.

Messrs S Weerasiri, P G Sigera, Laboratory Attendants and Messrs L Piyasena, W D S Dharmawardene and J A Dayaratne were on duty throughout the year.

Research Students

Miss Krishanthi Muthukrishna, Miss Champa Wellapilli and Mr S Amaratunga, Msc students from University of Sri Jayawardenepura have started their research projects on Oil Resistant Properties Of NR blends, Epoxidation of Natural Rubber and Use of Depolymerized Rubber as a Processing Aid in the Tyre Industry, respectively, under the supervision of Senior Research Officers.

Mr W P M Abeysekera MSc student from University of Moratuwa completed his project on the processing behaviour of TPNR and submitted the thesis, in October 1992.

Overseas Visits

Dr Pushpa Goonetilleke visited Singapore on a training programme on FTIR Spectroscopy, in January 1992.

Reports

Suitable antioxidant systems for radiation pre vulcanized latex.

Microstructure analysis of radiation pre vulcanized natural rubber latex by probe electron spin spectroscopy.

Chlorinated paraffin wax as a co-sensitizer for radiation pre vulcanization of natural rubber latex.

The above Three reports were submitted by Mr H N K K Chandralal to Japan Atomic Energy Research Institute on the research work carried out in Japan under the Scientists Exchange Programme.

A report on 'Using FTIR Spectroscopy for Analysis' by Pushpa Goonetilleke submitted after a visit to Singapore connected with training on FTIR Spectroscopy.

Latex collection and Preservation from Dalkeith Estate by K G Karnika de Silva, W G M Seneviratne, N M V Kalyani and Anoma Gunawardena.

Publications

De Silva, K G Karnika (1992). Depolymerized natural rubber and Thermoplastic Natural Rubber, *Science Update-SLAAS News* 8, No.2, May 1992

Lectures/Seminars/Testings/Visits

Dr K G Karnika de Silva and Dr Pushpa Goonetilleke served as lecturers for MSc course on Polymer Science & Technology conducted by the University of Sri Jayawardenepura. The Senior Research Officers served as supervisors in their practical classes conducted at RRISL.

Dr K G Karnika de Silva served as a lecturer for the Diploma in Polymer Science course organized by the PRI.

The Research Officers participated at seminars on Brabender Plasticorder and FTIR Spectroscopy at Ramada Renaissance Hotel and Mt. Lavinia Hotel organized by Analytical Instrument and Analytical respectively.

Dr K G Karnika; de Silva participated at meetings at the EDB, Rubber Controllers Office and at the Institute of Chemistry regarding the exhibition stalls at the BMICH and Buttala.

The members of the PRI participated at the PRI Annual General Meeting at the Taj Samudra Hotel.

Dr K G Karnika de Silva served as a moderator at the workshop organized by NORAD at the BMICH.

Dr K G Karnika de Silva Participated at the Scientific Committee meeting held at SLAAS and the Rubber Council meeting held at the Tea Board.

Dr Pushpa Goonetilleka participated at a workshop organized by SLAAS.

Dr K G Karnika de Silva served as a moderator for the science examinations conducted by Sir John Kotalawela Defence Academy.

The Department staff participated at a seminar on Post Harvest Operations held at Sausiripaya.

The Research Officers served as lecturers for the Diploma course for Factory Officers organized by the NIPM.

Mr S M C E Silva conducted a lecture on adhesives for the small and medium scale industrialists at a seminar at Ratnapura organised by the Ministry of Industries.

Dr K G Karnika de Silva participated at a workshop on 'The Promotion of Invention & Innovation' at the Sri Lanka Foundation Institute organized by the Sri Lanka Inventors Commission.

Field & Laboratory investigations

1. Depolymerized Natural Rubber

Tender Procedures were followed in offering the method of manufacture of Depolymerized Rubber to an interested party. A detailed document on technical know how had been prepared and handed over to Associated Speciality Rubber (Pvt) Ltd who won the tender. A promotional brochure had been printed, samples had been sent

to the respective buyers and a market tour in Europe had been carried out in order to find markets for this new, non-toxic product. According to the latest information the current market for depolymerized rubber is about 3000t per annum.

A new dryer will be installed at the factory where commercial scale depolymerized rubber will be produced. The commercial production is likely to commence next year.

New applications on depolymerized rubber were found for the local consumer of this rubber. A successful application had been the development of pipe stems out of ebonite produced using depolymerized rubbers as the raw material. Currently the local adhesives industry also consumes depolymerized rubber to stick labels to metal boxes, paper and vulcanized rubber to concrete (K G Karnika de Silva, S M C E Silva and L P Vitharana).

Experimental trials on developing a new primer based depolymerized rubber for water proofing applications have been successful. The commercialization of the product will be done once the quality of the product is guaranteed on reproduction (Pushpa Goonetilleka, K G Karnika de Silva, H N K K Chandralal, S L G Ranjith).

2. Thermoplastic Natural Rubber

Rheological characteristics of Thermoplastic Natural Rubber had been studied using the facilities available at the University of Moratuwa. A computerised capillary rheometer was used in this study to find the best composition of PP, NR and crosslinking resins to give high impact strength to the material. A filler carbon black has also been incorporated to give the UV stability to the material and the physical properties had been studied. A MSc thesis has been submitted on this study (K G Karnika de Silva, W P M Abeysekera).

Latex coagulating pans and latex collecting cups have been produced in large scale at Hirani Industrial works and at Nawaloka Polysaks Ltd. Introduction and distribution of TPNR coagulating pans among the estates and smallholders had been carried out during the year. The demand for these pans is very high and Nawaloka Polysacks now finds it difficult to produce the material to meet the demand. Recycled material from PP waste had been tried in the production of TPNR.

Coagulating pans were issued to estates and smallholders directly or through the Regional Officers of the ASD at a cost of Rs.45/= per pan. A TPNR cup is sold at a rate of Rs.2.20 and over Rs.40 000/= worth of coagulating pans and cups have been sold during the year.

Inquiries had been made for latex collecting cups of 1 L capacity out from TPNR to be used on puncture tapped rubber trees with high volume latex collection.

TPNR material has been tried out in blow moulding as requested by an

industrialist. Certain improvements have to be made to use TPNR for this purpose.

The production of TPNR for the export market will be tried out by an Industrialist in 1993 at his new factory in Piliyandala. Initial discussions were held at RRISL Ratmalana recently in this regard (K G Karnika de Silva, S S Warnapura and S L G Ranjith).

3. Cyclised Rubber

Preparation of cyclised rubber on a large scale was carried out at Chemanex. It has been observed that more care has to be taken on controlling the reaction conditions for the large scale trials. The filtration process was carried out utilizing the filter press at the CISIR. Drying was also carried out on a large scale at the CISIR using vacuum drying and air drying to find the most economical and efficient method. Vacuum drying takes lesser time but air drying is more economical. Further work was carried out to rectify the other problems encountered with the cyclisation reaction and solubility of the product (Pushpa Goonetilleke, S M C E Silva, L P Vitharana, Indra Denawaka).

a. Preparation of Road Marking Paint

Formulations used to make Road Marking Paint were modified and the paint prepared was tested for its performance in road applications with the collaboration of the Road Development Authority. The abrasion resistance was poor when compared to other road marking paints. Therefore the formulation has to be perfected and further work to improve the quality of the paint is in progress (Pushpa Goonetilleke, S M C E Silva, L P Vitharana).

4. Epoxidation

ENR latex of different epoxy content have been successfully prepared. The stability of the ENR latex was found to be good. Resultant latex of 25% epoxy content was concentrated by centrifuging without coagulating problems. Analysis of ENR was carried out by FTIR and NMR spectroscopy. Further experiments are to be conducted to epoxidise latex in a larger scale and to test the suitability in applications such as gloves (Pushpa Goonetilleke, S M C E Silva, Champa Wellapilli (MSc student University of Sri Jayewardenepura, Chithra Kuruppu and L P Vitharana)

5. Positex

Prevulcanized positex was prepared by using a modified formulation. Tackiness of the latex films was a problem in earlier trials. Latex films prepared by the modified formulations were satisfactory. The retention of tensile properties after ageing was also found to be better than the conventional centrifuged latex systems (Pushpa Goonetilleke, Chithra Kuruppu and S L G Ranjith).

a. Positex/Bitumen Mixtures for water proofing

Positex was blended with bitumen in various proportions and the water permeability was measured by a simple laboratory technique. It has been observed that these mixtures form a film which is impermeable to water. A sample has been submitted to Tea Research Institute for such applications.

b. Positex in concrete

Rubber when incorporated to cement gives remarkable improvement in certain properties such as crack resistance, water permeability and crushability. Positex can be mixed with cement and sand without destabilisation. Mixtures of latex and cement have good binding properties to steel and can be used to repair concretes. A collaborative research project has been commenced at University of Moratuwa to carry out a detailed study on this subject. Preliminary experiments were conducted to evaluate the setting behaviour of latex/cement mixtures. The non rubber substances present in latex was found to affect the setting time and other properties (Pushpa Goonetilleke, Anura Nanayakkara (Uni. of Moratuwa) and S L G Ranjith).

6. Determination of gel content of latex

A study has been started to determine the effect of the maturation on the gel content of latex in clonal basis and it has been found that irrespective of the type of clone, maturation time has marked influence on the gel content. Reduction of gel content is an important aspect in the modification of natural rubber latex. Further work is in progress to identify the causes which control the formation of gel in latex stage (Pushpa Goonetilleke, S L G Ranjith, L P Vitharana).

7. Superior Processing Rubber (SP Rubber)

Commercial batches of SP 10,20 and 40 were prepared at Associated Speciality Rubbers at Yataderiya factory on their request. Sample have been distributed among the potential buyers in Europe.

The film properties of heat resistant formulations have been tested in the laboratories and found that high retention of properties after ageing can be achieved with these new formulations. It was also found that leaching in water is an important step to get improved physical properties in the end product.

Prevulcanization using the peroxide system to prepare SP rubbers have been tried out. Industrialists are now very keen in replacing very toxic materials from the vulcanizing medium in many applications. However, the trials conducted in the laboratories have not been very successful due to long prevulcanization times. This may occur due to the possible side reaction of accelerators and peroxides. Further work in these trials are in progress (K G Karnika de Silva, Chitra Kuruppu and S L G Ranjith).

8. Modified Lattices (For screen printing/textile coating/metal coating/shoe cleaning/rubber based emulsion paints)

Applications on modified lattices have been continued to improve the quality according to the customer requirements. Several new formulations have been tried out and the samples have been handed over to small scale industrialists for testing. Reports on some products have been satisfactory and it is intended to follow the tender procedures to handover the technical know how of the developments to interested parties.

Some of these projects need very low capital investment and can be therefore implemented under the Janasaviya programme.

9. NBR/NR Composites

Useful information including literature and analysis of the elastomers used in printing rollers have been given to Multipacks on request. It has been found (FTIR Spectroscopy) that the printing rollers fabricated locally use purely NR in the outer layer, which is not suitable for this purpose, since natural rubber does not have solvent resistant properties. The printing rollers are frequently cleaned with kerosene oil and the rubber tends to swell before using if for a considerable period of time.

The blends of NR/NBR have been tested for solvent resistant properties to improve the quality and performance of the end product. The method of mixing seems to have a marked effect on the performance of the material. Further work on the project is in progress (K G Karnika de Silva, S S Warnapura, Krishanthi Muthukrishna (Msc student Univ. Sri Jayawardanepura).

10. Development of a Primer

A request for development of a Natural Rubber based Primer to be used in water proofing applications was made by Lankem Development Ltd to replace a costly primer currently imported from India. Two compounds were developed using two different methods and were found to be superior to the imported primer. The properties of these samples will be evaluated (Pushpa Goonetilleke, K G Karnika de Silva, H N K K Chandralal and S L G Ranjith).

11. Determination of unsaturation using FTIR spectroscopy

Degree of unsaturation is a useful parameter in evaluation of the properties of modified rubbers as well as other unsaturated rubbers. The present method is a titrimetric method which is time-consuming and inconsistent. IR spectroscopy can be used to evaluate the unsaturation of rubber and a study was initiated to determine the degree of unsaturation of cyclised rubber which is related to the degree of cyclisation. IR spectra were obtained for cyclised rubber and uncyclised rubber. Further work is underway to improve the method (Pushpa Goonetilleke, S M C E Silva, Indra Denewaka)

12. Vulcanization of NR latex using UV/visible radiation

A new project was commenced in collaboration with University of Colombo to study the possibilities of vulcanization of NR latex by UV/Visible radiation. Different types and quantities of sensitizers were used to crosslink rubber by exposing to UV/Visible light for various time intervals. The crosslink density was determined by the solvent swelling test (S M C E Silva, Dayal de Silva (Univ. of Colombo) S S Warnapura and L P Vitharana).

13. Chlorinated Rubber

Chlorine was generated *in situ* to avoid handling of chlorine gas directly. Modified lattices with high stability were used for this purpose as the starting material. Further work on the project is in progress (K G Karnika de Silva, S L G Ranjith).

14. Latex stability and composite systems for low ammonia stabilized latex.

Several experiments are in progress to improve the stability of LATZ latex. Heating and passing steam to the latex medium reduced the storage time required to achieve the maximum stability to centrifuged latex. It is not very certain whether TMTD and ZnO on prolonged grinding could react to give ZDC which is less effective as a preservative compared to TMTD. However, more experiments have to be conducted before arriving at any conclusions. The ZBUD which is a more acceptable and non toxic chemical than TMTD has been tried out as a preservative system. Long term observations have been made and technological properties have to be evaluated in the future (K G Karnika de Silva, Lalin Karunanayake, Anoma Gunawardena).

15. Utilization of NR waste material

A project had been commenced to utilize the vulcanized and partially vulcanized waste shoe and slipper compounds from Bata Shoe Co Ltd. Initial trials were conducted and it has been observed that when the vulcanized material is blended with NR, the chemical used in compounding can be reduced significantly. The compound show low die swell and hence high dimensional stability due to the effect of the vulcanized compound present in the blend. Further work is in progress (K G Karnika de Silva, Lalin Karunanayake, Nimal Karunathilaka).

Industrial Extensions

Following industries were given assistance in their product developments, product improvement or testing. (In most cases speciality rubbers and modified lattices developed by the Department had been used).

Associated Speciality Rubbers	- SP Rubber/depolymerized rubber
Bata Shoe Co. Ltd.	- Bloom Analysis
DSI	- Identification of polymer in shoes by FTIR spectroscopy
Multipacks Ltd.	- NBR/NR blends for printing rollers
Plymouth Industries	- Rubber based adhesive for shoe waxing and canvas coating
Water Resoruces & Drainage Board	- Load bearing pads

Microcels	- Flame resistant mats
Mason's mixture	- FTIR analysis of resins
Lankem Ltd.	- Primer Développement
Sri Lanka Customs	- Identification of resins by FTIR spectroscopy
Korean Lanka Footwear	- Adhesives
PK Precision Industries	- Adhexives for labels
Palms	- Ageing of samples
Army Rehabilitation Centre	- Microcellular pads for invalids
Imperial International (PA) Ltd	- Screen printing
Inter Coir Ltd.	- Carpet backing, rubber paint coated metal frames
Various Industries on latex based paints	- Baby teats with low water absorption, shoe cleaning fluids, natural rubber

RAW RUBBER AND CHEMICAL ANALYSIS

L M K Tillekeratne

SUMMARY

The Raw Rubber and Chemical Analysis Department was engaged in the following activities during the year.

- (a) Analysis, grading and issuing shipping certificates for all TSR produced in the country.
- (b) Analysis of rubber chemicals and water used in the industry.
- (c) Analysis and certification of concentrated latex manufactured in the country for local industries and for export.
- (d) Research work was carried out to;
 - * Develop a non-toxic/preservative system for centrifuged latex.
 - * Increase mechanical stability of latex within a short period of time.
 - * Find out the effect of DAHP on the stability and KOH No.of centrifuged latex.
 - * Observe, the effect of seasonal variations on the stability of latex.
- (e) Assistance was given to other Departments in their research and extension work by analyzing dry rubber, latex, chemicals and water.

DETAILED REVIEW

Staff

Dr L M K Tillekeratne, Director who is over looking the Raw Rubber and Chemical Analysis Department, was on duty throughout the year except for a break of 3 months from the beginning of May to end of July.

Mr L Karunanayake, Asst. Specifications Officer proceeded to UK for his MPhil degree at University of North London in mid September 1992. Miss Anoma Gunawardane, Asst. Rubber Chemist was on duty throughout the year.

Experimental officers Mr A S Dekumpitiya and Mrs Sriyanthi Weeraman were on duty throughout the year.

Technical Officers Mrs Nanda Baduge, Mrs Leela Wanigatunge, Mrs Vasantha Gamage, Mr R S Wijesundara and Mrs Champa Lokuge were on duty throughout the year. Instrument Technician Mr P L Lelwala, was on duty throughout the year.

Specifications Assistants Messrs W Nandasena and K N Karunathilake, successfully completed the Diploma in Rubber Technology, conducted by the Rubber and Plastic Institute.

Specification Assistants Messrs G Wanigatunge, B Gunasiri and P L Perera were on duty throughout the year.

Specification Asst. (special grade), Mr W A S Wijesekara was transferred to Adaptive Research Unit with effect from 1st Jan.92.

Mr K K Austin retired from service on the 18th of Oct.92.

Miss Sumudu Dekumpitiya assumed duties as a temporary technical officer with effect from 13th Jan.92.

Laboratory Attendants Messrs W Vithanage, S Gallage and laboratory labourers Messrs G Somasiri and Piyasena, were on duty throughout the year.

Visits

Mr L Karunanayake visited Statcon Rubber Factory and the Centrifuged Latex Plant at Waharaka. Miss Anoma Gunawardane visited Plymouth Industries, F.T.Z. Katunayake and Microcells Limited, Piliyandala for extension and development work.

Training

Mr L Karunanayake and Miss Anoma Gunawardane delivered lectures to factory officers from SLSPC, JEDB and other estates for the diploma course organized by the NIPM. They also delivered lectures on "Rubber Products Manufacture" for rubber smallholders from Kegalle district, organized by the Rubber Technology and Development Dept.

Meetings & Seminars

Miss Anoma Gunawardane attended a two day seminar on "Methods of Chemical Analysis of Rubber Products" organized by the JETRO at CISIR on 13th and 14th July 92.

Publications

Kalyani, N M V and Gunawardana, Anoma. Evaluation of Performance of Flat Bark Crepe, Scrape Crepe and RSS in Tread Compounds. *J. of Rubber Research Institute*, to be published.

Sarath Kumara, P H and Weeraman, Sriyanthi. Test Methods for Rubber Bleaching Agents. *J. of Rubber Research Institute*, to be published.

LABORATORY INVESTIGATIONS AND FIELD EXPERIMENTS

Effect of seasonal variation on the stability of Natural Rubber Latex

The latex samples for the above project were collected every other week from Dartonfield Estate. In this project clonal variation was also studied.

Latex samples were frozen in a deep freezer and the frozen serum was analyzed for the following parameters.

1. Protein content
2. Mg²⁺ content
3. Fe²⁺ content
4. Density
5. Ash content

(L Karunanayake, W Nandasena and A Amarasekara)

New Preservation Systems for Latex

The project was started during the 2nd quarter of the year. Following chemicals were added to centrifuged latex as preservatives. DRC, TSC, NH₃ content, MST and specially VFA No. were determined along with the control samples.

1. 0.7% NH₃
2. 0.1% TMTD/ZnO + 0.2% NH₃
(as 0.1% TMTD/ZnO in 10% NH₃)
3. 0.2% NH₃ + 0.025% ZDC
4. 0.2% NH₃ + 0.05% ZDC

5. 0.2% NH₃ + 0.04% ZDC
6. 0.2% NH₃ + 0.04% ZDC + 0.01% ZnO
7. 0.2% NH₃ + 0.03% ZDC + 0.01% ZnO
8. 0.2% NH₃ + 0.025% ZBUD

Improved properties such as VFA have been observed in the new preservative systems, but as there were variations in the results these experiments were repeated with slight adjustment in the preservative systems used.

1. 0.7% NH₃
2. 0.2% NH₃ + 0.025% TMTD/ZnO
3. 0.2% NH₃ + 0.04% ZDC
4. 0.2% NH₃ + 0.03% ZDC + 0.01% ZnO
5. 0.2% NH₃ + 0.03% ZBUD + 0.01% ZnO
6. 0.2% NH₃ + 0.03% ZDC + 0.01% ZnO
7. 0.2% NH₃ + 0.03% ZDC + 0.01% ZnO

The tests were completed and the results are being evaluated (L Karunanayake, Anoma Gunawardane, K G Karnika de Silva and Leela Wanigathunge).

Methods to increase Mechanical Stability of Latex in a Short Period of Time

Experiments on this project have been performed with field and centrifuged latex. The field latex samples do not show any promising results. First, the treatments were done to both high ammonia and low ammonia centrifuged latex. On the basis of these results only the low ammonia centrifuged latex was taken into consideration in this study.

Treatments were as follows;

- (i) By increasing the temperature of latex
- (ii) By incorporating chemicals

The increase in temperature was done as follows;

- (i) Heated in a water bath at 60° C, for 30 min.
- (ii) Steam was passed through latex at 60° C, for 30 min.
- (iii) Hot water added to latex as 1:1 and the sample was centrifuged (Double centrifuging)

These treatments showed promising results.

The chemicals were incorporated as follows;

- (i) 0.1% of papain on latex
- (ii) 0.2% of papain on latex
- (iii) 0.3% of papain on latex

These samples also showed promising results, but after sometime they coagulated during MST testing. We are now repeating this experiment with different treatments (L Karunanayake, Anoma Gunewardena, K G Karnika de Silva and Vasantha Gamage).

Effect of DAHP on the stability and KOH No. of the centrifuged latex

It was found that there is a significant increase in KOH No. when DAHP is added in excess.

In the next trial the amount of DAHP was decreased below the usual amount (L Karunanayake, K G Karnika de Silva and W Nandasena).

Test Method for water soluble rubber bleaching agents

An analytical test method has been developed to determine the level of active ingredient in the water soluble rubber bleaching agent. It is essentially a titration method which gives highly accurate results. In this method, sodium salt of the mercaptan is reacted with std. silver nitrate solution added in excess and the amount of unreacted silver nitrate is determined by back titrating it with std. ammonium thiocyanate solution. Therefore the amount of the sodium salt of mercaptan reacted with silver nitrate could be worked out and hence the concentration of the salt solution is easily calculated (P H Sarath Kumara and Sriyanthi Weeraman).

New process for production of skim rubber

The skim latex was treated with soaps of different fatty acids in order to get a firm, coagulum. For this purpose P_0 and PRI values were compared with the control sample without addition of soaps. Further, the samples were compounded according to ACS 1 formula and tensile strength, modulus and elongation at break were measured (L Karunanayake and Anoma Gunewardena).

Extension Work

Bloom Analysis, for Plymouth Industries, F.T.Z., Katunayake.

The UV and IR spectra of the chemicals/powders bloomed on the surfaces of the shoes manufactured by Plymouth Industries were taken and compared with the spectra of authentic chemicals. The blooms were identified as MBTS (N M V Kalyani and Anoma Gunewardena).

Precoagulation of Latex, for Ansell Lanka Limited, Paiyagala.

The dispersions used as preservative agents supplied by Ansell Lanka Ltd., to different estates were analyzed. Their TSC and ZnO content were determined. Mg²⁺ contents of latex from these estates were also analyzed.

Trials were carried out to see the effect of time of addition of this dispersion to latex on their VFA No. and stability. Further the viscosity of the lattices were also measured. These trials were carried out at Dartonfield Estate (K G Karnika de Silva, N M V Kalyani, G Seneviratne, Anoma Gunewardene, Leela Wanigatunge and K N Karunathilake).

Flame Resistant Carpets, for Microcells Ltd., Piliyandala

Development of a formulation for flame retardant carpets has been under taken. Testing of the physical properties of normal carpets are being done at the moment. Compounding of a flame retardant compound is delayed due to lack of chemicals and testing equipment. Director of Microcell Ltd. has promised to supply them early (Pushpa Goonetilleke, Anoma Gunewardena and K N Karunathilake).

Testing of teats, for Kojakee Latex Products, Meerigama

Tests were carried out on the teats manufactured by Kojakee Latex Products, Meerigama, and they were compared with Doctor baby brand teats.

Following tests were carried out,

- (1) %Acetone Extraction
- (2) %Free sulphur
- (3) pH value
- (4) %Tension set

% Acetone extraction and % free sulphur were tested again after immersing the teats in boiling water (at 100° C) for 6 hrs, % swelling was also measured during these tests (K G Karnika de Silva, Anoma Gunewardene and Vasantha Gamage).

Miscellaneous

Table 1. *Number of samples tested from each TSR factory during 1992*

Code	Producer	No. of samples
AA	Sri Lanka Rubber Manufacturing Co. Ltd., Mawanella	40
AD	Statcon Block Rubber Factory, Getahetta.	776
AF	Ceymac Block Rubber Factory, Horana	3606
AE	Sherman Block Rubber Factory, Ingiriya.	1774
AI	Associated Traders Co. Ltd., Colombo	340
	Total	6536

Table 2. *Miscellaneous samples tested during the year.*

Rubber samples	1061
Latex samples	240
Chemical samples	38
Water samples	13
Gloves	17
Master Batch	17
Polythene	6
Total	1392

RAW RUBBER PROCESS DEVELOPMENT & CHEMICAL ENGINEERING

W M G Seneviratne

SUMMARY

Treatment and disposal of effluent from rubber factories were given high priority during the year and suitable systems were proposed to factories where the problems were found to be severe. Dr W M G Seneviratne also visited Malaysia to undergo a training on effluent disposal and treatment at the Rubber Research Institute of Malaysia. After extensive evaluation of literature on treatment methods available to treat industrial effluent, RRI now suggests a treatment method which involves both aerobic and anaerobic treatment in one unit, as one of the most successful and cost effective ways of treating effluent discharged from rubber factories in Sri Lanka. This method is being experimented on pilot plant scale and highly successful results were obtained.

Manufacture of Low Nitrogen Natural Rubber for export continued and few more trials will be carried out to improve the colour of LNNR without affecting the other raw rubber properties as some overseas buyers have shown interest in the colour of the product.

Blends of NR with rejected gloves in various proportions were tested in tyre tread formulations and the test results of the physical properties have shown that these blends are very much comparable to that of NR vulcanisates of the same formulation.

Few tyres retreaded using oil extended NR are under investigation to intensify the use of this material with a view to achieve desired physical properties expected from a tyre.

The prize for the second best stall was awarded to RRI at the exhibition Environlanka '92 held during the end of the year. The staff of the Department actively engaged in the preparation of the stall and actively participated at the exhibition to achieve this credit and distinction for the RRI.

The first batch of trainees successfully completed their course of training on rubber products manufacture at Dartonfield.

DETAILED-REVIEW

Staff

Dr W M G Seneviratne, Acting Head of the Department, visited India to present a paper on "Rubber modified thermoplastics" at the International Natural Rubber Conference held in Bangalore from 5th - 8th February. He also proceeded to Malaysia to attend a training programme on "Exposure to rubber effluent water treatment processes carried out in Malaysian raw rubber processing and products manufacturing industry" during the period 17th August and 5th September. This programme was conducted by the Rubber Research Institute of Malaysia and sponsored by the IRRDB.

Mr Susantha Siriwardane, Assistant Rubber Chemist, was on duty throughout the year.

Mr S L Weerasinghe, Experimental Officer resigned from the Institute on 15th May 1992.

Messrs P H Sarath Kumara, C Senanayake, T A S Siriwardane, Mrs Chandrika Nalini, Technical Officers were on duty throughout the year.

Messrs U Dharmasena and H A Ariyaratne were also on duty throughout the year.

Research Students

Mr A M S Abeykoon, MSc student from University of Sri Jayawardanapura, continued a research project on "The recycling of rubber glove rejects to be used as a raw material/blend for rubber products manufacture" from July 1992 under the supervision of Dr W M G Seneviratne.

Six students from the University of Moratuwa were trained under the National Apprenticeship Board Scheme.

Visits

Advisory visits to Estates:

The following estates were visited during the year in order to sort out the problems encountered in each factory.

Adapana State Plantation

Smoke house which has been burnt during the insurgency period was inspected and a building plan for a new smoke house was forwarded since it was decided that the demolished smoke house could not be renovated upto a reasonably standard condition at a nominal cost.

Culloden State Plantation

Some white patches occasionally appeared on sole crepe produced in this factory. The effect is more pronounced during the rainy periods. It was found after examination that this problem was due to the entrapped drops of water between thin laces of crepe and these water drops come into contact with dried laces due to leaks in the roof of the drying tower.

Elpitiya Estate

An inspection was carried out following a complaint made with regard to pink discoloration which appeared more often on the finished crepe laces. The reason for this was found to be the delay in processing particularly because the machinery available in the factory is unable to cope up with the daily crop and a comprehensive report was sent.

Neuchatal Estate

Analysis of water used on the process lines of the factory indicated it contained unacceptable levels of iron which caused the discoloration of their crepe rubber. The supply of water to this factory is from the nearby river and is used without a proper filtering system. Hence, higher metal contamination is unavoidable and instructions were given to construct a water filtering tank.

Reucastle Estate

The main reasons for mottled appearance on blanket crepe on storage appeared to be the slightly varying thickness of the laces and insufficient drying and also longer drying time on the loft. The manager was requested to fix two expeller fans in the loft.

Sapumalkande Estate

Development of mould in patches on storage of crepe was found to be due to the varying thickness and insufficient drying. Advice was given to improve the drying condition and the conditions of the machinery.

Tiriwanaketiya Estate

The same problem which was encountered at the Culloden Estate was reported in this estate too. On inspection, it was observed that the dried laces are contaminated with rainy water which beats into the drying tower with the blowing winds and necessary instructions were given to eliminate the problem.

Elston Estate

Detailed survey was carried out with an engineer from M/S Industrial Engineers in view of setting up an effluent treatment plant. Detailed sketches of the plans of the proposed aerated pond with a report was submitted.

Lalan Rubbers

On our instructions M/S Lalan Rubber Co Ltd. tried out the effluent cascading treatment technique on a small scale to study the feasibility of the method.

SRMC - Silverdale Factory

A comprehensive report was submitted to SRMC with plans etc. to commence the RSS manufacture in the factory where only pale crepe is manufactured at present.

SRMC - Mawanella Rubber Complex

This factory was visited twice during the year. Detailed plan of a proposed effluent treatment plant was furnished with the assistance of M/s Industrial Engineers.

Dalkeith Estate

Entire crop of latex of this estate is bought by M/s Ansell Lanka Ltd. for the production of centrifuged latex. Increase in VFA No was constantly observed in latex of this estate and as a result, pre-coagulation occurred in numerous occasions. This was studied in detail and a comprehensive report was submitted. The study included the

analysis of Mg content over a period in the Kalutara, Kegalle and Mawanella regions.

Rambukkande Estate

A comprehensive report, on the expansion of factory to cater to another 1500 kg of anticipated bought latex, was submitted. The report included the introduction of two more smooth mills, bulking and coagulating tanks and also the increase in drying facilities. Introduction of forced air drying system was suggested to the drying tower in place of existing boiler-radiator system. This installation would easily facilitate the drying of another 2000-2500 kg of rubber.

Devalakande Estate

This estate was visited and necessary advice was given to increase the percentage of No 1 scrap crepe.

Advisory visits on LNNR manufacture:

More inquiries were made in this year by several estates regarding the manufacture of LNNR.

Elpitiya Estate

A trial was carried out and successful results were obtained. Though this factory possesses bulking and coagulating facilities, large scale manufacture of LNNR in this estate could not be done due to lack of milling facilities.

Nakiadeniya Estate

Several trials were carried out and required properties except colour were achieved. The colour could be improved after another trial, but with a slight drop in PRI.

Kiriwanaketiya Estate and Yatadola Estate

Factories were visited on the requests of the superintendents and necessary instructions were given to produce better quality LNNR. A special trial was carried out later at Kiriwanaketiya Estate using a brightener in order to obtain LNNR with a lighter colour.

Visits on effluent treatment and disposal:

Large number of estates were visited following many complaints from the residents near rubber factories. The most suitable treatment technique was recommended to each estate, after evaluating the environment, the volume of the effluent discharged daily, the location of the factory and the availability of space for the treatment plant etc..

Reports and sketches of plans of treatment plants were sent to relevant estates and personnel.

Visits on energy management:

High consumption of energy was reported at Nakiadeniya Estate. Inspections revealed that the capacitors fixed in this factory were not in order and they were not fixed to the two roll mills.

Meetings and seminars

Dr W M G Seneviratne addressed a seminar on "Effluent treatment and disposal" organized by the RRI at Savsiripaya for new management personnel of the plantation sector.

Dr W M G Seneviratne attended the NIPM Technical Committee Meetings.

Dr W M G Seneviratne addressed a seminar on "Manufacture of better quality rubber" organized by the Kegalle Plantations Limited at the Planters Club in Kegalle.

Dr W M G Seneviratne addressed the A.G.M. of the Planters Association on "Usage of chemicals in rubber industry and Effluent disposal systems" at Tebuwana Planters Club.

Mr P H Sarath Kumara attended a seminar on "Process Control and Quality Control" organized by the Export Development Board, at the Rubber Products Development & Services Centre, IDB, Peliyagoda, on 10th July, 1992

Dr W M G Seneviratne served as a visiting lecturer on Polymer science and Technology course at University of Sri Jayawardanapura and University of Colombo.

Dr W M G Seneviratne attended a few Rubber Council Meetings held during the year.

Dr W M G Seneviratne and S Siriwardane attended two meetings, held in Horana and Colombo, with SLSPC Chairman and the SEC delegation to finalize the matters connected with the construction of an effluent treatment plant at Neuchatal Estate.

Publications

Seneviratne, W M G. Some Studies on Rubber Modified Thermoplastics, *Proc. of the Int. Nat. Rub. Con., Bangalore, India. 5th - 8th, February, 1992.*

Training

The project started to train Janasaviya recipients on manufacture of latex based products was continued during the year. It was noticed that most of the trainees were reluctant to attend the training programme, which was thought to be due to non-availability of an allowance during their training. When the assistance of N.A.B. was sought, through Mr Imetias Bakeer Marker, Hon. State Minister for Housing, we were able to obtain a monthly allowance for these trainees for the latter 6 months of their training. Mr P H Sarath Kumara was assigned the task of conducting this training programme under the supervision of Dr W M G Seneviratne.

Dr W M G Seneviratne, Mr S Siriwardane and Mr S L Weerasinghe delivered lectures to the factory officers from SLSPC, JEDB and the private sector at a seminar organized by the NIPM. Dr W M G Seneviratne attended the Field Day for Planters of SLSPC, Galle.

LABORATORY AND FIELD INVESTIGATIONS

Extraction of the thiol from oil based solution of the Rubber bleaching agent and conversion to Water Soluble form

At the request of Elastomeric Engineering Co Ltd., laboratory trials were conducted and a very convenient and simple method was developed to extract the

mercaptan from the solvent and readily convert it to the salt to make it soluble in water. A demonstration followed at Elastomeric Eng. Co. Ltd. at Horana (W M G Seneviratne, P H Sarath Kumara, S Siriwardane).

Study of the possibility of using serum as a coagulant in RSS manufacture

Initial trials were conducted at the Dartonfield rubber factory using serum from crepe manufacture. The coagulum was processed into thin crepe and raw rubber properties were tested as the first step of the project. Results obtained are given below.

Ratio of field latex:serum	Dirt	Ash	V.M.	N	Po	PRI	Remarks
Field latex coagulated with acid	0.016	0.15	0.49	0.24	50	64	clear serum
1:1	0.019	0.19	0.72	0.26	49	52	resultant serum is slightly milky
2:3	0.012	0.15	0.66	0.23	55	65	- do -
1:2	0.016	0.14	0.64	0.23	57	87	- do -

The results indicate that the raw rubber properties of serum coagulated rubber is comparable with that of the control sample which indicate that serum can be used as a partial coagulant in combination with acid.

Some RSS sheets were also manufactured using acid/serum and the samples are to be tested for raw rubber properties (S Siriwardane, P H Sarath Kumara, T A S Siriwardane).

Oil extended Natural Rubber

OENR was prepared incorporating 20 parts of oil in the latex medium at the Dartonfield rubber factory. The vulcanisate prepared using an improved formulation for truck tyres based on the Fourth Interim Report published by UNIDO on "Truck Tyre Retreading Materials" was tested for physical properties and the results obtained are as follows;

Sample	Tensile Strength (mpa)	Elongation at Break (%)	Abrasion (cm ³ /1000 rev)	Tear Strength (mpa)
20%OENR/80% NR	22.3	500	0.0475	13.4
NR (control)	21.1	400	0.1524	6.9

Results indicate that the blend is superior in properties when compared to that of control sample.

Few tyres were retreaded using this blend at Associated Motorways Ltd. and road trials are now underway (W M G Seneviratne, C Senanayake and C K Nalini).

Recycling of Rubber Glove Cuttings

Several blends of glove rejects with SLR 20 were compounded according to a standard tread formulation and tested for physical properties. Evaluation of results indicate that upto 20 parts of glove rejects could easily be incorporated in the blend with minimal detrimental effect upon the physical properties.

Processing safety and the reversion resistance of the compound could be greatly improved when the ZDEC/MBTS vulcanizing system with 3.5 pphr stearic acid were employed in the formulation according to an earlier work.

Further work on this project will be continued and a comprehensive report on it will soon be published. Since the glove manufacturing industry in Sri Lanka continues to grow, this project will have an important bearing on the tyre retreaders if they wish to use this blend in their retreads. Plans are underway to commence large scale trials (W M G Seneviratne, A M C Abeykoon, P H Sarath Kumara).

Low Nitrogen Natural Rubber (LNNR)

Although, the method of manufacture of LNNR has been perfected, some overseas buyers informed the manufacturers through the brokers that they are also interested in the colour of the LNNR. While use of whiter coloured clonal lattices is a pre-requisite in the manufacture of lighter coloured LNNR, few trials were carried out using mixed lattices as well, under varying conditions to find out the possibilities of meeting with the above requirement, without affecting the other properties.

The colour of all these LNNR samples was found to be satisfactory compared to that of the earlier batches. Slight reduction of PRI could either be due to clonal effect or most of the antioxidants present in rubber may have been washed off as a result of excess dilution and maturation. Further work is being continued (W M G Seneviratne, S Siriwardane, C Senanayake).

Chlorination of NR latex

Few stabilizers and their combinations were tested to stabilize NR latex for chlorination in the presence of hydrochloric acid with a view to find a suitable stabilizer system which will result in a soluble chlorinated product.

Varying solubility was observed with different stabilizer systems and attempts are now focussed on the use of this product in conjunction with other synthetic polymer lattices in order to increase the chemical resistant properties when used in the paint industry as a binder (W M G Seneviratne, S Siriwardane, U Gamlath).

Effluent treatment and disposal

Dr W M G Seneviratne underwent a training on effluent treatment in Malaysia which was conducted by the Rubber Research Institute of Malaysia between the period 17th August to 5th September 1992. This was sponsored by the International Rubber Research and Development Board and gave an extensive exposure to the various effluent treatment techniques adopted by rubber factories in Malaysia. These techniques involve ;

- 1) Anaerobic/facultative ponding system
- 2) Oxidation ditch system
- 3) Activated sludge system
- 4) Rotating biological contactor method
- 5) Land disposal

Anaerobic/facultative ponding system is the most common treatment technique adopted by many rubber processing factories in Malaysia because of the availability of abundant space in most places. Although, the total retention time largely depends on BOD levels of the effluent, it will not be less than a month. Hence, ponds will cover an extensive area of land and may not be suitable for most rubber factories in Sri Lanka. Oxidation ditch, activated sludge and rotating biological contactor system are suitable for places where space is a deciding factor for setting up of a treatment

plant. However, operational and maintenance cost of these treatment plants are very high and hence become not viable to implement in most Sri Lankan rubber factories except in very few places.

The technique of disposing effluent by way of distributing on land is found to be satisfactory in places where it is practiced. In certain factories in Malaysia, this has been continuing for the last fifteen years and found that the method is not only a satisfactory way of disposing the effluent but also it acts as a fertilizer to the plants. Although, the operational cost is low, cost of implementation is somewhat higher. Since air pollution due to liberation of obnoxious gases from anaerobic digestion is very significant in places where effluent is distributed on land, it is advisable to apply this technique in fairly remote areas of the estate .

Anaerobic enclosed digestion coupled with aerobic treatment method

After an extensive evaluation of the previously available techniques, RRI now managed to develop a cost effective treatment technique in which both anaerobic and aerobic treatments are involved. Basically treatment plant consists of the following.

1. Anaerobic enclosed digester
2. Aerobic treatment plant/pond
3. Sedimentation lagoon

Based on preliminary investigations an enclosed deep septic tank filled up with rubberized coir was selected as an anaerobic digester. Rubberized coir act as a carrier medium for anaerobic bacteria which grows in the digester .

In anaerobic-facultative ponding treatment system volumetric loading rate is 0.12-0.15 kg BOD per unit volume of the anaerobic pond per day with hydraulic retention time of ten days, whereas, in the rubberized carrier anaerobic digester even at organic volumetric loading rate of 3-4 kg BOD per reactor volume per day, about 60-70% treatment is easily achieved with hydraulic retention time is only approximately 16 hours. This justifies the size reduction of the anaerobic digestion pond when a carrier matrix is used compared with normal anaerobic pond. Pilot plant scale treatment plant of this technique has been set up at Matugama Rubber Mills and results mentioned above are more encouraging and satisfactory than that obtained so far from any anaerobic treatment carried out for rubber effluent.

Anaerobically treated effluent should further be treated by aerobic treatment for removal of rest of the organic. RRI has developed the following techniques and found to have given successful results from pilot plant experiments.

- 1) Effluent cascading technique

- 2) Rotating coirbelt contractor system
- 3) Fine bubble aeration technique

Effluent is finally discharged after sedimentation of sludge in a lagoon only for 1-2 days.

Treatment plants

Neuchatal estate	aeration technique Tanks required for treatment are completed.
Pallegama estate	rotating coirbelt contactor unit Plant is in operation.
Atale, Siriniwase	rotating coirbelt contactor technique Although plants are not yet ready, work of making rubberized coir brushes mounting frames are finished and will be commissioned soon.
Mahaoya	anaerobic digester, coupled with rotating coirbelt will soon be in operation in the factory.
SRMC Mawanella	anaerobic digester with aeration system suggested for centrifuged latex factory.
Padukka estate	at the first stage, setting up of the anaerobic digester was suggested and hopefully will be in operation soon.
Matugama Rubber Mills	anaerobic coupled with effluent cascading set up and it is now in operation successfully.
Nakiadeniya oil palm and rubber factory	anaerobic digester with aeration system has been proposed. Project will be commenced shortly.

Other Activities

1. Effluent cascading treatment plant and related material were displayed at the Gam Udawa Exhibition held in Buttala from 23rd June to 3rd July 1992.

2. Effluent cascading treatment plant was displayed at the exhibition "Chemistry & Environment" organized by the Institute of Chemistry at the BMICH.

3. The Department participated at the exhibition ENVIRONLANKA'92 organized by the Ministry of environment and parliamentary affairs at the BMICH from 10th to 12th December. The exhibits displayed at this exhibition reflected the advances made by the RRI in the development of techniques for treating rubber factory effluent. This exhibition was the first of this kind to be held in Sri Lanka with a view of making people aware of the importance of the protection of the environment and the control of the environmental pollution created due to discharge of industrial waste by various industries in Sri Lanka. The RRI was awarded the 2nd prize for the best stall out of over 82 participants both from the public and private sector among which the NERD centre, CISIR, Water Resources Board were some from the public sector.

ADAPTIVE RESEARCH

N Yogaratnam

SUMMARY

Few new programmes were started in smallholder fields which included the use of rubber serum as fertilizer, the use of plastic cups and varnish coated coconut shell for latex collection, coagulating pans for rubber coagulation and multicropping of rubber lands with tea.

Most of the smallholders showed keenness in participating in these programmes, although a few trials had to be discontinued due to lack of interest by smallholders.

Tea plants were not affected by drought in the Tea + Rubber experimental plots on state sector estates.

DETAILED REVIEW

Staff

The Deputy Director (Research), Dr N Yogaratnam coordinated the activities of this unit. Mr S M M Iqbal, Research Assistant in Agronomy and Assistant Development Officers Messrs F P W Silva, P P Jayasinghe and W C Dayaratne were on duty throughout the year. Mr K B Karunasekera, Assistant Development Officer continued working in the Genetics and Plant Breeding Department while helping the adaptive research programme. Mr E A T Senadeera, Senior Technical Officer continued to work in the Kegalle region. Mr W A S Wijesekera, Specification Assistant (Special Grade) of the Raw Rubber and Chemical Analysis Department was transferred to the Adaptive Research Unit and was stationed in Galle.

Other scientists and extension personnel involved in this programme are:

(a) **Scientists:** Dr N E M Jayasekera, Head/Genetics and Plant Breeding Dept., Dr A Nugawela, Head/Plant Science Dept., Dr (Mrs) L Samarappuli, Head/Soils & Plant

Nutrition Dept., Mr V H L Rodrigo, Research Assistant in Intercropping and Mr L S S Pathiratne, Assistant Botanist.

(b) **Extension Personnel** : Mr K Meegahawatta, Head/Development Division, Advisory Services Dept., Mr P Samaranayake, RAO/Kalutara, Mr M C Samarasekera, RAO/Galle, Mr A I H Silva, RAO/Colombo, Mr A H Kularatne, RAO/Ratnapura and Mr D D Dasanayaka, RAO/Kegalle.

Visits

The Adaptive Research Unit staff made advisory visits to plantations and rubber smallholdings.

Meetings

The Assistant Development Officers attended the field days and monthly conferences in all regions with REO's and smallholders.

Training

Mr S M M Iqbal was involved in the following programmes:

1. Field day for the Planting Executives in Kegalle Region – multicropping of rubber with tea.
2. Rubber farmers training programme conducted by ASD.
3. Two weeks course of training on statistical package for social science (SPSS) organized by CARP.

Mr W C Dayaratne presented an informative letter at the AGRINET user seminar at the Ruhunu University in November 1992.

Publication

Dayaratne, W C (1992). 'Agricultural Extension and Farmer' (Sinhala Translation) *Rubber Puwath*, 15, 19 – 23.

FIELD INVESTIGATIONS

Adaptive Research Programme in Rubber Smallholdings

1989 Programme

- | | |
|----------------------------------|-----------------------|
| 1. Field Establishment Practices | (Dr A Nugawela) |
| 2. Clones | (Dr N E M Jayasekera) |
| 3. Planting Density | (Dr A Nugawela) |
| 4. Intercropping | (Dr A Nugawela) |

The 1989 programmes were in progress on rubber smallholder fields in Kalutara, Colombo, Galle, Matara, Kegalle and Ratnapura regions. Some trials in these regions were terminated due to continuous neglect by the growers. Some trials were also affected by drought in Kegalle and Ratnapura regions.

Results obtained from some of these trials are presented in Table 1.

Table 1. *Average girth of rubber plants - 1989 programme*

Treatments	Average girth (cm)				
	Ratna- pura	Kegalle	Kalutara	Colo- mbo	Galle/ Matara
1. 12'x18'; RRIC 100; Bare root	18.58	-	-	-	35.96
2. 12'x18'; RRIC 100; Poly bag	-	-	-	25.5	-
3. 12'x18'; PB 86; Bare root	19.31	-	20.04	-	11.96
4. 12'x18'; RRIC 100					
50% Bare root	23.71	-	21.22	16.91	21.51
50% Poly bag	23.35	-	22.66	20.08	22.65
5. 14'x14; PB 86; Bare root	24.27	-	17.53	-	-
6. 8'x27'; RRIC 100	-	-	-	-	25.96

RRIC 102	-	-	-	-	30.82
RRIC 121	-	-	-	-	25.04
7. 9'x22'; Bare root					
(Banana)With intercrop.	30.48	18.64	-	-	-
Without intercrop.	-	16.05	-	-	-
8. 8'x27'; RRIC 100					
Poly bag with intercrop.	24.98	-	24.98	25.00	-
Poly bag without intercrop.	19.30	-	19.03	23.36	-
Bare root with intercrop.	24.92	-	24.98	25.00	-
Bare root without intercrop.	26.45	-	24.92	21.84	-
9. 8'x27'; Bare root					
RRIC 100 with intercrop.	-	-	22.16	-	-
RRIC 100 without intercrop	-	-	25.01	-	-
RRIC 102 with intercrop	-	-	23.26	-	-
RRIC 102 without intercrop	-	-	24.57	-	-
RRIC 121 with intercrop	-	-	23.66	-	-
RRIC 121 without intercrop	-	-	23.14	-	-

(L Rodrigo, F P W Silva, W C Dayaratne, E A T Senadeera, S W Wijsekera and R A S K Ranatunga).

1990/91/92 PROGRAMME

I. Clone evaluation

1990 Programme

The following treatments were tested under this programme in the Kalutara and Kegalle regions.

Treatments

Clones RRIC 100, RRIC 110 and RRIC 121 with provision of comparisons of

- (a) Smallholder Management Practice (SMP)
- (b) RRISL Recommendations (RRI)

(Dr N E M Jayasekera)

Girth measurements were taken in some of the plots (Table 2). It is too early to make any conclusions from this programme. Few trials were discontinued as smallholders did not follow the recommendations of the RRI.

Table 2. *Girth of the rubber plants - Clone evaluation programme (cm)*

Clone	Kalutara		Kegalle	
	SMP	RRI	SMP	RRI
RRIC 100	18.27	18.37	14.09	18.13
RRIC 110	18.05	19.91	-	-
RRIC 121	19.03	19.07	-	-

(F P W Silva and W C Dayaratne)

II. Intercropping

1990 Programme

Experiments with banana, vegetables, pepper and pineapple with provision for comparison between smallholder management practices (without intercrops) and RRISL recommendations were continued in all the regions. A few sites were abandoned due to lack of interest by the growers.

1991 Programme

The following smallholders were selected to implement an intercropping programme of Rubber with banana/pineapple in the Colombo region.

1. Mrs Swethasinghe, Oruwela. Extd. 3/4 Acres. Clone RRIC 100
2. Mr N G K Perera, Padukka. Extd. 1 1/4 Acres. Clone RRIC 100

Inputs viz intercrops and fertilizer to the intercrops were provided. Yield of banana and pineapple in the year 1992 are as follows (Table 3).

Table 3. *Yield figure, expenditure and income in 1991 intercropping programme*

Site	Yield		Expenditure (Rs.)	Income (Rs.)
	Banana (Kg)	Pineapple (Kg)		
1.	180	1400	3,486/=	20,698/=
2.	825	600	11,770/=	21,167/=

Minimum labour was used in site one, as the farmers family labour carried out the field labour work. In site 2, hired labour was used in most of the field work. (L Rodrigo and F P W Silva).

1992 Programme

The following trials were started with the on set of the south west monsoon at Kegalle.

Smallholder & Address	Extent	Treatment
1. Mr T W S Welideniya, Malawita Road, Thalawela, Hollimulla.	1.1.25 Ac.	Pineapple/Coffee Bush legumes. RRIC 100.
2. Mr W R Punchibanda, Owigitamuwa, Undugoda.	2 Ac.	Coffee PB 86.
3. Mrs W A Z Warunasinghe, Udugama, Atale.	-	Pineapple/Banana RRIC 100.

III Soil moisture and conservation practices

Programmes in the Kegalle and Kalutara regions were continued. Girth of rubber plants were measured (Table 4). Some of the trials in both regions were discontinued due to poor response from the smallholders.

Table 4. *Effectiveness of growing bush legumes on girth of the rubber plants (cm).*

Treatment	Kegalle (1990 programme)	Kalutara (1991 programme)
With legumes	19.09	13.47
Without legumes	18.27	13.22

(Dr (Mrs) L Samarappuli, F P W Silva, W C Dayaratne and E A T Senadeera).

IV. Use of yield stimulants and rainguards were continued.

These programmes were continued. (Dr A Nugawela and L S S Pathiratne).

V. Use of organic manure

1991 Programme

In these programmes application of poultry litter to mature/immature rubber and pineapple were in progress in the Kalutara and Colombo regions.

Yield data collected from the poultry litter trial in the Colombo region is as follows:

Smallholder	Treatment	Average rubber yield/200 trees
V. Sirisena Perera, Batawela.	1. Poultry litter with rubber	4.82 kg.
	2. Control	2.96 kg.

(Dr (Mrs) L Samarappuli and F P W Silva)

VI. Rubber processing and use of rubber factory effluent

1992 Programme

a) Latex collection cups

Varnish coated coconut shells were tested along with plastic collection cups at Bentota, Kesbawa and Matara.

Use of plastic trays for latex coagulation introduced in the Colombo and Kalutara regions performed well (P P Jayasinghe).

b) Use of rubber factory effluent as fertilizer

Two trials were in progress in Kegalle region on vegetables and paddy. Another programme started at Kalutara using serum and poultry litter as fertilizer for banana intercrop was continued (P P Jayasinghe).

All adaptive research programmes are partially funded by the Council of Agricultural Research Policy (CARP) under their contract research programmes. (Dr N Yogaratnam).

VII. Multicropping of Rubber with Tea

State Sector I

Studies on multicropping of rubber with tea were continued on seven estates. Yield figures of made tea and annual expenditure in each estate were collected. It was noted that the yield of tea in the year 1992 was very low, as the tea fields were rested during the drought period (Table 5). Tapping of rubber plants were also recorded in December 1992.

Table 5. *Yield of Tea (made tea) - (January to September 1992)*

Estate	Yield of made tea (kg/ha)		Remarks
	Tea only Plots	Rubber+ Tea Plots	
1.Miriswatta Welipenna	476	500	Rubber spacing 8'x30'.
2.Perth Ingiriya	512	582	- do -
3.Neuchattle Neboda.	231	273	Rubber spacing 8' x 30' plots in Tea only were affected by severe droughts.
4.Panawatta	248	744	Rubber spacing 8' x 40'. Heavy casualties found in tea only plots.
5.Kiripo-ruwa	421	1030	Rubber spacing 8' x 40'.
6.Karundu-pona	917	784	- do -
7.Sapumal Kanda	1021	976	- do -

State Sector II

These experiments were started in Agalawatta, Kuruwita and Avissawella to study the effect of Multicropping of rubber lands with tea on growth and production of rubber and tea.

Experiment 1: [RRISL Sub-Station, Kuruwita]

In this experiment, the following work were done during the year under review.

- * Planting of tea in unrehabilitated tea plots.
- * Lopping of *Gliricidia* and manuring.
- * Girth of the rubber plants.
- * Growth assessment of tea plants.
- * Sampling of leaf and soil.

Yield of tea was recorded (Table 6) but it is too early to make any comments.

Table 6. *The effect of multicropping of rubber lands with tea on yield of tea [January 1992 to June 1992]*

Treatments	Made Tea Mean Yield/kg/ha/6 months
Rubber 8'x27' + Tea unrehabilitated	580
Rubber 8'x40' + Tea unrehabilitated	541

Experiment II: [RRISL Agalawatta]

The second experiment on multicropping of rubber with tea was in progress at Dartonfield, Agalawatta.

Experiment II: [Artherfield - Avissawella]

This experiment was terminated as the area was taken over for some other project.

Smallholder sector

Three smallholdings in the Kegalle region were selected for this programme. Rubber was planted at wider spacing of 8' x 40' and seven rows of tea were planted in between two rows of rubber. Planting material was supplied by the RRI.

These programmes are partially funded by the Council of Agricultural Research Policy under their contract research programme (N Yogaratnam, S M M Iqbal, G de Mel and E A T Senadeera).

AGRICULTURAL ECONOMICS

H Talgaswatta

SUMMARY

Preliminary analyses were carried out to derive the response functions for girth and yield to different fertilizer combinations and detailed economic analysis on the use of paddy straw as mulch in rubber plantations.

Two separate surveys were carried out to analyze technical efficiency of rubber smallholders and plantations according to their farm size.

Price elasticity of excess demand was estimated using calculation method based on Yantema formula. This is useful to evaluate optimal tax policy on Sri Lankan rubber. The results indicated that the price elasticity of excess demand for Sri Lankan rubber was -14.02.

Preliminary work was started to evaluate the environmental damage caused by effluent.

A cost-benefit analysis on use of TPNR latex collecting cups was estimated in collaboration with the Polymer Chemistry Department. Results indicated that the use of TPNR cups instead of coconut shells were financially and economically worthwhile in the state sector estates.

DETAILED REVIEW

Staff

Mr H Talgaswatta, Assistant Agricultural Economist, returned from Lincoln University, New Zealand on 20th August 1992 to continue his PhD research work on a split programme basis. Mr I N Samarappuli functioned as Agricultural Economist until 24th November 1992 while pursuing his PhD degree in Agriculture specializing in Agricultural Economics from the Post Graduate Institute of Agriculture (PGIA), Peradeniya. Mr P H M U Herath, Assistant Agricultural Economist, completed his Masters Degree in Agriculture specializing in Agricultural Economics from the Post

Graduate Institute of Agriculture, Peradeniya and commenced work on 1st October 1992. Mrs S Amaratunga continued her Post-graduate studies at the Colombo University.

Mr Talgaswatta was awarded a Masters Degree in Agricultural Economics from Lincoln University in 1991 and was promoted to senior staff grade II with effect from 25th August 1992.

Research Students

Mr K G Tillekeratne, Manager, Illuktenna Estate worked on the research project "Economic Viability of Rubber Plantations and Role of C.O.P. and N.S.A." in partial fulfillment of the requirement of the Diploma course in plantation management, under supervision of I N Samarappuli.

Training

Mr I N Samarappuli attended a computer training programme on SPSS+ from 24.02.1992 to 06.03.1992 at the John Keels Training Centre in Colombo.

Meetings

Mr I N Samarappuli,

Participated in discussions with the Rubber Research Board in briefing the activities documented in the Corporate Plan under the Agricultural Economics Unit.

Served as a member of the Sri Lankan delegation at the ANRPC fourth meeting on Natural Rubber Statistics held at Hotel Ramada Renaissance from 10th - 12th September.

Attended the inaugural seminar on the Biological Aspects of Rubber Plantations conducted by the RRI Scientists to the personnel of the New Management companies.

Publications

Talgaswatta, H (1991). Price Elasticity of Excess Demand for Sri Lankan Rubber, MSc Thesis submitted to the Lincoln University, New Zealand.

RESEARCH

Economic Analysis of Mulching with Straw

A detailed economic analysis was done to assess the Net Benefit and Benefit/Cost ratios of the 'Mulching Technique' under different situations (I N Samarappuli and L Samarappuli).

Response Function Analysis

Preliminary analyses were carried out to derive the response functions for girth and yield (dependent variables) to different fertilizer combinations (independent variables) in collaboration with the Soils and Plant Nutrition Department and Biometry Unit using SAS-RSREG Procedure (I N Samarappuli, W Katulande, L Samarappuli).

Survey on production efficiency

Two separate surveys were carried out to collect necessary data to analyze technical efficiency of rubber production by both rubber plantations and small-holdings according to their farm size.

The objectives of the study are:

To measure and compare technical efficiency in the rubber industry according to their farm size.

To compare the attributes of those farms operating near the frontier of production efficiency with those of farms operating far from the frontier.

To calculate farm specific technical efficiency for individual farms.

To provide policy recommendations.

The major rubber growing districts of Kalutara and Kegalle were selected to conduct the survey. Necessary data were collected from records and by interviewing farmers. 300 small-holders from Kalutara district and 240 small-holders from Kegalle district were interviewed. 12 farmers were interviewed from each Rubber

Extension Officer's(REO) range and 24 REO ranges were randomly selected from Kalutara district and 20 REO ranges from Kegalle district.

A secondary mail survey was also carried out to collect data on mature rubber stand of small holders. The information gathered were actual total number of trees by year of planting, number of trees in tapping, number of trees not in tapping and reasons. The same farmers of above survey from Kegalle and Kalutara districts were selected for this survey (H Talgaswatta).

Price Elasticity of Excess Demand for Sri Lankan Rubber

Price Elasticity of Excess demand for Sri Lankan rubber was estimated using calculation method, latest development of Yantema formula to study the optimal export tax policy for Sri Lankan natural rubber.

Basically the calculation method consists of three components, estimation of own-price demand elasticities of consuming countries, own-price supply elasticities of supplying countries, price transmission elasticities and their trade shares with respect to Sri Lankan rubber exports. The basic model is given below:

$$\eta_{ED} = \sum_i \eta_{ii} \phi_{iSL} \frac{D_i}{X_{SL}} - \sum_j \eta_{jj} \theta_{jSL} \frac{S_j}{X_{SL}}$$

Where: η_{ED} - Price elasticity of excess demand for Sri Lankan rubber;
 η_{ii} - Own-price elasticity of demand country i;
 η_{jj} - Own-price elasticity of supply country j;
 ϕ_{iSL} - Price transmission elasticity country i;
 θ_{jSL} - Price transmission elasticity of country j;
 D_i - Quantity demand country i;
 S_j - Quantity supply country j;
 X_{SL} - Quantity exported by Sri Lanka.

The own-price demand elasticities were estimated by using a partial adjustment model which is given below:

$$Q_{it} = \alpha + \beta_0 \ln Q_{it-1} + \beta_1 \ln P_{it} + \beta_2 \ln P_{it-1} + \beta_3 \ln IP_{it} + U_t$$

where Q_{it} - Quantity demanded by Country i ;
 Q_{it-1} - Quantity demanded by country i previous year;
 P_{it} - Relative price of natural rubber in country i ;
 P_{it-1} - Relative price of natural rubber in country previous year;
 IP_{it} - Industrial production in country i .

The above model was re-specified to estimate the long-run equilibrium elasticities which is given below:

$$\ln Q_{it} = a + b \ln P_{it-1} + c \ln IP_{it} + d \ln Q_{it-1} + U_t$$

Table 1. Results of regression of partial-adjustment model

Country	b	d	b(1-d)	R ₂	Normality	Durbin-h
UK	-0.1220* (0.0378)	0.9570* (0.0679)	-2.83 (4.4191)	0.94	0.2086	-0.7094
France	-0.1699 (0.5109)	0.5102* (0.1752)	-0.2449 (0.1439)	0.92	0.6373	1.0625
Germany	-0.1693* (0.0512)	0.5587* (0.1426)	-0.3838* (0.1783)	0.83	0.9341	0.3468
Italy	-0.0665 (0.0625)	0.2503 (0.1746)	-0.0887 (0.0840)	0.92	0.9759	0.7102
Japan	-0.0812* (0.044)	0.3248* (0.1890)	-0.1203* (0.0613)	0.98	0.9588	1.5552
USA	-0.2625* (0.0996)	0.5276* (0.1772)	-0.5558* (0.2626)	0.97	0.5793	-0.5735

Sample period - 1960-1983

Figures in parentheses are standard errors.

Asterisks indicate 5 percent significance level.

Normality = 5.99 at 5% significance level.

Durbin-h = 1.96 at 5% significance level.

Note : The standard errors of all the long-run elasticities in this dissertation were obtained using PCGIVE econometric package where the method developed by Bardsen (1988).

Own-price supply elasticities have been collected from published sources. Price transmission elasticities for country i's and j's were estimated using a partial adjustment distributed lag model. The results of the

$$\ln P_{it} = a_2 + b_2 \ln P_{it-1} + c_2 \ln P_{jt} + d_2 \ln P_{jt-1} + U_t$$

model is given in table 2.

Table 2. Results of regression of price transmission using AD(1,1) model.

Country	C_2	$(C_2+d_2)/(1-b_2)$ (LR)	t-test $H_0:$ LR=1	R^2	Normality	BPLM-test
Consuming countries:						
UK	0.9668* (0.1185)	0.817* (0.1132)	1.6166	0.88	0.223	0.612
France	0.7952* (0.0735)	0.395 (0.3208)	1.8859*	0.92	1.413	0.582
Germany	0.77* (0.0647)	0.727* (0.0788)	3.4644*	0.95	0.948	2.089
Italy	0.7019* (0.0868)	0.639* (0.1595)	2.2633*	0.89	2.3	0.41
Japan	0.9486* (0.1156)	0.864* (0.1203)	1.1305	0.90	1.35	0.056
USA	0.9694* (0.1000)	0.787* (0.0823)	2.588*	0.90	0.158	0.323
Producing countries:						
Liberia	0.7428* (0.1498)	1.113* (0.1941)	-0.6137	0.88	9.194*	0.728
Malaysia	0.9653* (0.1131)	0.805* (0.1216)	1.6036	0.89	1.422	0.56
Thailand	1.0113* (0.0969)	0.805* (0.0935)	1.1016	0.93	2.398	1.076
Indonesia	0.7672* (0.1121)	0.054 (0.7534)	1.2556	0.87	0.475	1.632
Nigeria	0.9417* (0.1774)	0.903* (0.2642)	0.3671	0.87	3.63	0.794

Sample period - 1960-1983

Standard errors are in parentheses.

* = 5% level of significance.

Critical value for normality = 5.99 at 5% significant level.

Critical value for BPLM test for autocorrelation = 5.99 at 5% significant level.

Trade shares were calculated from international rubber study group data for the period 1960 to 1983.

By using above information price elasticity of excess demand for Sri Lankan rubber was calculated as -14.02 (H Talgaswatta).

Valuation of environmental damage caused by effluent

Preliminary data collection on this study was started. Quantification and valuation of environmental damage caused by effluent was the main aim of this study. Information from previous studies were collected and the quantification was carried out. Outcome of this study will be useful to develop strategies at reasonable cost levels to overcome this problem. Hence this study will be useful in giving a numerical value for the damage caused by effluent (P H M U Herath).

Cost-Benefit analysis on TPNR cups

A cost-benefit analysis was carried out based on research findings of Polymer Chemistry Department experiments on the use of TPNR cups for collection of latex (data Dec. 1990 to Ap. 1991). This study indicated that the use of TPNR cups instead of coconut shells gives 17 percent yield increment due to low wastage of latex scrap. It has been assumed that the coconut shells are durable for a period of one year where as TPNR cups could be used for 4 years.

Based on the above information this study showed a positive value for Net Present Value(NPV) and a value more than one for Cost-Benefit ratio in the financial and economic analysis. Hence it is concluded that the use of TPNR cups is likely to be more economical than the use of coconut shells. However under smallholder conditions socio-economic factors would play a major role in deciding on the success of the use of TPNR cups (P H M U Herath and K de Silva).

Data base of RRIC 100 series clones

As RRIC 100 series clones have now become popular both in the state and the smallholder sector estates, it has been planned to have a computerized data base of RRIC 100 series clones at the RRI. Initially, information such as clones already planted, acreage, year of planting, location etc will be gathered from the "Green forms" available with the Rubber Control Department (Sunethrani Amaratunga).

BIOMETRY

Wasana Wijesuriya

SUMMARY

The Biometry section continued to assist the Research Departments in designing field experiments, analysis and interpretation of results. Possible measures were taken to minimize experimental error in trials by use of suitable covariates and proper experimental designs.

The meteorological station at Dartonfield, and the computer database were maintained satisfactorily. Rainfall records for the last 59 years were analyzed in order to identify the trends in annual rainfall and sequences of wet and dry years.

The application packages installed during the year were SPSS PC+ and Microsoft-Windows with Mouse support. A plotter was also purchased during the year under review.

DETAILED REVIEW

Staff

Mrs Wasana Wijesuriya, Assistant Biometrician and the Senior Technical Officer, Mrs Nandani Wanigatunga were on duty throughout the year.

Symposia and Workshops

Mrs Wijesuriya attended the following during the year 1992.

- Short course supported by UNDP on "Time series analysis" at the Department of Census & Statistics during 10th to 28th February.
- NETCON '92 - Networking Conference at the University of Colombo on 04th April.
- Workshop on "Multivariate Analysis" from 4th - 15th May at the University of Peradeniya.

Publications

Katulande Wasana, Amala Jayasekera and K Sanmuganathan (1992). Management of irrigated sugarcane fields with inadequate drainage facilities for sustained land productivity. *Proc. 2nd Sym. on Integrated Land Use Management for Tropical Agriculture*. Brisbane, Queensland.

Statistical Services

The service provided assistance to the research staff and students by means of experimental designs, selection of lands, layout of experimental plots, analysis of data and interpretation of results. Statistical techniques include, analysis of variance and covariance, non parametric methods, categorical and discrete multivariate methods, regression techniques i.e. linear, nonlinear and analysis of response surfaces.

Computing services

Programming -

The computer program written in BASIC language for the Soil and Foliar analysis was redesigned. Further modifications were made in the program for the analysis of uniformity trails for simulation of plots in different orientations.

Word Processing -

Five project reports of University students and the report on final accounts of the Institute were prepared during the year.

Database management -

Meteorological observations of the Dartonfield station were recorded daily and the database was successfully maintained. The data were provided monthly to the Department of Meteorology and to outside Institutions on request. The database for personnel and Project Summary data of Research Officers at RRI, payroll information and program budgets was also maintained.

Equipment

The following were installed in the computer unit during the year, 1992.

- Graphtec MP-4100 Pen plotter.
- Mouse.

RESEARCH

Statistical Analysis of Rainfall Records.

Over the period for which data were available (1933-1991), the observed annual rainfall at the Dartonfield meteorological station showed no significant trend (Fig. 1). The sequence of wet and dry years was examined on the definition of 99% lower and upper confidence limits (designated as $X_d = 4078$ mm and $X_w = 4408$ mm). A normal year is defined with a rainfall between these limits.

The recurrence intervals suggest that runs of 2 wet (or dry) can be expected only once in a decade, runs of 3 wet (or dry), once in every 30 years and 4 wet (or dry) years can be expected once in every 60 years (Table 1).

Table 1. *Observed frequencies of consecutive wet and dry years*

Event	Frequency	Recurrence interval
consecutive 2 years Wet	6	$59/6 = 9.8$
consecutive 2 years Dry	5	$59/5 = 11.8$
consecutive 3 years Wet	2	$59/2 = 29.5$
consecutive 3 years Dry	2	$59/2 = 29.5$
consecutive 4 years Wet	1	$59/1 = 59.0$
consecutive 4 years Dry	1	$59/1 = 59.0$

Although the annual rainfall data do not subscribe to any trend, there appears 15 year periods viz. 1933-1946, 1947-1961, 1962-1976 and 1977-1991, with similar alternate pattern (Fig. 1). Hence, there is a good expectation of plentiful rain in the period 1992-2006. This study is being continued to identify a time series methodology for reliable future predictions.

Meteorological Summary - 1992

The annual rainfall experienced during 1992 was 4092 mm, which is similar to the magnitude of the preceding year. During the year, 9 months have exceeded the 75% expected values (fig. 2).

The distribution of rainfall in monsoonal and inter-monsoonal seasons is given below.

	Amount (mm)	No. of rainy days	Highest intensity (mm/hr)
<i>Monsoonal Seasons</i>			
Dec 91-Feb 92	322	23	2.2
May 92-Sep 92	2287	104	36.8
<i>Inter-monsoonal Seasons</i>			
Mar 92-Apr 92	426	17	42.9
Oct 92-Nov 92	1008	40	38.2

The graphical presentations of other important meteorological factors are given in figure 3.

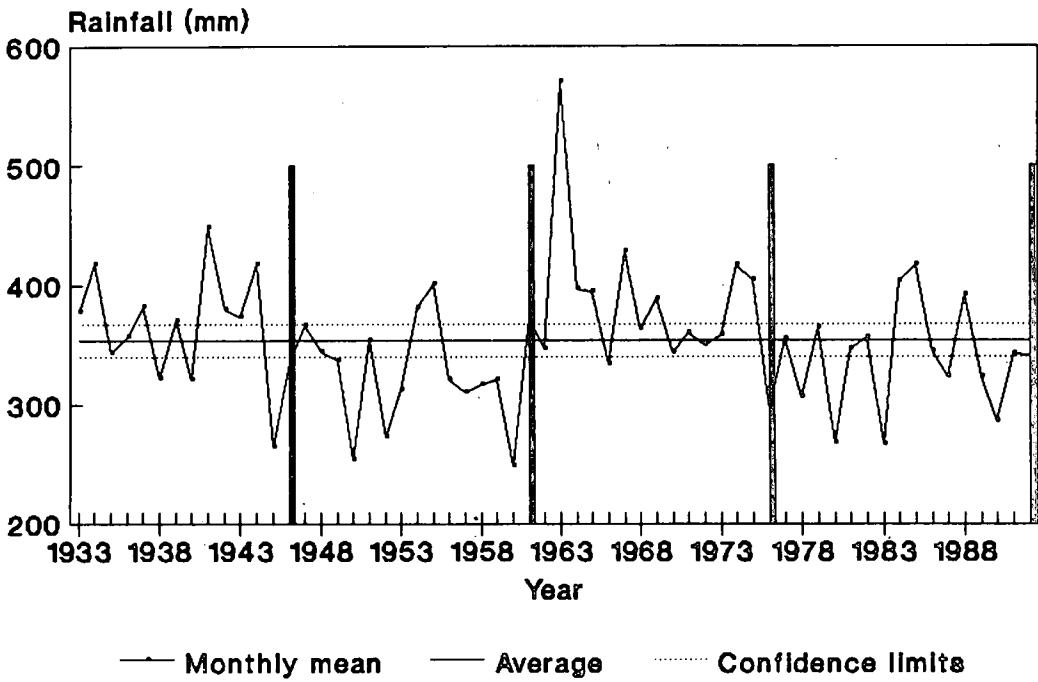


Fig. 1 Variation of rainfall during last 60 years

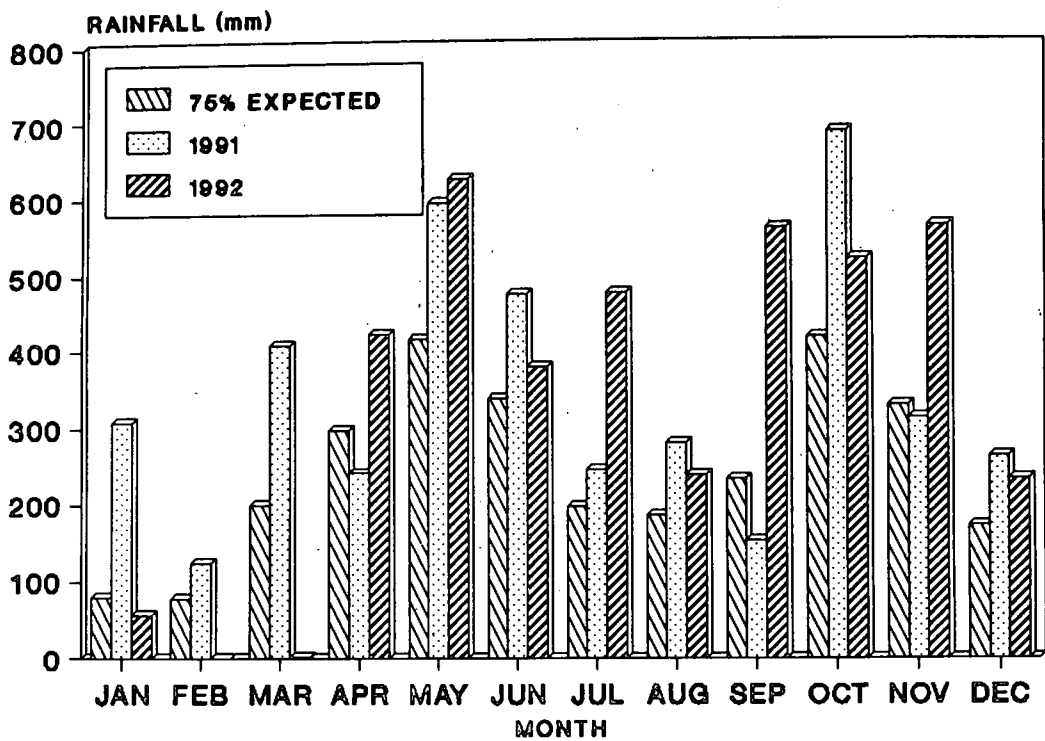
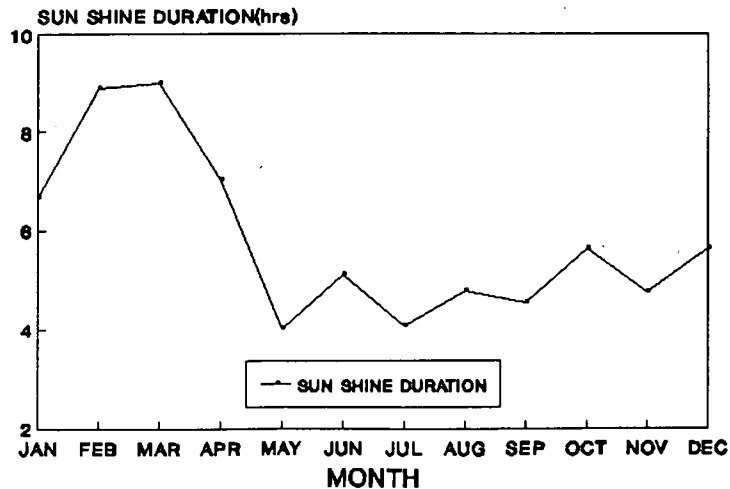
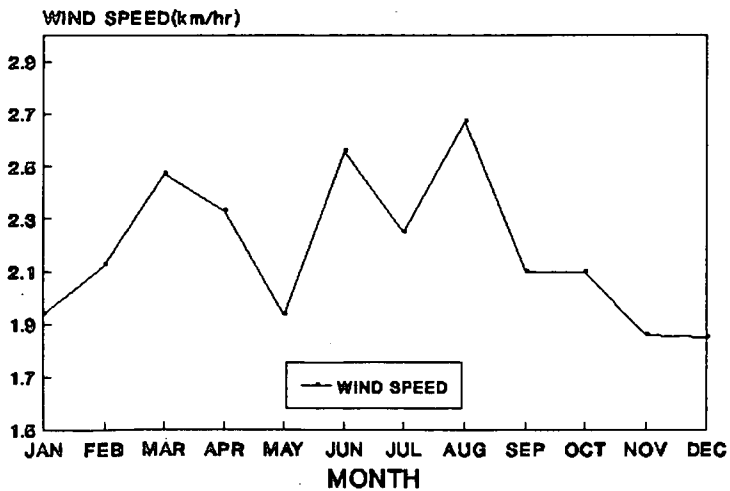
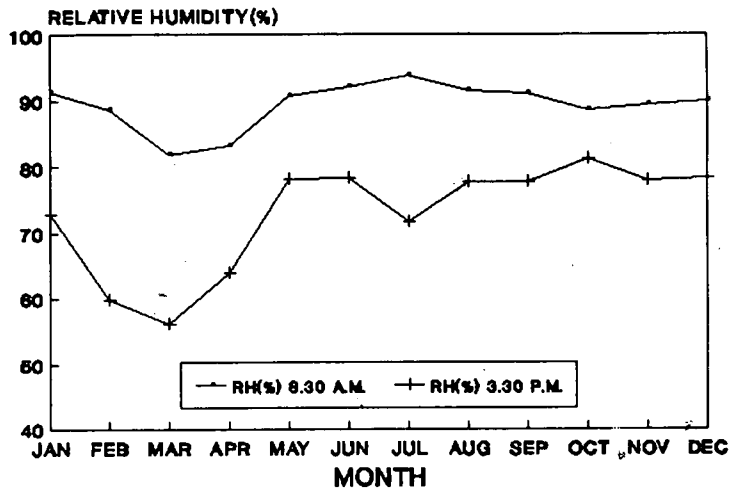
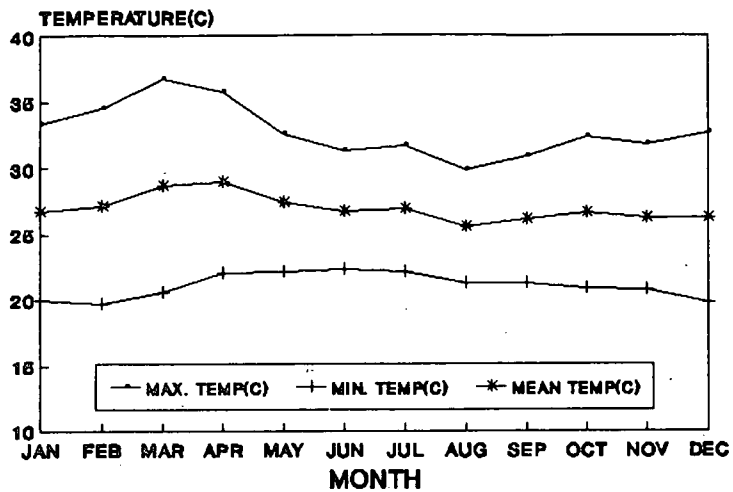


Fig. 2 Distribution of rainfall at Dartonfield



LIBRARY AND PUBLICATIONS

Kamani Perera

SUMMARY

Main functions of the Library & Publications Section such as maintaining, processing and publishing of the Institutes regular publications and collecting and disseminating of information on all aspects of Natural Rubber and related areas have been carried out successfully throughout the year 1992.

DETAILED REVIEW

Staff

Mrs Kamani Perera, Librarian & Publications Officer, Mrs Tilaka Dantalarayana, Library Assistant & Assistant Publications Officer (Colombo Office) and Mrs Ramani Amaratunga, Clerk/Typist were on duty throughout the year.

Acquisitions

Books & Periodicals

With the addition of 129 acquisitions, Book collection recorded at 4492 and the bound volumes to 2728.

The Library subscribed to 60 Journals and about 50 other Journals were also received as gift/exchange. RRI is grateful to all those Persons and Organizations who continually donate documents to the RRI Library collection.

Seminars/Workshops

The Librarian & Publications Officer attended the following seminars/workshops regarding Library & Information Science:

SLLA AGM at SLLAS Auditorium on 20.03.92.

British Council exhibition - 'One Stop Infor' - Opening ceremony at Public Library, Colombo on 27.02.92.

The meeting of the Monitoring Committee on editorial policy held on 04.06.92, at Ministry of Plantation Industries, Colombo.

AGRINET Workshop on 'Agricultural Library Automation & Management' sponsored by CARP and held at CRI, Lunuwila from 9th July - 13th July.

'The better Librarian Communicates' - Seminar held at National Library Auditorium on 25.07.92.

AGRINET User Seminar held at University of Ruhuna on 28.11.92.

'Consultancy skill development/project proposal writing for Librarians' conducted by SLLA at OPA Auditorium on 09.12.92.

'Standards for Libraries' conducted by SLLA at OPA Auditorium on 11.12.92.

Reports

Perera, Kamani (1991). Review of the Library and Publications Section, Annual Review. Rubb. Res. Inst. Sri Lanka, 1991

Publications

Processing and publishing of RRISL publications were continued. The following publications were published during the year.

Annual Review 1991

RRISL Journal Vol.70, 1990

Rubber Puwath Vol. 15, 1992

RRISL Bulletin Vol.29, 1992 (In press)

Annual Report 1990

Advisory Leaflets

01. Fertilizer to Rubber (Sinhala/English) - 1992/01
02. *Corynespora* Leaf Disease (Sinhala) - 1992/02
03. *Phytophthora* Disease (Sinhala) - 1992/03
04. White Root Disease (sinhala) - 1992/04
05. Control of Nursery Disease (Sinhala) - 1992/05

06. Budwood nurseries (Sinhala) - 192/06
07. Budgrafting (Sinhala) - 1992/07
08. Green budding (Sinhala) - 1992/08
09. South American Leaf Blight (English) - 1992/09
10. Soil Conservation (English) - 1992/10
11. Ground Covers and cover management (English) - 1992/11

Equipments

Memory and display Unit for the Library Canon Electronic Typewriter (AP 8000) was purchased during the year.

Furniture etc.

Arrangements were made to purchase a Catalogue Card Cabinet from Gaylord Bros., USA and 06 Nos periodicals display racks (Metal) from local supplier.

Information services

Various services were provided based on the information intake. The Library & Publications Section also organized procurement of photocopies, news clipping service, current acquisitions list, current awareness service, selective dissemination of information (SDI) service etc., with a view to disseminating the right information to the right user at the right time. The facilities and services of the Library were also extended to planters, manufacturers and others connected with the rubber industry. Research Scholars and students from Universities and technical Colleges also utilized the services of the Library.

AGRINET Services

We received content pages of 60 journals titles according our User requirements and vice versa we too forward contents of 32 journal titles to AGRINET Libraries.

Inter Library Loans

Photocopies of articles and Journals, Text books etc., were received from other National and International Libraries when requested for our users and we did same for them.

DARTONFIELD GROUP

A Nugawela & T H Wijesena

SUMMARY

Dartonfield Group managed by the Rubber Research Institute has three divisions namely, Dartonfield, Gallewatte (in the Agalawatta Electorate) and Nivitigalakele (in the Matugama Electorate).

The total extent of the Group is 331.88 hectares and the planted area is 269.25 hectares of which 135.13 hectares were in bearing during the year.

A severe drought was experienced during the 1st quarter and wet weather prevailed throughout the balance months. The year ended with a recording of 3974.4 mm. of rainfall, an increase of 114.4 mm over last year.

The Replanting Programme could not be undertaken as per schedule, due to the delay caused by the Contractor in not keeping to the date of completion.

Budwood of clones RRIC 100 and RRIC 102 were issued to the smallholders of the area.

All agricultural practices were carried out in the nurseries, immature and mature areas of the Group.

DETAILED REVIEW

Staff

Mr V M Katugaha, Estate Superintendent, Mr S A L Chandrawansa, Chief Clerk, Mr K K P Gunawardene, Senior assistant Clerk, Mr K D Sumanasena, Mrs C Dissanayake, Mr A K A Wickremasinghe, Junior Assistant Clerks, M/s A K D Hemapala, H M J Premalal and S K S de Silva, Field Officers, Mr J A Wimalasena, Assistant Field Officer, M/s S R Vadivel, T Somaratne and N L D Reggie, Field Supervisors, Mr D S K Ranaweera, Rubber Factory Officer, Mr W D D Senanayake, Factory supervisor, Mrs C H Hettiarachchi, Creche Attendant, Mr H L Sarath, Jeep Driver, Mr A K Piyasena, Office Peon, were on duty throughout the year.

M/s A K D I Rukmal, J K Nakandala, K A Sarath Kumara, and B M Siriwardena were appointed as Assistant K.P.P, as from 16th March 1992.

The following Officers were transferred during the year:-

Mr K D Sumanasena, Junior Assistant Clerk, was transferred to Accounts Department, in the capacity of Assistant Store-keeper, with effect from 15th July 1992.

Mr H L Sarath, Jeep Driver was transferred to the Advisory Services Department with effect from 09.05.1992.

The Group Cadre stood at twenty one at the end of the year, made up as follows:-

Senior Staff	01
Assistant Staff	19
Minor Staff	01
	21

Hectarage:

A summary of the Hectarage is given in Table 1.

Table 1. *Land distribution in Dartonfield Group*

	Dartonfield	Gallewatte	Nivitigalakele	Total
Mature area	10.68	79.61	44.84	135.13
Immature area	30.50	88.66	-	119.16
Nurseries	7.27	-	7.69	14.96
Paddy fields/Deniya	-	1.22	-	1.22
Earth Slip Area	1.65	1.26	2.62	5.53
Rocks	.29	1.80	1.21	3.30
Waste Land	.19	.18	-	.37
Jungle	.80	-	.71	1.51
Roads	3.27	6.86	.32	10.45
Buildings	16.14	5.07	7.79	29.00
Abandoned	-	-	8.06	8.06
Reserved for buildings	2.08	-	-	2.08
Streams	-	.84	-	.84
State land taken-in	.27	-	-	.27
	73.14	185.50	73.24	331.88

Weather

Rainfall figures (m.m.) for 1992 and 1991 are given below in Table 2:-

Table 2. *Rainfall distribution for 1992 and 1991*

	1992	1991
January	70.2	291.8
February	46.2	102.3
March	2.6	314.4
April	306.3	260.7
May	572.1	531.0
June	417.3	478.6
July	526.8	199.9
August	232.7	263.2
September	593.0	129.2
October	512.2	660.4
November	473.4	423.3
December	221.6	205.2
TOTAL	3974.4	3860.0
Total number of wet days	163	185

The highest rainfall was recorded during the month of September 1992, which was 593.0 mm on 18 wet days.

Crop

The yield data for the last five years is given below:-

Table 3. *Yield per hectare records from 1988 to 1992*

	1992	1991	1990	1989	1988
Dartonfield Division	605	709	696	612	1094
Gallewatte Division	740	636	805	795	802
Nivitigalakele Division	771	632	929	706	1083
Average	740	640	866	738	1002
Estimated	883	715	740	700	1244
Tapping Hectarage	135.13	145.14	108.00	107.00	148.00

In comparison to the previous year, a slight increase in yield has been recorded during this year. The short-fall from the estimated crop is mainly due to the wet weather that prevailed during the latter part of the year. 118 tapping days were lost due to wet weather and wintering.

The tapping standard was good and the tapping panels were treated with fungicides.

Manufacture

A summary of manufacture records during the year is given in Table 4.

Table 4. *Details of crop manufactured in Dartonfield (Aggregate of latex and scrap percentage)*

	Total kgs.	Crop %
Pale Crepe No.01	74856	67%
Pale Crepe No.03	13073	12%
Scrap Crepe No.01	4942	04%
Scrap Crepe No.02	1679	02%
Scrap Crepe No.03	217	-
Smoked Sheet No.01	17018	15%
Smoked Sheet No.03	313	-
	112098	100%

11.703 kgs. of latex were purchased from Mohamedi State Plantation, during the month of August 1992. The practice of purchasing latex from smallholders was not in operation during the rest of the season in 1992. The price paid per kilo of latex was Rs.29.81.

Factory Machinery

Condition of the factory machinery could be considered satisfactory.

Factory Building

The repairs to the factory building including the Smoke House and the Drying tower were satisfactorily effected.

Roads

The macadamised roads which are leading to the Institute Bungalows and the estate divisional roads were maintained satisfactorily.

Pests and Diseases

The periodical diseases which were evident were controlled.

Fertilizer

Fertilizer applications for mature and immature fields were carried out as per programme.

Replantings

The scheduled programme for planting during the year could not be undertaken due to the Contractors defaulting in not keeping to the date of completion. These have been programmed to be planted in 1993.

Nurseries

All nurseries were well maintained.

All unproductive nursery accounts were closed down.

Field and Factory Experiments

The research Departments were given the necessary assistance in carrying out their field and technological experiments.

Institute Buildings

The general maintenance expected from the Estate Department was undertaken and individual problems attended to, when necessity arose.

Labour and Health

All non-working resident children over 01 year of age and below 13 years continued to be paid the cost of 1/4 lb. bread per day per head. In addition, cash payments were made in lieu of half cream milk to resident non-lactating mothers with infants under 01 year of age.

The health of the entire population was satisfactory during the year.

National Tree Planting Campaign

Medicinal and herbal plants were planted in Dartonfield Group on the 17th of September 1992.

Accounts

Final Accounts for the year 1992 have been completed and forwarded.

Estimates

Estimates of Capital and Revenue expenditure for 1993, in respect of Dartonfield Group, were submitted to the Estate Committee, for approval.