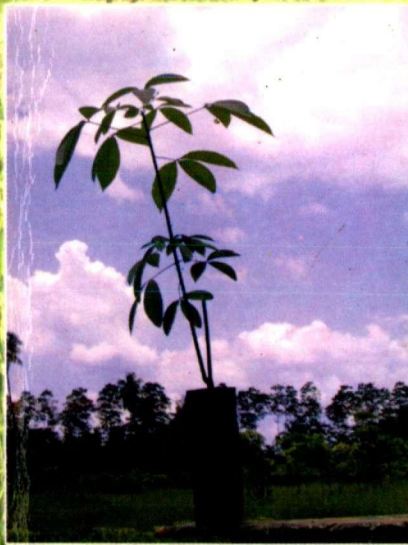


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RUBBER RESEARCH INSTITUTE OF SRI LANKA



Annual Review 2003

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Rubber Research Institute of Sri Lanka

Annual Review – 2003

1 st January 2003 to 31 st December 2003

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C K Jayasinghe, PhD (Sri Lanka)

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Dartonfield
Agalawatta**

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CEO, Kahawatta Plantations Ltd.
CEO, Lak Latex (Pvt.) Ltd., Centrifuging Factory
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Mr Rifaadh, Sinwa
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• Mr Justin Seneviratne, Director, Lalan
Mr K A R Manju Perera, Ansell's
Mr Lakna Paravitana, Consultant, USAID/TCI
Mr Lal Motha, Plastic & Rubber Institute
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Dr G Seneviratne, Deputy Director Research (Technology), RRI
Mr P P Jayasinghe, RRI
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Mr M R C Peiries, PRI

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Mr H H Jayasinghe, Elected committee Member

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Secretary to the Board	Mrs L J C Perera
Confidential Clerk/Stenographer	Mrs P Balasooriya

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Director	011 - 2605171
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RUBBER RESEARCH INSTITUTE OF SRI LANKA

STAFF

DIRECTORATE

<i>Director</i>	L M K Tillekeratne, BSc (Cey.), MSc (Aston), PhD (Aston), FI Chem C, FPRI, FNASSL
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<i>Deputy Director – Research (Technology)</i>	W M G Seneviratne, BSc (SL), PhD (Sussex)

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---	------------------------------

RESEARCH DEPARTMENTS

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*Mrs S Herath, BSc Agric (SL), MSc (Japan)
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B M S G Peiris
I D M J Sarath Kumara

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Clerk/Typist

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Mrs S D P K L Peiris

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Head of Department

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PhD (Bath)

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(Principal Research Officer)*

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K C Fernando

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K K P Gunawardena

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W D D Senanayake

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T Somaratne
N L D Reggie
H M J Premalal

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Kuruwita Sub-Station

Visiting Superintendent

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(NIBM), AMIPM

Assistant Estate Superintendent

S A R Samarasekera

Junior Clerk

D S Jayasinghe

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G Gunawardena

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D R A M G Abeydissanayake
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I Kiridena
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G D N Seneviratne
K P Jayasinghe
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S G G Wijesinghe
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Mrs L Somawathi
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Miss Chitra Gunatilleke
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Clerk/Typists

* On study leave overseas
** On no pay leave overseas

Presidential Award for Inventors - 2003 Merit Award



Mrs M K Mahanama, an Experimental Officer attached to the Rubber Technology and Development Department of the Institute was awarded a merit award of the Presidential award for inventors, for her development of natural rubber latex based ornamental flowers. Mrs Mahanama was awarded a cash prize and a certificate for this invention on 1st August, 2003.

RUBBER RESEARCH INSTITUTE OF SRI LANKA

DIRECTOR'S REVIEW

L M K Tillekeratne

Even though Sri Lanka is the pioneer in introducing *Hevea* rubber (NR) to South East Asia, where 95% of the world NR requirement is produced today, the total rubber extent in the country has declined from 202,000 hectares in 1978 to 128,000 hectares at present. Of this extent 64% is in the hands of smallholders, majority of them owning less than ½ acre of land. Private companies manage the balance 36%. With the sharp increase in the rubber prices as correctly predicted by the RRI from 1998 the total rubber production showed a slight improvement in year 2003 reaching 92,000,000 kg. However, Sri Lanka has not been able to reap the benefit of this unexpectedly high price of rubber in the world market purely due to the negligence of the plantation by the smallholders and also due to crop diversification. Some of the crops grown in potentially high yielding fields by replacing rubber are even unfavourable to the environment of the country. In the smallholders sector out of around 4,500 ha. ear-marked for replanting only around 35% have been replanted during the past year. In the privately managed estates the situation is even worse and in many company owned estates, no significant replanting has been done. This is the reason why unlike in other countries in the region; Sri Lanka has not been able to increase the rubber production in line with the increase in world market NR prices.

The rubber products industry however, has shown a fair improvement thereby increasing the foreign exchange earnings of the country. In 2003, 55.5 million Kg had been used locally, which is about 60% of the total rubber production. Over and above this, 9,200 MT of it has been imported from neighbouring countries for value addition, both in latex and in dry forms. With this, the total consumption in the country during 2003 is 64 million kg. This could have been achieved locally, if rubber plantations were not diversified into other crops which are not earning the income generated by rubber today while protecting the environment of the country. Hence, in order to cater to the growing local demands and also to export high quality premium grades of raw rubber over other grades of rubber such as latex, sole crepe and even Lankaprene, tailor made for medical food and infant applications, the strategies planned by the institute are as follows:

- a. Short term strategy of laying rain-guards. Last year, RRI owned Dartonfield Estate has been able to recover 92 days of additional tapping with rain guards while earning an additional income of over Rs.25,000/- per hectare of land.
- b. Long term strategy No. 1 of increasing productivity of rubber lands to 1500 kg/ha from the present level of 1005 kg/ha.

- c. Long term strategy No. 2 is planting rubber in intermediate zone *viz.* Moneragala and Buttala and in abandoned tea lands at elevations above 1000 ft. There are about 29,000 ha. of such land in the country according to TRI statistics.

The prime requirement of achieving the potential yield of the clones recommended by RRI is to plant quality plants produced under careful conditions in the field. Since 2003 this task of certifying the quality of rubber plants was assigned to the RRI.

A nursery was started at Monaragala to cater to the needs of this district from 2004 onwards where there 260,000 plants planted already. The balance requirement for this district for this year only, will be provided through company owned estate nurseries and from private nurseries under the supervision of the Institute. The rubber Cluster is also planning to commence a nursery to produce the plants requirement for their new plantations from 2005 onwards by obtaining guaranteed plants of the recommended clones released by the RRI to establish bud wood nurseries on their own. RRI would provide technical support for this project too.

While, undergoing a severe financial crisis, it was possible for technological labs at Ratmalana to purchase the equipment needed for assessing the leachable protein level in dipped products, namely the ASTM D 5712-99 method. Hence, in the future all the examination and surgical gloves and other latex based products exported from Sri Lanka will be certified for quality with regard to this parameter which is affecting the selling price of such products in the world market severely.

Technology Department was able to work jointly with D. Samson Industries, using waste tyre dust, to develop a soaker tube which can be used for irrigating plantation crops during the drought at minimum cost. This product patented jointly with this Company is being exported by the Company. The same tube is now used for irrigating coconut plantations in Putlam district which were affected during last drought in 2002/2003.

The Institute has strongly supported the proposal of the Ministry of Plantation Industries to extend the cess benefits for replanting to private management Companies as well as they are major producers of raw rubber for export. The same requirement can be requested to be extended to the four supporting small-holder to lay rain-guards as well.

If all these measures are taken, increasing the rubber production to the expected target within the next couple of years will not be a difficulty. However, increasing rubber prices further, to above Rs.150/- will not be healthy for the rubber producing countries as the rubber products manufacturers even in Sri Lanka will be reluctantly compelled to go for cheap synthetic substitutes for the end-products to bring the cost of production down.

OVERSEAS VISITORS

Mr Shinzo Kohjiya, Kyoto University, Japan

Mr Chee Kheng Hony, Malaysia

Dr S Sivakumaran, Malaysia

GENETICS AND PLANT BREEDING

D P S T G Attanayaka

SUMMARY

The clone recommendation was revised in view of the susceptibility of RRISL 201, RRISL 202 and RRISL 217 to the *Corynespora* leaf-fall disease (CLD). RRISL 202 was removed from the recommendation while RRISL 201 and RRISL 217 were downgraded to group III. Nevertheless these three clones continued to give high yields in ECTs.

RRISL 203 proved it's suitability for large scale planting in the country. In the ECTs this clone has shown its potential by recording a nine year average per hectare yield of 2400 kg. RRISL 2001 too have recorded a yield over 2500 Kg/ha in the second year of tapping under commercial planting conditions. Under the same ECT conditions the clones RRISL 205 and RRISL 206 have given 1660 Kg and 1739 kg respectively during the second year of tapping.

Analysis of results of the Genotype Environment interaction studies showed that the clones RRISL 215 and RRISL 217 to be highly stable for girthing ability in all the sites tested.

Observations on the 1992 seedling population showed that the superiority of the seedling progenies of RRIC 100 × PB 235 and RRIC 121 × PB 255 origin, which can be identified as suitable seedling planting material. It is therefore important to consider revising the structure of the present clone recommendation in order to incorporate the judicious use of the seedlings in rubber cultivation.

The growth performance of RRISL 201, RRISL 203 RRISL 205 and RRISL 206 was shown to be very satisfactory in rubber smallholders trials.

The annual hand pollination programme was not carried out in this year due to unavailability of funds.

DETAILED REVIEW

Staff

The Head of the Department, Dr D P S T G Attanayaka, Mrs S P Withanage, Assistant Geneticist and Plant Breeder, Experimental Officers Mr B M S G Peiris, Mr K W Rupertunga, Mr L S Kariyawasam, Mr I D M J Sarath Kumara, Technical Officers, Mr T M S K Gunasekera, Mr H P Peiris and Mrs S D P K L Peiris, Clerk/Typist were on duty throughout the year. Mr K B Karunasekera Development Officer was transferred from the Adaptive Research Unit to the Genetics and Plant Breeding department with effect from 29th October. Mrs A K Gamage, Technical Officer was on maternity leave from 23rd August to 28th December. Mrs S P Herath, Assistant Geneticist and Plant Breeders continued her postgraduate studies at the University of Nagoya, Japan.

Research students

- Miss R S Dharshanie a final year student from the Agriculture Faculty of the University of Peradeniya completed her research training at the department.

Meetings and Workshops attended

Officer	Subject	Organizations
Dr D P S T G Attanayaka	Specialist Group on Plant Breeders, Tissue Culturists and Biotechnologists	CARP
Dr D P S T G Attanayaka	Board of study in Biochemistry & Molecular biology	PGIS
Mrs S P Withange	Presented her research work on the adaptability of different rubber genotypes for agro-climatic variability in Sri Lanka to the panel of reviewers of the Climate Change Enabling Activity Project.	Ministry of Environment

LABORATORY INVESTIGATIONS

Molecular biology of *Hevea* GPB/MM/97

The laboratory work on *Hevea* molecular biology was continued with little progress due to the non-availability of funds and technical staff. DNA was extracted from the selfed progenies of the Diallel crosses to study the genetics of disease resistance (S P Withanage).

FIELD EXPERIMENTS

Hand pollination (HP) programme

Hand pollination programme was not carried out in this year due to limitation of funds.

Evaluation of hand pollinated progenies

Small scale clone trials

A series of new experiments were planted to test HP progenies derived from the year 2000 pollinations. The list of the Small Scale Clone Trials monitored by the Department to-date is given in Table 1.

Table 1. *Details of small scale clone trials*

HP year	Site	Planting date
1986	Kuruwita	May 1990
1987	I) Clyde- Kethhena	May 1993
	II) Galawatta	June 1988
1988	Dartonfield	July 1993
1992	Dartonfield	May 1993
1995	Sorana	June 1998
1996	Kuruwita – I & II	May 1999
1991	Pallegoda	August 2000
	Vogan	November 2000
1997	Clyde - I & II	June 2000
1998	N'Kele I, II & III	June 2001
	Kuruwita I, II & III	July 2001
1990	Kuruwita	July 2002
1999	Kuruwita I,II & III	June 2002
2000	Arappalakande, I- III	May 2003
2000	Dalkeith I & II	June 2003
2000	Elston I & II	July 2003
2000	Nivithigalakele I & II	July 2003

Evaluation of 1986 H.P. Selections - Kuruwita Sub station (GPB/BST/HPS/86)

Results of the Duncan's Multiple Range Test for thirteenth year girth measurement of the promising clones are given in Table 2. Yield data relevant to the fifth year of tapping based on nine test tappings are given in Table 3. The highest girth was obtained from clone 86-81 followed by 86-21. The highest yield was obtained from the control clone RRIC 121. The yield of two clones 86-87 and 86-10 was consistent with the previous year.

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

Results of the Duncan's Multiple Range Test for tenth year girth (DMRT) are given in Table 4. Six test tappings were done during the year. Mean yield of the four high yielding test entries of this trial in the fifth year of tapping is given in Table 5. Very high bark consumption rates were observed in this clearing.

Table 2. Mean girth (13th yr) in cm of promising H.P. clones

Clone	Mean girth (cm) and DMRT grouping
86-81	80.75 ^A
86-21	75.39 ^{AB}
RRIC 121	74.63 ^{AB}
86-77	73.65 ^{ABC}
86-24	70.10 ^{BCD}
86-87	69.76 ^{BCD}
86-76	67.62 ^{BCDE}
86-37	66.32 ^{CDEF}
86-82	66.21 ^{CDEF}
86-22	65.93 ^{DCDEG}
RRIC 110	65.66 ^{CDEFG}

Table 3. Mean yield of promising 1986 H.P. clones

Clone	Yield (g/t) and DMRT grouping
RRIC 121	46.82 ^A
86-87	46.16 ^A
RRIC 110	44.16 ^A
86-10	42.27 ^{ABC}
86-22	37.13 ^{ABC}
86-11	36.60 ^{ABC}
86-25	36.29 ^{ABCD}
86-24	36.28 ^{ABCD}
86-40	35.31 ^{BCDEF}
86-17	32.03 ^{BCDEF}

(D P S T G Attanayaka, H P Pieris and K B Karunasekera).

Table 4. Mean girth and the results of DMRT of the 1987 H.P. Selections

Clone	Girth in cm	DMRT grouping
RRIC 121	73.31	A
87-370	69.53	B
RRIC 110	68.85	BC
87-371	66.04	BC
87-364	63.65	C D
RRIC100	62.14	DE
87-372	60.33	DEF
RRIC 102	59.46	EFG
87-383	58.21	FGH
87-375	58.08	FGH

Table 5. Mean yield and the results of DMRT of the 1987 H.P. Selections

Clone	Yield (g/t/t)	DMRT grouping
RRIC 121	52.06	A
87-370	41.97	B
87-372	37.67	B
RRIC 110	36.18	B
87-382	35.74	B
87-364	35.46	B
RRIC 100	28.82	C

(D P S T G Attanayaka, I D M J Sarathkumara and K B Karunasekera)

Evaluation of 1987 H.P. Seedlings - Galewatta division Dartonfield estate (GPB/BST/HPS/87/2)

Yield data relevant to the 4th year of BO-2 panel of each family are based on six test tappings. Progeny size, mean girth (15th year) and mean yield of the seedling families are given in Table 6.

Table 6. Mean girth and mean yield of the 1987 HP seedling families

Family	Progeny size	Mean girth (cm)	Mean yield (g/t/t)
RRIM 600 × RRIC 101	08	79.62	35.52
RRIC 101 × GT 1	27	61.12	39.15
RRIC 100 × GT 1	47	82.37	69.03
RRIC 100 × RRIC 101	10	75.15	60.82
RRIC 100 × RRIC 110	08	80.68	55.01
RRIC 100 × RRIC 121	28	80.00	54.80
PB 86 × RRIC 121	14	76.46	39.62
RRIC 102 × GT 1	03	90.33	91.84
RRIC 121 × RRIC 110	25	75.10	40.65
RRIC 110 × RRIC 100	06	73.16	81.62
RRIC 110 × RRIC 121	02	65.50	-

(D P S T G Attanayaka, T M S K Gunasekera and K B Karunasekera).

Evaluation of 1988 H.P. Selections - Dartonfield estate (GPB/BST/HPS/88)

The tenth year girth measurement was taken and the mean girth of clones were grouped using the Duncan's Multiple Range Test (Table 7). Mean yields and the DMRT grouping of some selected clones based on nine test tapings in the third year are given in Table 8 along with control clones.

Table 7. Mean girth in cm of the 1988 HP progeny

Clone	Mean girth and DMRT grouping
88-31	68.03 ^A
88-32	65.29 ^{AB}
88-15	64.63 ^{AB}
RRIC 102	63.02 ^{ABC}
88-28	62.60 ^{ABCD}
88-16	62.15 ^{ABCD}
RRIC 100	58.88 ^{BCDEF}
RRIC 110	56.96 ^{CDEFGH}

Table 8. *Mean yield (g/t) of the 1988 HP progeny*

Clone	Mean yield and DMRT grouping
88-10	34.93 ^A
88-16	34.44 ^A
RRIC 102	34.37 ^A
88-26	33.09 ^{AB}
88-9	32.33 ^{AB}
88-50	31.36 ^{ABC}
RRIC 121	30.34 ^{ABCD}
RRIC 100	21.64 ^{DEFG}

(D P S T G Attanayaka and L S Kariyawasam)

Evaluation of 1992 H.P. Seedlings Dartonfield estate (GPB/BST/HPS/92)

The trees of this trial are in fourth year of tapping. The family means of the ninth year girth measurements taken at 150 cm from the ground level and the yield based on seven test tappings are given in Table 9. It is interesting to note that the seedling progenies derived from RRIC 100 × PB 255 and RRIC 121 × PB 255 have shown good performance with respect to both growth and yield.

Table 9. *Family means of girth and the yield of the 1992 HP progeny*

Family	Girth (cm)	Yield(g/t/t)
RRIC 100 × RRIM 712	59.68	22.63
RRIC 100 × PB 255	68.28	35.60
RRIC 100 × PR 255	59.18	20.72
RRIC 121 × PB 255	68.00	32.15
RRIC 102 × PB 255	62.52	16.39
BPM 24 × RRIM 712	59.91	16.75
RRIC 100 × PR 309	63.83	26.72
RRIC 121 × PR 255	58.90	26.73
RRIC 102 × PR 309	53.50	6.05
RRIC 121 × PR 309	57.87	20.59

(D P S T G Attanayaka, A K Gamage and K W Rupatunga)

Evaluation of 1995 H.P. Selections Sorana estate (GPB/BST/HPS/95)

The fifth year girth taken at a height of 120 cm is given in Table 10. Clones 95-55, 95-50 continued to show very vigorous growth.

Table 10. *Mean girth in cm of the 1995 HP progeny*

Clone	Mean girth and DMRT grouping
95-55	55.46 ^A
95-50	53.35 ^{AB}
95-51	52.54 ^{ABC}
95-47	52.01 ^{ABCD}
95-48	51.92 ^{ABCD}
95-45	51.91 ^{ABCD}
PB 255	49.06 ^{C DEF}
RRIC 121	47.82 ^{D EFG}

(D P S T G Attanayaka, I D M J Sarathkumara and K B Karunasekera)

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

Fourth year girth measurements of the experimental clones were better than the control clone RRISL 205 compared to both, 96-1 and 96-2 (Table 11). Girth measurements were taken at a height of 120 cm.

Table 11. *Mean girth at 120 cm of the 1996 HP progeny*

Mean girth (cm) from 96-1 trials		Mean girth (cm) from 96-2 trials	
Clone	Girth	Clone	Girth
96-59	38.03	RRIC 121	35.28
96-31	35.35	96-37	32.63
96-3	33.88	96-54	32.43
96-15	33.50	96-36	31.43
96-13	32.64	96-53	31.42
96-17	32.46	96-33	31.05
96-58	32.33	96-44	30.73
96-14	32.20	96-26	30.50
96-4	31.46	RRISL 205	30.23
96-5	31.14	-	-
96-16	30.90	-	-
RRISL 205	30.66	-	-
RRIC 121	30.57	-	-

(D P S T G Attanayaka, H P Peris and K B Karunasekera)

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

The third year girth measurements were taken at 120 cm from the two trials. Two HP entries from trail 1 and five HP entries from trial 2 have shown mean girth above the best control clone RRISL 205 and RRIC 121 respectively (Table 12).

Table 12. Mean girth of selected HP entries in cm of the 1991 HP progeny planted at Pallegoda and Vogan estates

Mean girth (cm) from 91-01 trials (Pallegoda)		Mean girth (cm) from 91-02 trials (Vogan)	
Clone	Girth	Clone	Girth
91-29	32.16	91-71	26.39
91-2	32.11	91-63	26.04
RRISL 205	31.89	91-62	24.76
-	-	91-75	24.25
-	-	91-53	23.60
-	-	RRIC 121	23.50

(D P S T G Attanayaka, K W Rupatunge and K B Karunasekera)

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

The third year girth measurement was taken at a height of 120 cm. In both trials there were 18 HP entries better than the best control clone. In trial 97/1 there were 16 HP entries better than the best control clone. In trial 97/2, ten HP entries have shown better girthing than the control clone. The girth measurements of the top ten HP entries of both trials are shown in Table 13 (D P S T G Attanayake, T M S K Gunasekera and K B Karunasekera).

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

Second year girth measurements were taken from the above six trials. Duncan's multiple range tests carried out for girth for each experiment have shown the presence of superior HP entries than the control clones.

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

This experiment was planted in 2002 to evaluate 25 HP entries derived from 1990 HP programme. Each clone has been replicated 8 times in a completely randomized design. The control clones included are RRIC 121, RRIC 130 and RRISL 205.

The first year girth measurements were taken at a height of 120 cm. There were 14 HP entries better than the best control clone RRISL 205.

Table 13. *Mean girth in cm of the 1997 HP progeny planted at Clyde estate*

Mean girth (cm) from 97-01 trial		Mean girth (cm) from 97-02 trial	
Clone	Girth	Clone	Girth
97-19	31.67	97-61	30.67
97-2	31.23	97-48	30.50
97-3	30.90	97-55	29.80
97-32	30.90	97-70	29.20
97-25	30.86	97-83	28.90
97-10	30.70	97-64	28.53
97-36	30.60	97-66	28.42
97-43	30.36	97-60	28.30
97-26	29.96	97-45	28.23
97-23	29.80	97-79	28.03
RRISL 205	29.23	RRISL 205	28.03

Evaluation of 1999 H.P. clones at Kuruwita estate (GPB/BST/HPS/99/01,02 & 03)

This experiment was planted to test the HP entries derived from 1999 HP programme. Three trials were planted using complete randomized design including three control clones RRIC 121, RRIC 130 and RRISL 205. Each clone was replicated 8 times. The trials 99/01, 99/02, 99/03 have 39, 39 and 38 HP entries respectively.

The first year girth measurements were taken from each trial.

Testing of proven foreign clones received under SRRP II (GPB/FC/SRRP/91/1-6)

Only the trial established at Salawa estate was monitored for growth and yield of the seven introduced clones and the two control clones RRIC 121 and RRIC 100. Mean girth and yield obtained from this trial are given in Table 14.

Genotype environment interaction (G X E) studies (GPB/GE/98)

The growth of the clones planted in this trial was monitored by taking the girth measurement. Analysis of variance of the fifth year girth showed the presence of highly significant differences in growth between clones, sites and the presence of significant genotype \times environment interaction effect (Table 15). Table 16 shows the mean girth measurements and the variance of the clones in the eight sites under study. Further analysis showed that the two clones RRISL 215 and RRISL 217 to have high stability with high mean performance.

Table 14. Mean girth (cm) and yield (g/t) obtained from SRRP II clone trial

Clone	Block I		Block II	
	Girth cm	g/t/t	Girth cm	g/t/t
PB 217	61.01	47.54	62.27	44.43
PB 235	65.24	55.07	61.97	48.06
PB 260	-	-	62.61	50.49
RRIM 712	53.27	45.30	54.23	42.93
PR 255	57.11	42.99	58.85	37.93
PR 261	60.18	35.36	59.39	35.04
BPM 24	54.90	39.09	55.08	29.91
RRIC 100	62.56	46.05	63.50	42.97
RRIC 121	64.72	40.79	67.23	44.19

(D P S T G Attanayaka, K W Rupertunga, I D M J Sarathkumara, B M S G Peiris, H P Peris and K B Karunasekara)

Table 15. The results of the analysis of variances

Source	DF	Mean square	Significance
Clones	14	22859.87	***
Sites	7	36122.99	***
Clone × Sites	98	7820.19	***

*** 0.1%

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

The third year girth measurement was taken. Highly significant differences between the treatments and blocks are evident. Table 17 shows the mean girth of each treatment, *i.e.* control monoclonal plots and plots of Bi - and Tri - clonal mixtures.

Open pollinated seedling progenies from commercial clones (GPB/BST/SP/00)

Third year girth measurements were recorded from this trial and shown in Table 18.

Table 16. Mean girth (cm) and the variance of the clones in each site

Clone	Ganepalla	Muwan Kanda	Atale	Palm garden	Pelmadulla	Baddegama	Bibile	Sorana	Clone mean	Variance
RL201	49.52	44.72	46.23	36.33	46.15	44.76	32.11	43.88	42.96	33.25
RL205	55.11	46.94	47.55	38.42	46.88	45.0	33.61	42.15	44.45	42.11
RL206	52.1	46.0	48.73	39.86	41.47	45.47	34.78	43.66	44.00	28.97
RL210	41.43	36.11	42.84	33.38	41.50	39.02	27.60	36.80	37.33	25.63
RL215	41.07	41.25	40.79	34.44	38.15	40.17	31.21	39.77	38.73	16.79
RL217	46.66	38.33	41.86	33.60	38.67	40.03	31.60	40.92	38.95	22.29
RL218	49.58	42.07	45.32	31.92	39.63	43.73	30.94	38.85	40.25	40.94
RL220	35.26	40.31	38.75	27.15	38.35	41.08	26.19	37.12	35.52	33.14
GPS 1	35.4	33.75	34.95	25.4	33.07	31.42	27.61	27.75	31.16	14.31
RRII105	43.23	38.62	43.18	32.07	41.46	42.36	27.78	37.94	38.33	32.04
RM712	30.91	36.55	37.5	26.47	36.33	37.69	27.55	37.07	33.75	22.08
RC130	41.53	36.17	38.15	35.91	39.76	38.30	29.65	41.70	37.64	15.11
HEN2	36.25	38.92	38.42	29.16	33.50	36.88	29.14	34.50	34.59	14.54
PB260	42.69	38.46	42.31	35.92	38.63	39.96	27.91	39.29	38.14	21.80
Site Mean	43.38	39.78	42.03	32.99	39.60	40.49	29.86	38.69	38.35	25.99

(D P S T G Attanayaka, K B Karunasekera, S P Withanage, K W Rupertunga, I D M J Sarathkumara and H P Peiris)

Table 17. Mean girth of each treatment

Treatment	Mean diameter (cm)
RRIC 102/RRIC 121	37.17 ^A
RRIC 121	37.06 ^{AB}
RRIC 102/RRIC 133/ RRIC 121	36.71 ^{ABC}
RRIC 133/RRIC 121	36.36 ^{ABCD}
RRIC 102	36.10 ^{ABCDE}
RRIC 100/RRIC 102	35.95 ^{ABCDE}
RRIC 102/ RRIC 133	35.73 ^{ABCDE}
RRIC 100/RRIC 102/RRIC 133	35.41 ^{BCDE}
RRIC 133	35.22 ^{CDEF}
RRIC 100/ RRIC 102/RRIC121	35.07 ^{CDEF}
RRIC 100/ RRIC 133/RRIC 121	35.02 ^{CDEF}
RRIC 100/RRIC 121	34.89 ^{DEF}
RRIC 100	34.46 ^{EF}
RRIC 100/ RRIC 133	33.68 ^F

(D P S T G Attanayaka, K B Karunasekera and H P Peiris in collaboration with Plant Science Dept.)

Table 18. Third year girth measurements obtained from seedlings and budded plants

Budded plants	Girth (cm)	Selected Seedlings	Girth (cm)	Unselected seedlings	Girth (cm)
PB 86	25.08	RRIC 100	32.36	RRIC 121	28.67
RRIC 121	27.69	RRIC 121	25.48	PB 260	30.09
PB 28/59	28.88	PB 260	30.12	PB 86	27.28
RRIC 100		PB 86	28.76	RRIC 100	29.35
PB 260	28.53	PB 28/59	24.68	PB 28/59	25.29

(D P S T G Attanayaka, K W Rupatunga and K B Karunasekera)

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

Annual girth measurements were taken from all the trials. Table 19 shows the girth measurement of the current year with the information on planting.

Table 19. Annual girth measurements recorded from ECTs

Clone	Site	Year of planting	Girth in cm
RRISL 201	Tempo	1996	57.6
	Moralioya	1996	58.8
	Kuruwita	1994	62.02
RRISL 202	Salawa	1999	34.78
	Moralioya	1996	55.6
	Kuruwita	1994	55.47
RRISL 203	Kuruwita	1991	-
	Galawatte	1987	68.32
RRISL 204	Neuchatel	1997, b-I	50.66
	Tempo	1996	-
RRISL 205	Pallegoda	1995	61.9
	Vogan	1997	56.3
	Neuchatel	1997, b-I	60.38
RRISL 206	Pallegoda	1995	55.5
	Vogan	1997	51.3
	Neuchatel	1997, b-I	54.36
	Salawa	1999	40.06
RRISL 211	Dartonfield	1994	61.2
	Siriniwasa	2001	17.33
RRISL 215	Tempo	1996	-
	Salawa	1999	44.1
	Siriniwasa	2001	19.76
RRISL 217	Kuruwita	1995	50.95
	Vogan	1997	47.4
RRISL 218	Pallegoda	1995	-
	Siriniwasa	2001	19.08
RRISL 220	Salawa	1999	36.8
RRISL 221	Salawa	1999	34.1
RRISL 223	Galawatta	1994	61.04
RRISL 225	Nivithigalakele	2002	12.44
RRISL 226	Salawa	1999	36.59
	Pallegoda	2000	-
	Siriniwasa	2001	16.70
	Pallegoda	1998	46.28
RRISL 2000	Nivithigalakele	2001	18.80
	Pallegoda	1995	56.5
RRISL 2001	Nivithigalakele	2001	15.60
	Pallegoda	1998	27.91
GPS I	Vogan	1997	-
	Nivithigalakele	2003	-
	Pallegoda	1998	39.5
RRII 105	Pallegoda	1998	39.5
RRII 176	Pallegoda	2000	25.53
RRIC 133	Kuruwita	1995	67.1
	Salawa	1999	34.98

(D P S T G Attanayaka, K B Karunasekera, K W Rупatunga, I D M J SarathKumara, L S Kariyawasam, H P Peiris, B M S G Peiris, T M S K Gunasekera and A K Gamage)

Yields from ECTs

GPB/BST/ECT/95/01

The 1997 trials planted at the Vogan estate, Neuchattle estate (Horahena division) and 1996 trial planted at the Tempo division of Neuchattle estate were opened for tapping in October 2003, at a height of 150 cm. Commercial yields from these trials will be monitored with the collaboration of the estate managers.

The second year commercial yield data obtained from the ECT trial planted at the Pallegoda estate are shown in Table 20. Yield per hectare for RRISL 205, RRISL 206 and RRISL 2001 calculated on the basis of the tappable percentage of trees (418, 373 and 453 trees in tapping/ha) and for 140 tapping days were 1660 Kg, 1739 Kg and 2713 Kg respectively. RRISL 2001 continued to give a very promising yield.

The estate yields obtained from RRISL 201, 202 and 217 of the Kuruwita ECT trial in the second year of tapping based on the metrolac reading figures are given in Table 21. The clones RRISL 201 and RRISL 202 have been tapped at 100% intensity while the clone RRISL 217 at 97%. The potential YPH of these clones are also shown in table 21. It is interesting to note that these clones have sustained very yields in spite of the CLD detected on these clones.

Number of test tappings done on the clones RRISL 211, RRISL 208, RRISL 219 and RRISL 216 planted in Dartonfield estate were inadequate to calculate the mean yields for the year. However the limited number of test tapping data recorded showed that RRISL 211 has the potential of giving an intake over 10 Kg per tapper.

The results from the two ECT trials (Galawatte and Kuruwita) established to test the performance of RRISL 203 have shown that RRISL 203 to be a very promising clone for large scale recommendation in group I. The commercial yields obtained for the early five years (commencing from 1999) collected from the ECT at the Kuruwita estate are shown in Table 22. The 7th, 8th, 9th and 10th year per hectare yields obtained from the trial at the Galawatte division are shown in Table 23 with planting and tapping details. The Incidences of TPD and foliar diseases on this clone in both locations were very negligible (D P S T G Attanayaka, K W Rupertunga, K B Karunasekera, B M S G Peris, I D M J Sarath Kumara, H P Peries, T M S K Gunasekera and L S Kariyawasam).

Table 20. *Tapping details of RRISL 2001, RRISL 205 & RRISL 206 from Pallegoda estate*

Clone	Month	No. of tappings	No. of trees tapped /day	Volume (liters)	DRC g/100 ml	Kg	g/t/t
RRISL 205	January	05	251	128	33	42.2	33.6
	February	10	251	182	33	60.0	23.9
	March	10	251	141	33	46.5	18.5
	April	08	251	107	33	35.3	17.5
	May	08	251	135	34	45.9	22.8
	June	10	251	182	33	60.0	23.9
	July	11	251	271	33	89.4	32.3
	August	13	251	296	33	97.6	29.9
	September	08	251	179	35	62.6	31.2
	October	09	251	192	35	67.2	29.7
	November	08	251	194	35	67.9	33.8
	December	14	251	362	38	137.5	39.1
	Total mean		114	251	2369	34	812.1
RRISL 206	January	12	224	283	30	84.9	31.5
	February	13	224	290	32	92.8	31.8
	March	13	224	238	32	76.1	26.1
	April	10	224	135	34	45.9	20.4
	May	08	224	156	34	53.0	29.5
	June	09	224	201	32	64.3	31.9
	July	11	224	278	33	91.7	37.2
	August	11	224	261	34	88.7	36.0
	September	10	224	238	34	80.9	36.1
	October	06	224	124	33	40.9	30.4
	November	09	224	233	36	83.8	41.6
	December	14	224	394	35	137.9	43.9
	Total mean		126	224	2831	33.25	940
RRISL 2001	January	12	272	891	30	267.3	81.8
	February	12	272	484	28	135.5	41.5
	March	12	272	532	25	133.0	40.7
	April	10	272	274	25	68.5	25.1
	May	09	272	226	26	58.7	23.9
	June	10	272	255	28	71.4	26.2
	July	11	272	613	27	165.5	55.3
	August	13	272	463	26	120.3	34.0
	September	10	272	363	24	87.1	32.0
	October	06	272	170	32	54.4	33.3
	November	09	272	401	30	120.3	49.1
	December	14	272	692	30	207.6	54.5
	Total mean		128	272	5364	27.58	1489.0

Table 21. Tapping details of RRISL 201, RRISL 202 and RRISL 217 from Kuruwita estate

Month	RRISL 201 (No. of trees tapped 304)		RRISL 202 (No. of trees tapped 303)		RRISL 217 (No. of trees tapped 197)	
	No. of tapping days	Yield Kg.	No. of tapping days	Yield Kg.	No. of tapping days	Yield Kg.
January	10	92	10	109	7	60
February	12	78	12	138	9	67
March	12	62	12	86	7	57
April	5	27	6	46	5	29
May	8	53	8	52	7	49
June	6	44	6	45	5	40
July	8	54	8	61	7	61
August	5	36	7	67	5	36
September	3	16	5	39	-	
October	11	83	10	100	5	27
November	9	65	6	65	4	34
December	15	128	15	160	9	94
Total	104	738	105	968	70	554
YPH*		1155		1506		1627

* for 110 days of tapping and 450 trees in tapping/hectare for RRISL 201 and RRISL 202 for RRISL 217 number of tapping days were taken as 90.

Table 22. The commercial yields obtained from Clone RRISL 203 at Kuruwita estate for the first five years of tapping. Potential YPH is also indicated. Tapping commenced in this trial in 1994

Year	Year of tapping	No. of trees tapped	No. of Tappings	Total Yield collected Kg	YPH*
1999	1	311	30 (Jan. - July data not available)	417	2190
2000	2	311	94	1167	2515
2001	3	311	104	956	1862
2002	4	311	54 (July - Dec. data not available)	623	2337
2003	5	311	43 (Jan.- July data not available)	448	2110

* YPH was calculated for 350 trees for the first year and 450 trees for the following years. Number of tapping days were taken as 140.

Table 23. *The commercial yields obtained from Clone RRISL 203 at Galawatte division for 7th to 10th years of tapping. Potential YPH is also indicated*

Year	Year of tapping	No. of trees tapped	No. of Tappings	Total Yield collected Kg	YPH*
2000	7	235	33 (Jan- Sept data not available)	290	2355
2001	8	235	104	935	2410
2002	9	235	114	1239	2913
2003	10	235	74	933	3380

* YPH was calculated for 450 trees and 140 tapping days

Smallholder/RRI collaborative clone trials - GPB/BST/SRT/01/01-03

Second year girth measurements were taken from these trials (Table 24). All three clones planted under this programme showed vigorous growth.

Table 24. *Mean girth of the SRT trials planted in 2001*

Site	Expt. No.	Farmer	Clone	Mean girth (cm)
Kegalle	SRT/01/01	K A L Munasingha	RRISL 201	20.2
			RRISL 203	19.4
Homagama	SRT/01/02	T A Bandula Kumara	RRISL 205	15.7
	SRT/01/03	D C Ratugama	RRISL 201	20.1
			RRISL 203	16.85
			RRISL 205	19.98

(D P S T G Attanayaka, K B Karunasekera, L S Kariyawasam and E A T Senadeera)

CARP Project 12/478/973 - Testing of new *Hevea* clones for rubber smallholders

The planting details of this experiment have been reported in the Annual review 2002 under GPB/BST/SRT/01/01-13. First year mean girth of the three clones obtained from three sites are given in Table 24. One site planted in the Ratnapura district had to be abandoned due to the acquisition of the land by the government for the distribution for the flood victims. The site planted by Mr K C Gunathilaka too very frequently affected by the floods resulting set back on plant growth. The damaged and weak plants were re-supplied.

Table 25. Mean girth of the CARP planted in 2001

Site	Expt. No.	Farmer	Clone	Mean girth (cm)
Kalutara	SRT/02/02	R A Gunathilaka	RRISL 201	6.98
			RRISL 205	5.91
			RRISL 206	6.82
			RRIC 121	5.21
	SRT/02/03	K C Gunathilaka	RRISL 201	6.04
			RRISL 205	6.44
Ratnapura	SRT/02/04	A L D Jayasena	RRISL 206	6.69
			RRIC 121	6.19
			RRISL 201	6.97
			RRISL 205	6.01
	C Gankanda		RRISL 206	5.27
			RRIC 121	6.18
			RRISL 201	
			RRISL 205	(abandoned)
		RRISL 206		
		RRISL 121		

(D P S T G Attanayaka, K B Karunasekera, L S Kariyawasam, H P Peiris, B M S G Peiris and E A T Senadeera)

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

With regard to this project only minimum maintenance work was possible due to lack of funds. Majority of the genotypes require pruning and propagation to prevent from extinction (D P S T G Attanayaka, K B Karunasekera, S P Withanage and T M S K Gunasekera).

New planting

GPB/BS/HPS/00/01, GPB/BST/HPS/00/02, GPB/BST/HPS/00/03 Arrapalakande

Three Small Scale Clone Trials were planted at Arappalakande Estate to test the 2000 HP progenies. In trial I progenies derived from 11 families are tested in three blocks. Each block contains 364 genotypes in completely randomized single tree plots. In Trial II a total of 258 genotypes derived from 10 families are tested in a completely randomized single tree plot experiment. Trial III contains 90 genotypes derived from a single family BPM 24 × PB 235 in a completely randomized design with four single tree plots per clone. RRIC 121, RRIC 130 and RRISL 205 were included as control clones. Each clone was replicated 8 times in a completely randomized design. Planting was done in July (D P S T G Attanayaka, H P Pieris and K B Karunasekera).

GPB/BS/HPS/00/04, GPB/BST/HPS/00/05 Dalkeith estate

Two small scale clone trials were planted to test the 2000 HP seedlings at Dalkeith estate.

In trial 1, 112 genotypes derived from two families (56 from each family) were planted in a completely randomized design with three single tree plots per clone.

In trial 2, 98 genotypes from two families (53 & 45) were planted in a completely randomized design with three single tree plots per clone.

GPB/BS/HPS/00/06, GPB/BST/HPS/00/07 Nivithigalakele division

Two small scale trials were planted to test 2000 Hp seedlings at the Nivithigalakele division. 46 genotypes from a one family with three single tree plots in a completely randomized design are being tested in Trial I. In trial II 193 genotypes have been included from a single family with three single tree plots in a completely randomized design.

Estate/RRI collaborative clone trials (GPB/BST/ECT/03/01)

A tapping task of GPS I was planted at the Nivithigalakele division in July.

CARP Project 12/478/973 - Testing of new Hevea clones for rubber smallholders

Three sites from Matara district were planted under the CARP project to test new clones for smallholders. Planting details are given in Table 25.

Table 25. Details of planting – CARP Project

Site	Farmer	Clone	No. of plants (date of planting)	
Kamburupitiya	T Wickramaratne	RRISL 201	100 - 31/07/3	
		RRISL 205	100	
		RRISL 206	100	
		RRIC 121	100	
Radawela	M Ranaweera	RRISL 201	50 - 31/07/2003	
		RRISL 205	50	
		RRISL 206	50	
		RRIC 121	50	
	Piyadasa Sirisena		RRISL 201	50 - 31/07/2003
			RRISL 205	50
			RRISL 206	50
			RRISL 121	50

(D P S T G Attanayaka, K B Karunasekera and L S Kariyawasam)

PLANT SCIENCE

P Seneviratne

SUMMARY

Rhyzogenesis was possible in calli originated from cotyledons and hypocotyls of *Mukuna bracteata*. Direct shoot regeneration and rooting was achieved from leaf explants of *Paulownia*.

One seedling produced 20 homogenous seedlings via rooting of cuttings. However, the progress of the experiment was affected by the defects in the Mist Propagator. Irrigating the rootstock nurseries with Aqua-Spa porous pipes confirmed better performance as far as root morphology and girth of the plants are concerned. A better seed production was observed in the trees in the intermediate zone than those in the wet zone irrespective to the clone and the age.

The girth increment and the growth patterns were different in trees grown in Dartonfield and Bibile. As expected, different trunk-crown combinations showed a variation in girth. Among the combinations tested, RRIC 121 trunk with RRIC 130 crown showed the best girth.

The plant production in government nurseries was increased by about 4 folds by opening a new nursery at Moneragala and by reopening the nursery at Gurugoda. All nurseries including Karapincha and Egaloya, which were incurring heavy losses should earn profits by increased production.

Girth of the plants at lower densities were better while clonal differences were also present. Trees opened at lower girth classes recorded lower yields irrespective of the clone. The performance of the clone RRIC 121 was better under low frequency tapping with stimulation.

In the study aimed to find out suitable spatial arrangements for long term intercrops with rubber, it was revealed that 2.7-3.0 m was better than 2.4 m for space given within the double rows whilst a space of 15-18 m was suitable between double rows. *Alstonia* showed a competitive effect on growth and yield of rubber. In order to minimize the competition on rubber, it is suggested to establish timber crops later, allowing first 2-3 years for the establishment of rubber. The trial on testing of four economically important medicinal plant species as intercrops with rubber were successfully completed in 24 rubber smallholdings.

DETAILED REVIEW

Staff

Dr (Mrs) Priyani Seneviratne, Head of the Department, Dr V H L Rodrigo, Principal Research Officer in Intercropping, Mr L S S Pathiratna, Botanist, Dr A M W K Seneviratne, Botanist, Mr N M C Nayanakantha and Mr N A A D Wickramaratna, Assistant Botanists, Mr K A G B Amaratunga, Mr R P Karunasena, Mrs G A S Wijesekera, Mr U S Weerakoon, Mr S Wilbert, Mrs R K Samarasekera, Mr T U K Silva, Mr M N de Alwis, Mr M K P Perera, Experimental Officers, Mr D L N de Zoysa, Mr P D Pathirana, and Mr P K W Karunatilaka, Technical Officers and Mrs D E Jayawardena, Clerk/Typist were on duty throughout the year.

Mrs P D A H M A de Almeida, Clerk/Typist joined the Department to attend to Government Nursery Management work which was under the Plant Science Department with effect from 1st August 2003.

Research students

- Mr S T G C de Silva, Research Assistant continued his project on “The possibility of expanding cultivation of rubber at elevations above 300m in the mid country wet zone” under the supervision of Dr A Nugawela.
- Ms Inoka Munasinghe, Research Assistant, continued her work on intercropping and farming systems project funded by DFID, under the supervision of Dr V H L Rodrigo.
- Miss Rasika Vidanapthirana of University of Peradeniya completed her final year project on “The Effect of wet weather on yield stimulation of Rubber (*Hevea brasiliensis* Muell Arg)” under the supervision of Dr A Nugawela.
- Mr Gamini Wickramanayake of University of Ruhuna conducted his final year project on “Impact of rain fall on yield stimulation of *Hevea brasiliensis*” under the supervision of Dr A Nugawela.
- Miss H A I Sajeewani of University of Ruhuna conducted her final year project on “Response of some selected *Hevea* clones in *in vitro* axillary bud proliferations” under the supervision of N M C Nayanakantha and Dr (Mrs) P Seneviratne.

- Miss H N Hapuarachchi of University of Ruhuna conducted her final year project on “Effect of explant and medium on *in vitro* propagation of *Paulownia* spp. under the supervision of N M C Nayanakantha and Dr (Mrs) P Seneviratne.
- Miss N D I R Wijayatilaka of School of Agriculture, Kundasale completed her project on “Micropropagation of *Paulownia*” under the supervision of N M C Nayanakantha.
- Miss P Damayanthi of Aquinas College of Higher studies, Colombo completed her project on “පොල්ලෝනියා ශාකයේ පටක රෝපණය” under the supervision of N M C Nayanakantha.
- Miss I P Kudawithana of Aquinas College of Higher studies, Colombo completed her project on “රබර් සඳහා පාර්ශ්වික අංකුර හා කළල රෝපණය” under the supervision of N M C Nayanakantha.

Seminars/Conferences/Meetings/Work-shops attended

Officer	Subject	Organization
Dr (Mrs) P Seneviratne	Meeting of Nursery Activities Scientific Committee Meeting	Ministry of Plantation Industries
Dr (Mrs) P Seneviratne & Dr W Seneviratne	Meeting of Three Crop Research Institutes	Ministry of Plantation Industries
Dr (Mrs) P Seneviratne & Dr W Seneviratne	Workshop on Planting material production	ARTI
Dr (Mrs) P Seneviratne & Dr W Seneviratne	Nursery Development Meeting with all Regional Deputy Directors	RRI
Dr V H L Rodrigo & Dr W Seneviratne	Workshop on nursery practices and tapping	Kahawatta Plantation
Dr V H L Rodrigo	Workshop on Exploitation Techniques	IRRDB (India)
L S S Pathiratna	Mid term Review Seminar on Contract Research Projects	Sri Lanka Council for Agricultural Research Policy
Dr W Seneviratne	Nursery Development Committee meetings	Rubber Development Department Nurseries
N A A D Wickramarathna	Screening of high yielding clones of <i>Hevea</i> for marginally dry areas	Ministry of Environment and Natural Resources

Officer	Subject	Organization
N M C Nayanakantha	An assessment on the vulnerability of <i>Hevea</i> seed production to climate change	Ministry of Environment and Natural Resources
N M C Nayanakantha	Research and development related to coconut industry	Coconut Research Institute, Lunuwila
N M C Nayanakantha	Common Research Programme for the Plantation Sector	Coconut Research Institute, Lunuwila
Dr V H L Rodrigo N M C Nayanakantha	Introduction to <i>Paulownia</i>	Paulownia Plantations (Pvt.) Ltd.

Training programmes

Client	Subject	No. of programmes
Smallholders	Budgrafting & Planting Techniques	15
Plantation Sector	Tapping	05
Plantation Sector	Quality of tapping	02
Plantation Sector	Marking of tapping panels	2
Rubber Development Department	Young budding technique	01

Advisory visits

Client	No. of visits
Plantations	10
Smallholders	10

LABORATORY INVESTIGATIONS

Tissue culture

Propagation of clonal Hevea

Response of some new RRISL series clones, *i.e.* RRISL 203 and 205 for *in vitro* regeneration of axillary buds was low compared to that of some RRIC clones (RRIC 121 and RRIC 102) cultured on different media containing high sugar. The respond pattern was RRIC 121 > RRIC 102 > RRISL 205 > RRIC100 > RRISL 203 > RRIC 130. Embryo cultured plants were maintained to be used for micrografting experiments (N M C Nayanakantha, P Senevirathne and H A I Sajeewani).

Micropropagation of other species

Mucuna bracteata

Rhizogenesis occurred in calli of cotyledonary and hypocotyl explants of *Mucuna* on MS medium with several hormone combinations. Induction of somatic embryos or direct organogenesis from calli grown on different media (WPM, SH and L2) with different hormone combinations was not possible. However, some dark green protuberances (direct shoot initiations) were observed in some cultures but they did not grow further.

Paulownia spp.

80% of *Paulownia* seeds which had been soaked in water for 48 and 72 hours and cultured in liquid WPM and WPM with 2g/l agar germinated within the first week of culture.

Leaf explants (petiole+half laminae), internodes, nodes and roots derived from one month old *in vitro* grown seedlings were cultured on 25 different combinations of 2,4-D and BAP on WPM according to a factorial design. Callus formation occurred in all hormone combinations and rhizogenesis occurred in some media containing high 2,4-D concentration.

Direct shoot formation occurred only in leaf explants grown in several media containing a higher concentration of BAP and no 2,4-D. A maximum of 5-7 shoots regenerated from a single leaf explant in same media. Rooting was also possible on the same media. Individual plantlets were separated and successfully cultured on WPM with activated charcoal and no hormones. About one month old plants were acclimatized in a mist propagator and planted in polybags containing top soil.

Direct axillary bud proliferation was possible with nodal explants harvested from one month old *in vitro* grown seedlings in media containing low concentration of BAP or no hormones. However, growth of seedlings was better in media containing activated charcoal and no hormones. Direct axillary shoot proliferation was difficult with nodal explants harvested from about 2-3 months and 1-1½ years old field grown plants mainly due to high rate of contamination and sensitivity to the disinfectants used (N M C Nayanakantha, P Seneviratne and H N Hapuarachchi).

Vegetative propagation of Paulownia

Stem and root cuttings harvested from about 1 and 1-1½ years old *Paulownia fortunei* plants were placed in sand in a mist propagator under continuous mist during day time. Axillary shoots grown from both stem and root cuttings were planted in polybags filled with top soil. In some cuttings axillary shoots grown on either side were separated by splitting in to two halves and then each was planted separately in polybags. Successfully grown plants were field planted after three months from the polybag stage (N M C Nayanakantha, P Seneviratne and G A S Wijesekara).

FIELD EXPERIMENTS

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

Plants produced in the mist propagator were maintained in the field. More rooted cutting of clone RRIC 121 and 130 were field planted during the year (P Seneviratne and G A S Wijesekera).

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

29 plants were produced from 4 high yielding individuals of clone RRIC 130 and 6 plants were produced from one high yielding tree of PB 28/59 at Mahaoya Estate. Progress of the experiment was affected by the failure in mist propagator (P Seneviratne, G A S Wijesekera and R K Samarasekera).

Phase change of Hevea

Seedlings were planted from the year 1991 consecutively in the field. Growth, flowering, wintering regeneration capacity *etc.* were monitored (Table 1).

Table 1. *Flowering and wintering data in year 2003*

Year planted the seedling	Wintering	Flowering
1991	✓	✓
1992	✓	✓
1993	✓	✓
1994	✓	✓
1995	✓	✓
1996	✓	✓
1997	✓	-
1998	✓	-
1999	✓	-
2000	✓	-
2001	-	-
2002	-	-

(P Seneviratne and G A S Wijesekera).

Variation in budded plants

Uniform seedling populations were raised from seedling individuals. So far, the highest number of plants that could be produced from one seedling was 20. Six other seedlings produced 12 plants each and 8 more plants produced 11 plants each. The rest of the seedlings produced less than 10 plants per plant. All these plants were raised through rooted cuttings and now most of them are in buddable stage (P Seneviratne and G A S Wijesekera).

Root system of Hevea (CP/1994/1 -NK)

Plants having different root systems but with the same genetic make up are maintained in the field for further study on growth and anchorage (P Seneviratne and G A S Wijesekera).

Rootstock nurseries

The effect of mist on the seed germination of rubber (RN/2002/3- Dartonfield)

Seed germination was tested in a mist propagator under a continues mist for 24 hours as stacks of about 1½ and 2½ feet height. Control was a normal germination bed with a single seed layer. Seeds were also placed as a single layer on a surface of bricks and then watered with Aqua Spa porous tubes for one hour (Table 2).

Table 2. *The germination percentage of seeds after different days from sowing in different methods*

Days	Germination percentage (%)			
	Stack (1½ feet)	Stack (2½ feet)	Watered by a porous pipe	Normal germination bed
7	57	51	1	31
9	69	62	15	51
11	78	73	18	61
13	84	80	23	65
21	97	94	34	72

Germination percentage was significantly high when seeds were sown as a stack of about 1½ and 2½ feet height under a continued mist for 24 hours compared to that with a normal germination bed. Germination percentage was very low when irrigated by Aqua Spa Porous Pipes may be due to limited water supply given to seeds through the pipes (P Seneviratne and N M C Nayanakantha).

The effect of method of watering on growth of seedlings (RN/2001/3-Dartonfield)

The monthly mean diameter values of plants (both polybagged and ground

rootstocks) irrigated by the Aqua Spa Porous pipes and normal overhead method revealed that there was a significant difference between two irrigation methods in certain months specially during dry spells (Table 3).

During 1st and 2nd months (*i.e.* September and October) from planting there was no significant difference in the mean diameter values of both plant types irrigated by porous pipes and manual method. In October, there was a high rainfall (total of 860mm) throughout the month receiving more water for control plants as well. From 3rd month to 7th month, a considerable reduction of rainfall and number of rainy days occurred. Especially in February (7th month) there was a significant mean diameter increment observed in both plant types irrigated by porous pipes confirming that it has improved the water availability at the root zone during dry periods.

At the end of the 3rd month, a well distributed tap root with more laterals were observed in ground rootstocks irrigated by porous pipes than by over head method. However, more or less similar feeder root percentage was observed in polybagged plants of both treatments. But at the end of 6th month, the tap root had been penetrated more in to ground with more laterals in most of the poly bagged plants irrigated with the porous pipes.

No significant difference was observed in growth when the porous pipes were placed on the bags too.

Table 3. Monthly mean diameter measurements of both polybag and ground rootstock with/without the Aqua Spa microporous irrigation system

Age (months)	Mean diameter (mm)				
	Polybagged nursery			Ground nursery	
	Aqua spa pipes placed on the bags	Aqua spa pipes in the ground	Control	Aqua spa pipes in the ground	Control
1	3.9±0.1	3.7±0.1	3.8±0.1	3.7±0.1	3.8±0.1
2	5.2±0.1	5.4±0.1	4.9±0.1	5.0±0.1	4.8±0.1
3	6.8±0.1	6.6±0.1	6.3±0.1	6.3±0.1	5.9±0.1
4	8.4±0.1	8.1±0.1	8.3±0.2	8.0±0.1	8.4±0.2
6	9.5±0.2	9.5±0.2	8.8±0.2	9.7±0.2	9.0±0.2
7	11.0±0.2	11.0±0.2	10.8±0.3	11.9±0.2	11.2±0.3
9	13.0±0.4	13.0±0.3	12.4±0.4	15.2±0.4	14.0±0.5

(N M C Nayanakantha and P Seneviratne)

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

A research grant was awarded to carry out the above study under the junior research programme of climate change enabling activity (phase II) project and first report (detailed work plan and methodology) was submitted. Flowering and seed fall were estimated in three genotypes (PB 86, RRIC 100 and RRIC 121) at two different age categories in 6 areas (three from Intermediate Zone and three from Wet Zone). Rainfall data was also collected from respective areas. A rapid appraisal based on a check list was conducted targeting the estate managers, senior field officers, *Kanganies* and laborers in order to gather information on past years seed production, nursery establishment, supply of seeds to those nurseries, disease incidences, number of plants issued from that particular estate *etc.*

The total number of inflorescence per hectare was higher in all the clones of both age categories in the Intermediate Zone than that in the Wet Zone. The total number of inflorescence produced per hectare was much lower in the clearings at the young age category than those at the old age category irrespective of the climatic zones, and genotypes (Fig. 1).

Clone wise, the no. of inflorescence production and no. of female flowers per hectare were higher in PB 86 of both age categories in both Zones compared to that in other clones.

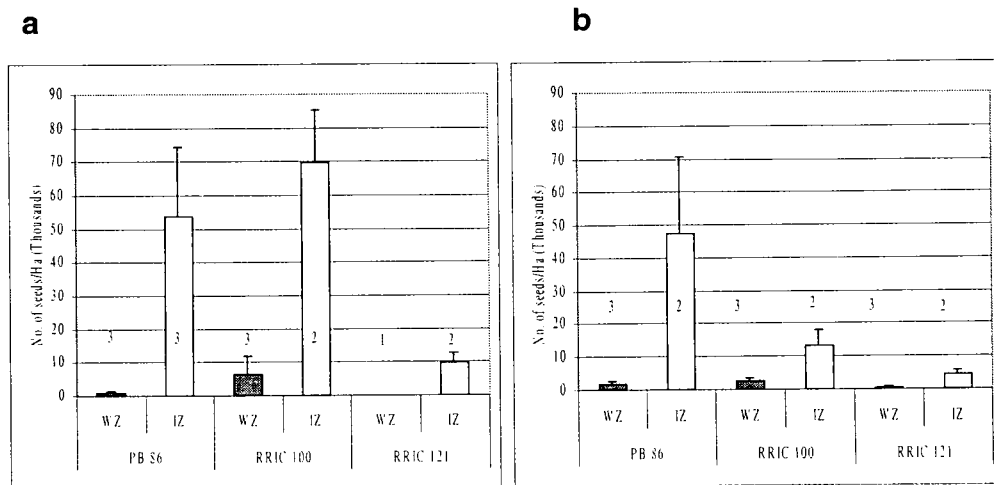


Fig. 1. Total seed production per hectare in each clone in all sites at the wet and intermediate zone in 2003 a) clones in 18-25 age category b) clones in 10-15 age category

The pod fallen (total of mature and immature) was significantly higher in the Intermediate Zone than that in the Wet Zone irrespective of the clone and the age category. Among clones, PB 86 showed a higher mature pods fallen in both the Zones at both age categories. Immature pods fallen in the Intermediate Zone was high in RRIC 100 at the old age category compared to that with other clones while it was high in PB 86 at the young age category compared to that with other clones. A satisfactory seed production was observed in the Intermediate Zone compared with the Wet Zone irrespective of the clone and the age groups. However, clonal and age effects were also existed in both zones. It seemed that the seed production was higher at a field boundary and lower in the centre plots irrespective of the clone and the age category in both zones.

RRIC 100 produced a higher number of seeds per hectare in both Zones at both age categories except for the intermediate zone at the young age category where PB 86 showed the highest seed production. RRIC 121 produced the lowest seed production in both zones irrespective of the age. In the Wet Zone, a considerable amount of seed production was seen in RRIC 100 at the old age category only. Generally a higher seed production was seen in clones at the old age category than those in young age category irrespective of zones (N M C Nayanakantha, P Seneviratne and V H L Rodrigo).

An assessment on the vulnerability of rubber crop (with respect to growth) for climate change (CC/2003/2)

A research grant was awarded to carry out the above study under the junior research programme of climate change enabling activity (phase II) project and first report (detailed work plan and methodology) was submitted. Monthly girth measurements were taken from five years old two genotypes (RRIC 100 and RRIC 121) in two different areas representing Intermediate and Wet Zones of Sri Lanka. Rainfall and Temperature data were also gathered on daily basis.

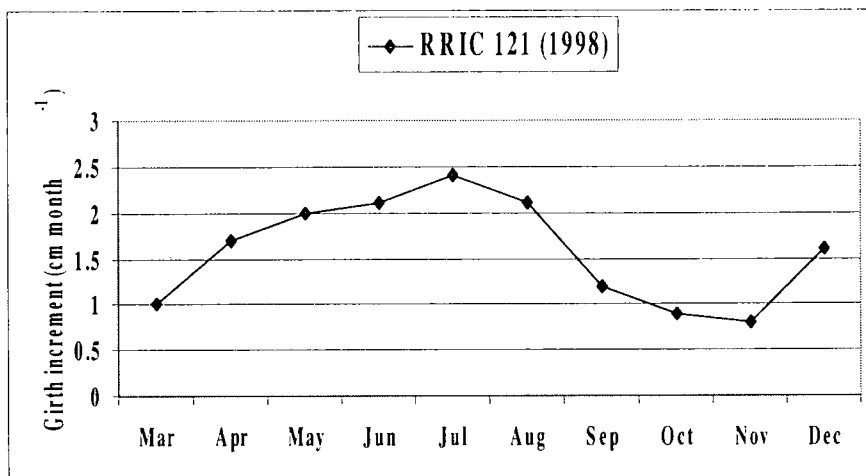
In RRIC 121, growth started from March and it continued up to July in Dartonfield but such a growth pattern was not observed in Bibile. Maximum growth of RRIC 121 (1998) in Dartonfield was observed in July while in Bibile it was observed in March (Fig. 2).

Girth growth started to decline in RRIC 121 in Dartonfield from August and it was minimal in November. The growth of RRIC 121 in Bibile during April and May was negligible and it was fluctuated from June (2003) to December as a zig zag pattern giving a minimum growth in September and in November.

In RRIC 100 in Bibile, maximum growth was observed in June while minimal growth was observed in October. The total annual girth from February to

December 2003 in RRIC 121 was significantly higher in Dartonfield (13.4 cm) compared to that in Bibile (7.7 cm) (Fig. 2 & 3).

a



b

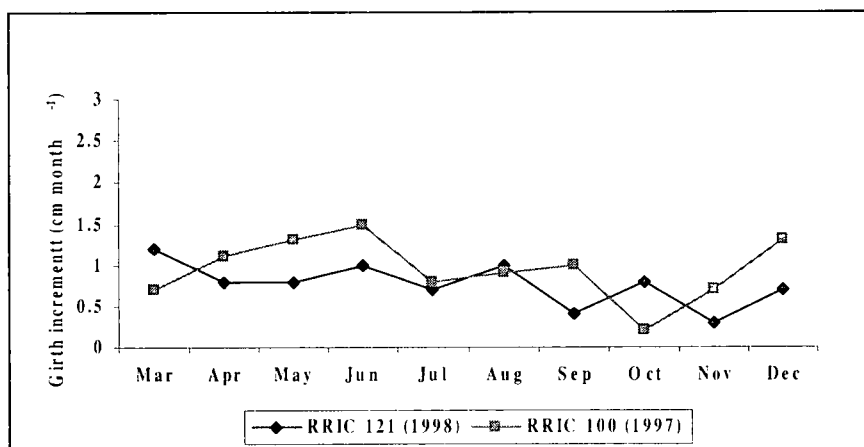


Fig. 2. Monthly variation in girth increment of RRIC 121 (1998) in the Dartonfield estate (a) and of RRIC 121 (1998) and of RRIC 100 (1997) in Bibile estate (b) from March 2003 to February 2004.

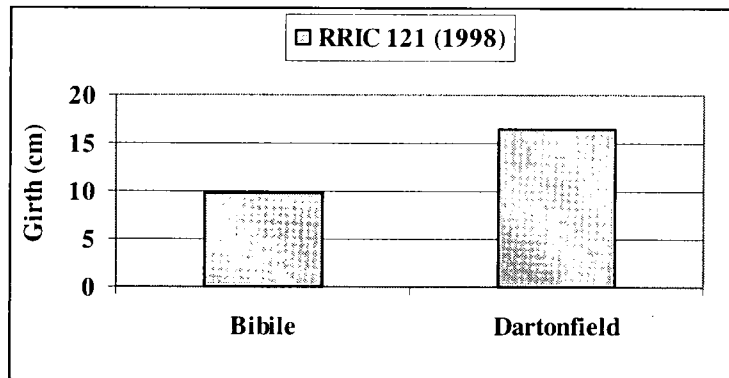


Fig. 3. Total annual girth increment of RRIC 121 (1998) from March 2003 to February 2004 in Bibile and Dartonfield estates (N M C Nayanakantha, B T J Perera and P Seneviratne)

Budgrafting

Successive grafting - BG/1999/1 - Dartonfield

Only one budgrafting was possible during the year. About five passages have been obtained up to now (P Seneviratne and G A S Wijesekera).

Crown budding

RRIC 110 (1994 and 1996 replanting) - CB/1998/1 - Padukka

Girth measurements of RRIC 110 trees crown budded with RRIC 100, 102, 117, 130 and *H. spruciana* at Padukka estate were not taken during the year (P Seneviratne, S Wilbert and M N de Alwis).

RRIC 121 trunks with RRIC 100 crowns - CB/1992/1 - Dartonfield

Mean girth and girth increments are shown in the Table 4. RRIC 121 showed better girthing as expected. No yield measurements were taken during this year (P Seneviratne and S Wilbert).

Table 4. Average girth of crown budded trees and their control trees

Treatment	Mean girth (cm)	Girth increment (cm)
T- RRIC 121, C – RRIC 100	59.06	3.9
RIC 121 (not crown budded)	83.60	4.0
RRIC 100 (not crown budded)	79.50	2.7
RRIC 121 (control)	56.0	5.7
RRIC 100 (control)	54.9	4.7

RRIC 130 trunks with *H. spruciana* crown - CB/1992/2 - Galewatta

Girth and girth increment values are shown in the Table 5.

Table 5. Girth and girth increment of crown budded and control trees of RRIC 130

Crown	Tree No.	Girth (cm)	Girth increment (cm)
<i>Hevea spruciana</i>	1	60.0	4.5
	2	61.5	5.5
	3	51.8	2.8
	8	75.0	5.0
<i>Mean</i>		62.1	4.45
RRIC 130	4	49.0	1.0
	7	-	-
	9	84.2	6.2
	10	88.3	7.3
	11	71.0	3.0
	12	59.0	1.5
	13	80.7	4.7
<i>Mean</i>		72.0	3.95

(P Seneviratne and S Wilbert)

Low girth of *Hevea spruciana* crown budded plants is due to the initial set back after crown budding. However, girth increment is higher with *Hevea spruciana* crowns. Yield measurements were not taken (P Seneviratne and S Wilbert).

RRISL 224 (1992 replanting of G & PB Dept) - CB/1999/1 - Galewatta

Girth of RRISL 224 trees were not taken during the year. This experiment was maintained by the Dartonfield estate (P Seneviratne and M N de Alwis).

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

Table 6. Mean girth of trees with different crown /trunk combinations

Treatment	Trunk	Crown	Mean girth (cm)
1	PR 305	Control *	28.82 ± 0.73
	PR 305	RRIM 717	19.82 ± 0.72
	PR 305	Pollarded	27.84 ± 0.79
2	RRIM 717	Control *	29.38 ± 0.52
	RRIM 717	PR 305	19.8 ± 0.55
	RRIM 717	Pollarded	26.74 ± 1.69
3	BPM 24	Control *	28.26 ± 0.9
	BPM 24	PB 260	18.0 ± 3.0
	BPM 24	Pollarded	25.1 ± 1.44
4	PB 260	Control *	31.67 ± 1.13
	PB 260	BPM 24	19.99 ± 0.64
	PB 260	Pollarded	29.0 ± 1.0
5	RRIC 121	Control *	33.0 ± 1.11
	RRIC 121	RRISL 217	23.12 ± 1.17
	RRIC 121	Pollarded	28.4 ± 1.31
6	RRISL 217	Control *	31.14 ± 0.73
	RRISL 217	RRIC 121	22.75 ± 0.48
	RRISL 217	Pollarded	27.74 ± 0.49
7	RRIC 121	Control *	32.93 ± 1.15
	RRIC 121	RRIC 130	24.5 ± 3.12
	RRIC 121	Pollarded	34.48 ± 1.13
8	RRIC 130	Control *	34.43 ± 0.91
	RRIC 130	RRIC 121	22.58 ± 0.66
	RRIC130	Pollarded	33.95 ± 0.88

* Not crown budded

Different trunk, crown combination show a variation in girth, RRIC 121 trunk with RRIC 130 crown (Tr.F) shows the highest (Table 6). Similarly pollarded RRIC 121 shows higher girth than control RRIC 121 (P Seneviratne and L Zoysa).

Budwood nurseries

Budwood availability

BN/1991/DF

About 288 trees in this nursery are not used and need to be uprooted.

BN/2000/DF

BN/2001/Olikanda

BN/2002/Olikanda

These budwood nurseries were established with new RRISL clones in order to provide authentic material for the establishment of budwood nurseries in Government nurseries and in Plantation Company Nurseries (Table 7).

Table 7. *Number of plants available from each clone*

Clone	BN/2000/	BN/2001/	BN/2002/
	Dartonfield	Olikanda	Olikanda
RRISL 200	14	7	-
RRISL 201	33	11	-
RRISL 202	27	3	-
RRISL 203	33	18	-
RRISL 205	33	15	-
RRISL 210	27	-	-
RRISL 215	31	5	-
RRISL 217	46	98	-
RRISL 218	27	-	-
RRISL 219	35	-	-
RRISL 2000	-	-	120
RRISL 2001	-	-	82
RRISL 2002	-	-	40
RRISL 2003	-	-	83
RRISL 2004	-	-	53
RRISL 2005	-	-	52
RRISL 2006	-	-	25
Total	306	157	455

(P Seneviratne, U S Weerakoon, M N de Alwis and L Zoysa)

Nursery inspection

21 nurseries were visited for clone identification (P Seneviratne, U S Weerakoon, M N de Alwis and L Zoysa).

RRISL Nurseries

The management of the government rubber nurseries which was under the Rubber Development Department was handed over to RRI by the Ministry of

Plantation with effect from 1st July 2003. The plant production for 2004 was increased by about four times that of 2002 (Table 8). Gurugoda nursery which was abandoned for years was re-started from 01.09.2003. It was possible to start a new nursery at Moneragala in November 2003, to cater to the massive new planting programme at Moneragla.

Table 8. Targeted plant production in RRISL nurseries for 2004

Nursery	Plants for May/June 2004	Plants for Oct./Nov. 2004	Total
Welikadamulla	250,000	200,000	450,000
Meerigama	150,000	200,000	350,000
Egaloya	150,000	200,000	350,000
Karapincha	60,000	290,000	350,000
Gurugoda	-	200,000	200,000
Moneragala	-	200,000	200,000
Total	610,000	1,290,000	1,900,000

(P Seneviratne, W Seneviratne, U S Weerakoon, M N de Alwis and L Zoysa).

Planting techniques

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

Mean girth values are shown in the Table 9 and Figure 4.

Table 9. Mean girth and SEM of the plants of different treatments

Treatment (Planting method)	Poly bag plants PB 260 (cm)	Young budding RRIC 121 (cm)
T1 - With the poly bags	35.06 ±1.2	34.6 ± 0.87
T2 – Without base of the poly bag	39.43 ±1.2	33.94 ±1.03
T3 – T2 + 4 slits on the bag	37.74 ±1.5	34.87 ±1.06
T4 – With 4 slits on the bag	37.9 ±0.7	35.46 ±0.99
T5 – Whole bag removed (current recommendation)	40.51 ±1.5	36.48 ±1.18

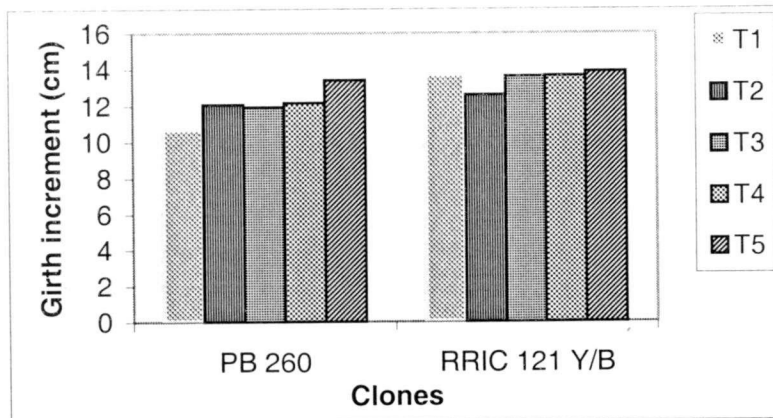


Fig. 4. Girth increment of different treatments (P Seneviratne and U S Weerakoon)

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

The girth increment for the year is satisfactory in all soil types. The mean girth of plants grown in bad, moderate and good soils are given in Table 10.

Table 10. The mean girth (cm), girth increment (cm) in 03 types of planting holes

Soil condition	Girth (cm)	Girth increment (cm)
Bad	18.68	11.69
Moderate	20.15	12.81
Good	19.00	11.9

The correlation between current and initial girth for good moderate and bad hole types are given in Table 11. As shown in the Table 11, a better correlation is observed in plants grown in moderate soil.

Table 11. The correlation between current and initial growth

		Bad	Moderate	Good
Initial girth vs girth	r	0.25262	0.47466	0.28044
after 2 years	p	<0.0025	<0.0001	<0.0001
	n	141	84	254

r - correlation coefficient, p - probability, n - number of plants
(P Seneviratne and L Zoysa)

Coppicing (CP/2002/1)***Shoot regeneration capacity of mature trees***

Height and girth measurements were taken during the year (Table 12).

Table 12. *Height and girth of regenerated shoots*

The height of pollarding	6"	12"	18"	24"
Mean height (cm)	158.31	140.8	157.86	254.05
Mean girth (cm)	8.515	6.69	7.66	16.35
No. of plants	3	3	8	2

(P Seneviratne and M Alwis)

CP/2003/IRRIC-52

This experiment was started in May 2003, 150 plants were cut at 6" above the ground level. Sprouting started after about one month (P Seneviratne and M Alwis).

Cultural practices during immature phase***Branch induction - CP/2000/1 - Pallegoda***

Details of this experiment are reported in the annual review for the year 2001. Girth and the girth increment for different treatments are given in the Table 13.

Table 13. *Girth and the girth increment of trees of different treatments (The SEM is given within brackets)*

Treatment	Girth (cm)		Girth increment	
	RRIC 121 only	Mean of all clones	RRIC 121 only	Mean of all clones
Leaf cap method (T1)	56.43 (1.23)	56.1 (1.0)	9.49 (1.72)	9.14 (1.42)
Cut and remove all leaves (T2)	54.04 (1.06)	53.06 (0.89)	9.15 (1.69)	9.22 (1.37)
Removing 3" portion of the apex (T3)	55.98 (1.03)	54.47 (0.84)	9.25 (1.85)	8.1 (1.22)
Control (T4)	54.5 (0.78)	56.96 (0.8)	9.31 (1.63)	8.72 (1.26)

(P Seneviratne and U S Weerakoon).

Planting at high density - PT/1992/1 - Kuruwita

Details of treatments and the experimental layout are given in the Annual Review 1992. Growth and yield parameters of the clones tested under four different densities are given in Table 14. The growth of rubber (as indicated by mean girth, bark thickness and % trees in tapping) has significantly decreased with the increase of planting density. Therefore, latex yield at individual plant level (g/t/t) was highest in the lowest density. However, number of trees in tapping increased with the increase in planting density resulting in marginal increase in yield per hectare (YPH). However, YPH at 700 trees/ha. showed a low value due to less number of trees in tapping. Plant height was comparable among planting densities but was significantly greater in RRIC 121 than in other two clones tested. In general, mean merchantable and total timber volume per tree along the main stem decreased with increase in planting density. However, it was vice versa on per hectare basis (V H L Rodrigo, A Nugawela and T U K Silva).

Planting at low density – PT/1996/Gallewatta and Nivithigalakele

Girth measurements were taken at 5 feet from the graft union towards the end of the year and are presented in Table 15. Tapping commenced in March 2003. Arrangement were made to record daily yield data according to the clones and density from January 2004.

Table 14. *Effect of planting density on growth and yield parameters of rubber In (a) mean plant girth (GT) and girth of trees in tapping (GT-TIT) (cm), bark thickness (BT) (mm) at 150cm height, % trees in tapping (TIT) and trees in tapping per hectare (TIT/ha), in (b) tree height (TH) (m), merchantable volume (MV), total timber volume (TV) along the main stem (m³) per tree and per hectare and in (c) tree yield (g/t) and estimated YPH (kg/ha/year)*

(a)

Density	RRIC 100					RRIC 110					RRIC 121				
	GT (cm)	GT- TIT (cm)	BT (mm)	% TIT	TIT/ha	GT (cm)	GT- TIT (cm)	BT (mm)	% TIT	TIT/ha	GT (cm)	GT- TIT (cm)	BT (mm)	% TIT	TIT /ha
500	58.71	58.71	7.31	92.57	463	56.30	57.37	6.92	70.96	355	65.23	66.09	7.19	91.15	456
600	57.75	57.75	7.19	88.41	530	51.92	55.31	6.40	63.96	384	61.68	62.63	7.05	90.56	543
700	55.23	55.63	7.01	84.14	589	49.83	53.52	6.45	51.63	361	60.00	60.73	6.60	86.67	607
800	55.26	55.42	6.93	84.04	672	48.70	53.20	6.17	51.15	409	58.00	59.15	6.50	89.88	719

(b)

Density (Trees/ ha.)	RRIC 100					RRIC 110					RRIC 121				
	TH (m)	MV (m3) /tree	TV (m3) /ha.	% TIT	TIT/ ha	TH (m)	MV (m3) /tree	TV (m3) /ha.	% TIT	TIT/ ha	TH (m)	MV (m3)/ tree	TV (m3)/ ha.	% TIT	TIT/ ha
500	18.67	0.14	68.03	0.23	115.78	18.50	0.09	39.04	0.19	83.77	22.37	0.20	101.90	0.31	156.22
600	16.20	0.12	73.50	0.21	124.20	18.07	0.09	52.22	0.19	109.18	22.50	0.16	93.76	0.28	165.66
700	17.35	0.10	71.02	0.21	145.23	17.50	0.11	72.64	0.21	134.46	20.82	0.13	93.60	0.27	184.77
800	18.40	0.09	68.45	0.21	163.59	18.32	0.08	51.24	0.19	129.28	19.45	0.10	82.94	0.23	180.87

(c)

Density (tree/ha)	RRIC 100		RRIC 110		RRIC 121	
	Yield (g/t/t)	Yield (Kg/ha/yr)	Yield (g/t/t)	Yield (Kg/ha/yr)	Yield (g/t/t)	Yield (Kg/ha/yr)
500	25.64	1228.72	27.78	1020.16	41.95	2001.14
600	25.49	1390.77	25.30	1018.34	35.21	2010.76
700	20.67	1238.30	25.72	937.04	31.34	1977.89
800	21.30	1481.06	26.09	1078.25	28.28	2130.77

Table 15. Mean girth (cm) of four clones at 4 densities

	RIC 100	RRIC 121	RRIC 130	PB 260
350 trees/ha	66.56 ± 2.13	69.08 ± 1.45	69.41 ± 2.70	63.36 ± 0.97
425 trees/ha	65.46 ± 2.34	66.73 ± 1.23	68.24 ± 1.49	64.78 ± 1.14
500 trees/ha	61.93 ± 1.41	63.37 ± 1.59	61.51 ± 3.22	57.08 ± 1.3
575 trees/ha	58.71 ± 1.18	60.99 ± 1.20	55.64 ± 4.08	58.79 ± 1.84

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

The possibility of expanding cultivation of rubber at elevations above 300m in the mid country wet zone

Replicates 1 and 2 were selected for testing the performance of *Hevea* at the altitude of 650m site. Exploitation was begun in mid 2003 by adopting two tapping systems. RRIC 100 and RRIC 102 were tapped on ½S d/2 system while RRIC 130 and PB 260 on ½S d/3 system. Latex volume and dry rubber content were recorded for each clone daily. Trees of two girth categories *i.e.* 45cm and 50cm were tapped in each clone to measure initial flow rate and plugging index at monthly interval. Dry rubber yield per tree per tapping (g/t/t), latex volume per tree per tapping and trunk girth were highest in clone RRIC 130. The dry rubber contents (DRC) were less in all four clones in this region (Table 16).

Table 16. Yield and growth performance of different *Hevea* clones

Parameter	Clone			
	PB 260	RRIC 102	RRIC 100	RRIC 130
Yield (g/t/t)	25.19	15.19	18.24	41.41
Latex volume (ml/tree/tapping)	100.89	59.11	71.45	165.01
Dry rubber content (%)	26.12	26.37	26.79	25.76
Trunk girth (cm)	39.60	46.80	50.30	52.20

Among the different clones initial flow rate is highest in clone RRIC 130. The plugging index is lowest in RRIC 130 and PB 260, the clones tapped low frequency at ½ S d3 system and recording highest g/t/t levels (Table 17).

Table 17. Clonal mean in Plugging Index and Initial flow rate at two different girth levels

Genotype	Initial flow rate		Plugging index	
	45cm girth	50cm girth	45cm girth	50cm girth
RRIC 100	0.041	0.046	2.170	2.368
RRIC 102	0.045	0.048	2.150	2.159
RRIC 130	0.078	0.082	1.657	1.511
PB 260	0.042	0.049	1.263	1.306

(A Nugawela, S T G C de Silva and K A G B Amaratunga)

Performance of Hevea genotypes in the mid country high elevation region of Sri Lanka. (Climate change project)

This experiment was initiated to investigate the influence of climatic factors to Latex yield of *Hevea* in mid country wet zone.

The relationship of latex yield to various climatic factors can be ascertained through a correlation analysis (Table 18 & 19). It was evident that in RRIC 100, the yield was negatively correlated with minimum temperature and relative humidity in afternoon. In PB 260 and RRIC 100 the yield showed a positive correlation with maximum temperature.

Table 18. Climatic parameters during the period of August to December

Month	CLIMATIC PARAMETERS				
	T. min. (°C)	T. max. (°C)	Rainfall (mm)	RH-1 (morning)	RH-2 (afternoon)
August	22.13	26.32	212	79.61	74.03
September	22.05	26.77	155	83.43	73.03
October	21.39	27.52	192	81.81	71.84
November	21.25	26.72	283	85.47	75.13
December	20.21	28.16	17	79.52	64.32

Table 19. *Correlation coefficients of latex yield (g/tree/tapping) of different genotypes of Hevea with climatic factors*

Clone	T. min.	T. max.	Rainfall	RH-1	RH-2
PB 260	-0.073	0.216 *	0.057	-0.135	-0.008
RRIC 100	-0.338 *	0.284 *	-0.098	-0.054	-0.171 *
RRIC 102	-0.142	0.094	-0.059	-0.054	-0.152
RRIC 130	-0.147	0.161	-0.061	0.038	-0.187

* Significant at 5%

Although the high rainfall and high number of rainy days were recorded in this area, remarkably higher number of possible tapping days could be observed (Table 20).

Table 20. *Number of rainy days and tapping days*

Month	Rainy days	Possible tapping days	
		Normal tappings	Late tappings
August	13	27	1
September	15	29	0
October	13	28	2
November	19	26	3
December	03	31	0

(A Nugawela and S T G C de Silva)

Exploitation

Developing of leech repellents – LR/2001/01

A citronella oil based mixture, which was fortified with a by product of nutmeg oil was found to be most effective with regard to the repelling ability. However, retention of compounds on skin has to be improved (N A A D Wickramarathna, V H L Rodrigo and A Nugawela In collaboration with Link Natural Product Ltd.).

Implementing an improved tapping knife

Testing a new tapping knife which is made out of high quality metal (from saw blade) was started from August 2003 and collecting data is in progress (P Seneviratne, V H L Rodrigo and K A G B Amaratunga).

Screening of high yielding clones of Hevea for marginally dry area (CS/2003/01)

A research grant was awarded to carryout the above study under the junior research programme of climate change enabling activity (phase II) project. A pot experiment was established identify the clonal variations with respect following physiological parameters under different levels of moisture stress. Clones RRIC 205, RRISL 2000 and RRISL 2001 were included.

- Leaf water potential (LWP)
- Relative water content (RWC)
- The rate of stomatal diffusive resistance and transpiration rate
- CO₂ assimilation rate

Three different moisture levels are

- Md - plants were watered daily up to the field capacity.
- Mw - plants were watered weekly up to the field capacity
- Mm - plants were watered monthly up to the field capacity

(N A A D Wickramarathna and V H L Rodrigo)

Girth at opening (TG/99/1)

In all clones tested, the annual yield per tree was less in trees opened at 40 cm (G₄₀) and 45 cm (G₄₅) when compared with that of 50 cm (G₅₀) Table 21. During first two years of commencing tapping the highest dry rubber yield per tree per annum was given by clone RRISL 211 irrespective of the girth at opening. The performance of clone RRIC 121 was better under low frequency tapping with stimulation. Effect of different tapping systems at different girth classes on total dry rubber yield per tree per annum of clones RRIC 102, RRIC 121 was better under low frequency tapping with stimulation (A Nugawela, V H L Rodrigo, K Gunasekera and R P Karunasena).

Low frequency tapping

Udabage estate – LFT/2000 -/1

Effect of ethrel stimulation on d/2 tapping was not promising. Although number of tapping days recorded in d/3 tapping was less than that of d/2 tapping, the rate of bark consumption was greater than the expected levels in d/3 systems, indicating that double tapping has been practiced excessively. Therefore, g/t/t was comparable between d/2 and d/3 systems (Table 22).

Number of ethrel stimulation on T3 treatment confined to 4 rounds due to rain interference. Hence the performance of T₃ and T₄ treatments was similar. Introduction of additional tapping cut (T₅) instead of stimulation on d/3 system led to high levels of bark consumption with no yield advantage (A Nugawela, V H L Rodrigo and S Wilbert).

Table 21. Total dry rubber yield per tree per annum (kg tree⁻¹ annum⁻¹)

Clone	Tapping treatment	Yield (kg/tree ⁻¹ annum ⁻¹)									
		1 st year			2 nd year			Mean for		Clones	
		G ₄₀	G ₄₅	G ₅₀	G ₄₀	G ₄₅	G ₅₀	1 st year	2 nd year	1 st year	2 nd year
RRIC 102	½ S d/2	0.98	2.22	3.04	1.40	2.59	4.55	2.08 ^A	2.84 ^A	1.80 ^A	2.39 ^B
	½ S d/3	0.74	1.31	2.73	0.83	1.84	3.36	1.59 ^B	2.01 ^B		
	½ S d/3 +1	0.94	1.71	2.54	1.13	2.34	3.51	1.73 ^B	2.33 ^B		
RRIC 121	½ S d/2	2.21	2.03	3.61	3.47	3.65	4.48	2.62 ^A	3.87 ^B	2.25 ^B	3.64 ^A
	½ S d/3	0.66	1.68	2.54	1.58	2.92	3.25	1.63 ^B	2.59 ^A		
	½ S d/3 +1	1.04	2.47	3.99	2.80	5.14	5.51	2.50 ^A	4.48 ^A		
RRIC 211	½ S d/2	1.07	3.62	5.30	2.96	4.33	6.18	3.55 ^A	4.49 ^A	3.09 ^A	3.79 ^A
	½ S d/3	1.31	3.15	3.65	2.25	3.30	3.97	2.71 ^B	3.17 ^B		
	½ S d/3 +1	1.58	3.06	4.44	2.54	3.61	4.95	3.03 ^B	3.70 ^B		
Opening girth mean		1.24 ^A	2.36 ^B	3.54 ^A	2.11 ^A	3.30 ^B	4.42 ^A				

Means with the same letters are not significantly different at p.0.05.

Table 22. *Effect of tapping systems on growth and yield parameters*

Treatment	g/t/t	Tapping days/Year	Yield tree/year Kg	Stand/Ha.	YPH (Kg)	Stimulation rounds/year	Girth increments (cm)	BCR (cm)	TPD %
T ₁ - ½ S d/2 – 100% control	25.28	150	3.79	332	1258.3	-	3.83	24.08	4.53
T ₂ - ½ S d/2 – 100% + E* 4/Y	25.32	151	3.82	332	1268.2	4	2.35	25.85	3.85
T ₃ - ½ S d/3 – 67%+E* 6/Y	27.26	102	2.78	332	922.9	4	2.43	22.56	4.30
T ₄ - ½ S d/3 – 67%+E* 4/Y	29.44	94	2.77	332	919.6	4	3.25	23.63	5.40
T ₅ - ½S(↓) -d/3 133%	36.13	100	3.61	332	1198.5	-	2.30	A- 19.52 B- 20.47	12.0

*E – E-2.5%, Ethrel Ba 1.6(2.5)

A-A panel, B – B panel

Details of this experiment appeared in the Annual Review for 2001 and 2002.

Gallewatta, 1986 Replanting LFT/2003/1

This experiment was started in June 2003 at Gallewatta to test the effectiveness of low frequency tapping systems, *i.e.* d/3, d/4 and d/6 in clones RRIC 100 and RRIC 121.

Details of the LFT systems together with stimulation schedule are given in Table 23.

Table 23. *Tapping systems and stimulation schedule of different treatments*

Treatment	Tapping system	Schedule of stimulation (ET 2.5% Ba)
T ₁	½ S d/3	June, September, December
T ₂	½ S d/4	June, July, August, September, October, November, December
T ₃	½ S d/6	June, July, August, September, October, November

Each treatment was replicated twice within each clone. Number of trees allocated to each treatment varied according to the availability of trees (30, 20 & 52 for T₁, T₂ & T₃ systems respectively).

Daily latex yields were monitored using volumetric measurements of latex and gravimetric method for DRC% (Table 24).

Table 24. *Differences in yield parameters between treatments*

Treatment	Clone	g/t/t	Tapping days (7 months)	Stand/Ha.	YPH (kg)	Average DRC (gm/l)
T ₁ ½S d/3 + 2.5%ET	RRIC 100	48.2	35	358	604	348
	RRIC 121	61.9	41	358	896	366
T ₂ ½S d/4 + 2.5%ET	RRIC 100	65.33	39	358	912	370
	RRIC 121	58.86	39	358	821	362
T ₃ ½S d/6 + 2.5%ET	RRIC 100	50.0	30	358	536	374
	RRIC 121	73.7	30	358	792	348

Based on 7 months yield records in clone RRIC 100 yield per hectare was significantly greater in d/3 and d/4 treatments when compared with that of d/6.

Only the yield of d/6 was greater than that of d/3 in clone RRIC 121 (V H L Rodrigo, A Wickramarathna and R K Samarasekera).

Dartonfield, 1988 Replanting LFT/2003/1

This experiment was started in July 2003 at Dartonfield to test the effectiveness of low frequency tapping systems in clones RRIC 100 and RRIC 130.

Details of the LFT systems together with the stimulation schedule are given in Table 25.

Table 25. *Tapping systems and stimulation schedule of different treatments*

Treatment	Tapping system	Schedule of stimulation (ET 2.5% Ba)
T ₁	½ S d/4	July, August, September, October, November, December
T ₂	½ S d/6	July, August, September, October, November, December
T ₃	½ S d/2	-

Twenty trees were allocated to each clone. Daily latex yields were monitored using volumetric measurements of latex and gravimetric method for DRC % (Table 26).

Table 26. *Differences in yield parameters between treatments*

Treatment	Clone	g/t/t	Tapping days (7 months)	Stand/ Ha.	YPH (kg)	Average DRC (gm/l)
T ₁ ½S d/4 + 2.5%ET	RRIC 130	66.8	40	281	750	372
	RRIC 100	45.35	42	313	596	300
T ₂ ½S d/6 + 2.5%ET	RRIC 130	70.39	27	281	534	426
	RRIC 100	42.82	27	313	361	312
T ₃ ½S d/2	RRIC 130	28.6	75.5	240	518	380
	RRIC 100	27.3	77	240	511	340

Based on 6 months yield records of clone RRIC 130 yield per hectare was greater in d/4 and d/6 treatments when compared with that of d/2) (V H L Rodrigo, A Wickramarathna and R K Samarasekera).

Tapping Panel Dryness (TPD/2002/01)

Council for Agricultural Research Policy (CARP) granted Rs.1,215,890.00 for the research project: 'Identification of physical factors affecting tapping panel dryness of high yielding clones of rubber (*Hevea brasiliensis* Muell Arg.), and some biochemical changes at the onset of tapping panel dryness (TPD)', from April 2003 for two years.

Results on TPD survey and continuous monitoring of TPD being conducted in some estates in Kalutara region are shown in the Tables 27 & 28, respectively (for details, see Annual Review 2002). The project will be continued until March 2005.

Even more than 6% of totally dry trees have been observed even in clearings being tapped in first virgin panel, A (Tables 27 & 28), and it is a very high incidence of TPD (A M W K Senevirathna, V H L Rodrigo, S Wilbert and S Perera).

Table 27. Summary of the survey of TPD in different clones under different tapping panels

Clone	Tapping Panel	No. of Tapping blocks	% TPD	
			Total	Partial
RRIC 100	A	7	6.9	3.1
	B	6	14.5	12.9
	C	4	22.7	5.6
	D	1	17.39	6.02
RRIC 102	A	2	4.0	2.4
	B	2	7.9	7.4
	C	-	-	-
	D	-	-	-
RRIC 121	A	2	6.1	5.3
	B	8	11.0	6.7
	C	4	11.4	8.1
	D	-	-	-
RRIC 130	A	5	1.2	2.1
	B	1	12.4	8.1
	C	-	-	-
	D	-	-	-

Table 28. Percentage total and partial TPD trees of a tapping block of rubber being tapped in the first virgin panel

Clone	Estate	Planting year	% TPD	
			Total	Partial
RRIC 100	Ambethenna	1995	6.5	12.0
	Culloden	1997	-	0.7
RRIC 121	Ambethenna	1996	1.4	8.8
	Uskvalley	1996	1.0	-
	Culloden	1997	-	-
RRIC 130	Culloden	1997	0.3	-
	Clyde	1997	0.3	1.0

Intercropping

Spatial arrangements

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

This study aimed to find out suitable spatial arrangements for planting rubber in order to facilitate long-term rubber based intercropping systems. Details of the experiment are given in the Annual Review 1992. There were five systems of spatial arrangements comprising 1) traditional single row (SR), 2) paired row (DR), 3) three-row (TR) systems, 4) three plant triangular (CT) and 5) four plant square cluster (CS) systems of planting. Planting density of rubber remained constant across the treatments and systems were assessed for a period of nine years. Plants in traditional avenue and cluster systems performed better than those in the rest with respect growth and yield (Table 29). However, canopy closure was rapid in these systems, hence poor light penetration (Table 30; Figure 5). Both paired and three row systems provided highest exposed area hence light penetration allowing greatest area for intercropping. Considering overall performance, paired row system (DR) of planting rubber offers practically feasible spatial system for intercropping perennials, provided increased space within the double rows in order to minimize intra-specific competition of rubber. The gap between rubber rows (*i.e.* of the avenue) in the presently recommended planting system for rubber/tea intercropping is 12 m and that has not been sufficient to provide required light for long-term tea cultivation. Hence, with the improved gap provided between alleys, *i.e. ca.* 14m, DR system would provide a better system; however further increase in the gap will be advantageous. In this regard, it is suggested that 2.7-3m should be considered for the space given within the double rows (*i.e.* instead of 2.4m), whilst a space of 15-18m may be suitable between double rows (V H L Rodrigo, T U K Silva and E S Munasinghe).

Table 29. *Treatment effect on crop establishment and yield. Treatment codes are, SR-single row, DR- double row, TR-three row, CT-cluster triangular and CS- cluster square*

Treatment	Casualties (%)	Weak plants (%)	Plants with TPD (%)	Trees in tapping (%)	Yield per hectare (kg/ha)	Yield per tree (g/t/t)
SR	0.00	0.00	9.29	90.71	1530.20	29.33
DR	11.43	2.56	0.00	86.00	1179.93	23.90
TR	10.47	5.13	2.19	82.22	1063.70	22.65
CT	21.10	0.00	1.85	77.04	1379.63	31.12
CS	12.94	0.00	1.75	85.31	1368.32	28.34

Table 30. *Summary of canopy spread in different spatial systems. Treatment codes are as for Table 29. Exposed distance and area indicate the gap available without the canopy cover between rubber rows/clusters, with respect to absolute distance and overall ground area, respectively. Shaded distance shows the distance covered by the canopy from rubber trees across the transect*

Treatment	7YAP			8YAP			10YAP		
	Exposed distance	Shaded distance	Exposed area (%)	Exposed distance	Shaded distance	Exposed area (%)	Exposed distance	Shaded distance	Exposed area (%)
SR	0.75	3.68	9.23	0.68	3.17	8.41	0.54	3.78	6.72
DR	6.74	3.68	41.62	5.49	4.30	33.90	4.69	4.71	28.94
TR	12.65	3.73	52.05	11.41	4.35	46.95	10.66	4.72	43.86
CT	0.00	2.47	0.00	0.00	2.47	0.00	0.00	2.47	0.00
CS	0.13	3.18	2.86	0.03	3.24	0.51	0.01	3.24	0.31

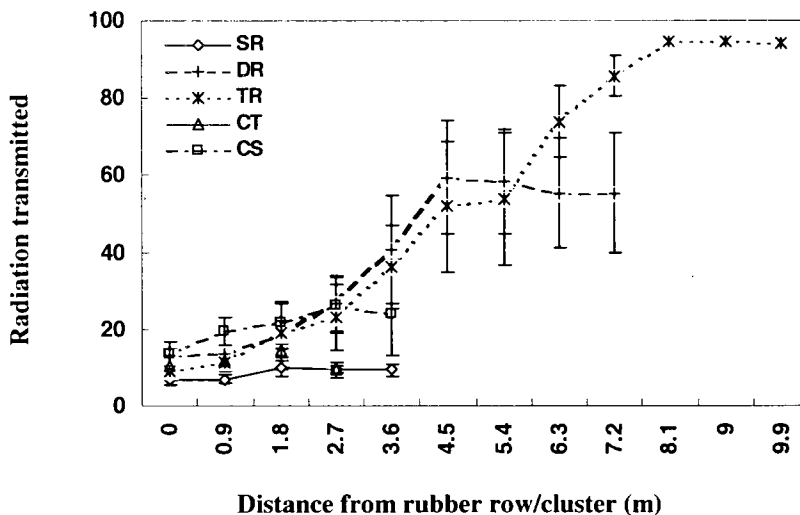


Fig. 5. Radiation profile across the gap available for intercropping between rubber rows/cluster. Error bars represent the S.E. of means where n=6 (i.e. for each half of the transect and three replicate plots). Treatment codes are as for table 29 (V H L Rodrigo, T U K Silva and E S Munasinghe)

Intercropping systems

Rubber/Timber – IC/RT/92/1&2

This study was aimed to investigate the feasibility of growing timber crops with rubber. In addition to the testing of timber species grown in between rubber rows (details were given in annual review 1992), the systems where timber species grown on the boundary and in vacant patches of rubber clearings (as a means of infilling) were assessed with a rapid appraisal. *Alstonia* showed a competitive effect on growth and yield of rubber, if both crops are established together. Establishment of Mahogany was successful under the shade of rubber, however it was not the case for *Alstonia*. In order to minimise the competition on rubber, it is suggested to plant timber crops allowing first 2-3 years for the establishment of rubber. The paired row system of planting rubber facilitated the establishment of timber crops even later stage, however this system must be improved in order to minimise the inter-specific competition of rubber. No clear competitive effect on rubber was found, if timber trees are grown either along the boundaries or in the vacant patches of mature rubber clearings. More details of the study can be seen in following papers.

- Rodrigo, V H L, Silva, T U K, Kariyawasam, L S and Munasinghe, E S (2002). Rubber/timber intercropping systems and their impacts on the performance of rubber. *Journal of the Rubber Research Institute of Sri Lanka* **85**, 10-26.

- Rodrigo, V H L, Silva, T U K and Munasinghe, E S (2002). Feasibility of growing rubber/timber intercropping systems. Proceedings of 11th International workshop of BIO-REFOR, Seoul, Korea. Pp. 172-179 (V H L Rodrigo, T U K Silva and E S Munasinghe)

Rubber/banana intercropping project

This project was aimed to assess the potential for adoption of intensified banana/rubber intercropping on smallholdings in Sri Lanka and funded by the Department for International Development (DFID), UK. The project was completed in year 2002 and the final technical report was submitted. The details of the project activities and outputs have been included in the final technical report of which a copy is available in the library of the RRISL. In brief, the study was located within two major agro-climatic zones, the Wet and Intermediate zones as on-farm trials.

The study confirmed the advantages of high density intercropping on growth of rubber and yield of banana. Growth and foliar nutrient content of rubber in the high density banana/rubber intercrop indicated that the benefits of intercropping on rubber could not simply be explained by improved access to soil nutrients when fertilizer was applied to the component banana intercrop. Instead, gas exchange studies implicated a role for the beneficial effects of shade in the intercrops, alleviating high radiation stress thereby allowing leaves to maintain a positive CO₂ fixation for a greater duration of the day. In addition to the benefits of intercropping on early growth of rubber, the study has also shown that intercropping results in long-term benefits in terms of earlier and higher latex yield returns.

Discounting analysis showed that whilst rubber and banana may not be as profitable as other crops such tea and pepper, the majority of smallholders preferred to cultivate them because of the low cost of establishment. Smallholders stated a clear preference for rubber due to its relatively low demand in terms of labour inputs. In addition, banana is very popular with smallholders because it is a highly flexible crop that has no particular seasonal demands for activities such as weeding, harvesting *etc.*

Full-time farmers, particularly the land poor in the Intermediate zone where infrastructure is less well developed than in the Wet zone, were identified as having the greatest potential to benefit from high density rubber intercropping. The major constraint to uptake being access to effective extension information and advice.

Traditionally, the performance of smallholder rubber has been considered inferior to that produced by the estate sector and the attempt was to raise productivity by promoting monoculture-based plantation practice. The outputs of this project show this approach to be severely misguided and in the case of smallholders, rubber-

based intercropping systems can be developed that are not only compatible with, but also improve the productivity of traditional systems. High density intercropping of rubber offers a win scenario; rubber can be successfully integrated with traditional cropping systems to provide many benefits to smallholders including earlier and greater latex yield, an additional income from the intercrop and better security of subsidy payments and property rights. Indirect benefits to soil fertility and stability will also accrue from the introduction of trees to traditional annual and perennial cropping systems. (V H L Rodrigo, A M W K Senevirathna, P D Pathirana, P K W Karunathilake and E S Munasinghe in collaboration with University of Wales, UK and University of Sri Jayawardenapura).

Screening crops for rubber based intercropping (IC/2002/01)

Measurements of photosynthetic rate of plants in deferent shade levels began in August 2003. Drastic decline photosynthetic rates was reported in plants grown in polybags, most probably due to the restriction to the root spread. Therefore, polybag grown plants were transplanted on the ground under same conditions.

Since the success of some species under zero shade was very limited (*eg.* Cardamon, Passion fruit, Tea, Pepper) that was supplied with plants from other treatments. However, the situation continued suggesting that shade has to be provided for in initial establishment (Table 31).

Table 31. *Establishment of crop species*

Crop	No. of plants remaining				% success			
	0% Shade	25% Shade	50% Shade	75% Shade	0% Shade	25% Shade	50% Shade	75% Shade
Coffee	7	10	10	9	87.5	100	100	90
Cinnamom	7	9	9	9	100	90	100	100
Tea	4	7	5	7	57	100	71.5	100
Peper	2	8	6	8	28.5	100	75	100
Alastonia	6	7	10	9	100	78	100	100
Mahogani	5	5	6	5	83.5	83.5	100	83.5
Passion fruit	2	7	4	6	33.5	100	57	86
Cocoa - w 5/5	5	6	6	8	83	85.5	85.5	100
- millawana	5	7	6	5	71.5	100	100	83.5
Cardamom -37	-	4	5	4	-	66.5	83.5	80
- mysoor	1	4	5	5	25	66.5	83.5	83.5

(V H L Rodrigo W Seneviratne and W Karunatilaka)

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

Details of experimental layout were reported in the annual report 2002. Plots of which soil was reconditioned with Mana grass were planted with tea in July 2003. Since the initial establishment of Durian was extremely poor and there was a scarcity of those plants the casualties of Durian were in filled only in one replicate. Growth measurements of all crops except Durian were made at six month intervals. Harvesting of tea in the un-reconditioned plots was begun June 2003.

Table 32. *Growth performance of rubber. Values for girth increment are given for a period of 12 months and measurements were made at 150cm height*

Treatments	Rubber			
	Planted in 2001		Planted in 2000	
	Girth (cm)	Girth increment (cm)	Girth (cm)	Girth increment (cm)
(3m x 3m)-15m	18.78	10.4	21.39	8.71
(3m x 3m)-18m	19.32	7.75	18.96	7.30
(3.5m x 3.5m)-15m	16.36	8.14	25.09	11.04
(3.5m x 3.5m)-18m	18.61	8.81	23.13	9.8

Table 33. *Growth performance of cinnamon Rambutan and tea together with tea yield. Growth of crops were assessed as either tree diameter or girth whilst tea yield was the mean fresh leaf weight for a month during June to December 2003*

Treatments	Cinnamon Diameter (mm)	Rambutan Girth (cm)	Tea	
			Diameter (mm)	Crop (kg/ Month)
(3m x 3m)-15m	17.39	14.43	15.18	45.76
(3m x 3m)-18m	13.29	12.66	14.55	63.41
(3.5m x 3.5m)-15m	16.01	13.42	13.11	55.38
(3.5m x 3.5m)-18m	16.86	14.05	13.42	72.46

No significant effect of different spatial arrangements for planting rubber on any intercrop was observed (Table 32 & 33).

(V H L Rodrigo, T U K Silva and P D Pathirana)

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

This intercropping trial was established in October 1996 with three indigenous species of rattan (Annual Review 1996). The growth of rattan was good

and it was difficult to measure the height of the plants due to the tallness, bending of the stems and inaccessibility due to the thorny fronds. The plants which could not cling on to the rubber trees started to fall and attempts were made to hang them on to branches of the rubber trees (L S S Pathiratna and M K P Perera).

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

The experiment was established at the RRISL Sub station in Kuruwita and the experimental details are given in Annual Review 1998.

Growth of rubber in none of the treatments differ significantly from that of the 8.4m inter row spacing treatment at this stage (Table 34).

The bark yield was highest in the treatment with the 12.0m spacing and was lowest in the 7.2m spacing in the single row system. Similarly high bark yields were obtained in 15.6m-18.0m treatments in the paired row system (Table 35).

In the other experiment where Cinnamon was established under mature rubber (1984 clg.), the treatment with the cinnamon spacing 0.9 × 0.61m, 1.2m × 0.91 m and 1.7m × 1.2m had comparable bark yields (Table 36). The level of fertilizer or the polythene barrier did not show significant effects at this stage (Table 37).

Table 34. *The growth of rubber measured as girth in the 6th year*

	Inter row spacing treatments (m)										
	7.2	8.4	9.6	10.8	12.0	13.2	13.2	14.4	15.6	16.8	18.0
Girth	47.3	49.0	49.0	50.1	51.4	51.9	48.2	48.9	47.8	46.5	48.1
(cm) *	cd	abcd	abcd	abc	ab	a	bed	abcd	cd	d	bcd

Table 35. *Cinnamon bark yield kg/ha*

	Inter row spacing treatments (m)										
	7.2	8.4	9.6	10.8	12.0	13.2	13.2	14.4	15.6	16.8	18.0
	S	S	S	S	S	S	P	P	P	P	P
Bark yield	197.5	196.8	339.1	402.3	633.8	611.6	464.5	559.5	682.2	647.6	606.9

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

Table 36. *Effect of spacing on the yield of Cinnamon under mature rubber*

Treatment (Cinnamon spacing)	Cinnamon bark yield
.91 m × .61 m	36.2 ^{AB}
1.2 m × .91m	42.2 ^A
1.7 m × 1.2 m	43.5 ^A
1.1 m triangular spacing	33.2 ^B

Table 37. *Effect of the level of fertilizer on the bark yield of Cinnamon*

Fertilizer level	Cinnamon bark yield (g/bush)
1	36.7a
2	39.1a
3	39.6a
4	41.0a

(CARP funded Project – Project no 12/463/349) (L S S Pathiratna and M K P Perera)

Testing of economically important medicinal plant species as intercrops with rubber (Hevea) under smallholder conditions

These experiments were conducted in twenty four rubber small holdings from the Kalutara, Ratnapura and Moneragala. Five species of medicinal plants viz: *Indigofera tinctoria* (Nilavariya), *Solanum virginianum* (Katuwelbatu), *Aerva lanata* (Polpala), *Plumbago indica* (Ratnitol) and *Piper longum* (Thippili) were cultivated.

Harvesting of Nilavariya and Katuwelbatu in most of the sites in the Kalutara were done in time and buyers were contacted for the disposal of the produce. This work was completed in August 2003 and the terminal report was submitted (Contract Research Project MP/RP/18, Sri Lanka Conservation and Sustainable Use of Medicinal Plant Project, L S S Pathiratna and M K P Perera).

REVIEW OF PLANT PATHOLOGY AND MICROBIOLOGY

C K Jayasinghe

SUMMARY

Incidence of *Oidium* and *Colletotrichum* leaf diseases were mild except in isolated instances where highly susceptible clones succumbed to the secondary leaf fall in vulnerable pockets. A moderate leaf fall was detected due to *Phytophthora* infections towards the end of the South West monsoon period. *Cylindrocladium* leaf spot disease, a malady reported from Malaysia and China was detected in a clearing of RRISL 206. This is the first report of the natural occurrence of *Cylindrocladium quinquesepatum* in rubber plantations of Sri Lanka. Embaralla (*Spondias pinnata*) and *Paulownia fortunei* were proved to be two new alternate hosts for *Corynespora cassiicola*.

DNA extraction method was perfected to obtain high quality DNA from rubber leaves. Most of the experiments based on RAPD - PCR technique were completed in developing a DNA probe to distinguish *Colletotrichum acutatum* from *Colletotrichum gloeosporioides*. Biochemical analysis revealed that an individual or synergistic effect of responsive reactions such as accumulation of toxic phenolic substances, pathogenesis-related proteins and increased activity of phenyl alanin-ammonialyase may responsible for the disease resistance in the rubber tree.

DETAILED REVIEW

Staff

Dr C K Jayasinghe, Head of Plant Pathology and Microbiology Department; Dr Priyanthi Silva, Principal Research Officer, Dr K E Jayasuriya, Principal Research Officer and Mr W Amaratunge, Audio Visual Production Officer were on duty throughout the year.

Experimental Officers Mr E B Fernando, Mrs T H P S Fernando, Mrs B I Tennakoon and Mrs D Wijeratne; Technical Officers Mr C Wijeratne, Mr S R D Peiris, Mrs N Dharmadasa and Mr E A D N Nishantha, Clerk Typist, Mrs P Amarasekera continued to work in the Department.

Research students

- Miss R A D Niroshani, an undergraduate from the University of Ruhuna commenced her final year project entitled "A study on induction of disease resistance of *Hevea brasiliensis* using biotic elicitors" under the supervision of Dr K E Jayasuriya.

Services offered in national committees and research forums

Officer	Discipline	Organization
C K Jayasinghe	Ad Hoc Committee on implementing quarantine regulations	CARP
C K Jayasinghe	Specialist Committee on Plant Protection	CARP
C K Jayasinghe	Pesticide Technical Advisory Committee	Dept. of Agriculture
C K Jayasinghe	National Committee on Coconut Mite	Coconut Research Institute
C K Jayasinghe	Research Committee to review the progress on crop protection research	Coconut Research Institute

Seminars/Conferences attended

Officer	Subject	Organization
C K Jayasinghe	Impact of phytosanitary agreements on developing countries	FAO-CARP
W P K Silva	International workshop on the technology of application of pesticides	National Science and Technology Commission
K E Jayasuriya	Regional workshop on "Biopesticides: Current Status and Future Trends"	Universities of Kelaniya and Peradeniya

Seminars/Conferences addressed

Officer	Subject	Organization
C K Jayasinghe	Plant Protection Research in Rubber	CARP

Training programmes conducted

Dr C K Jayasinghe, Dr Priyanthi Silva and Dr K E Jayasuriya served as resource personnel in following training programs.

Client	No. of programs
Plantation executives	1
Estate Managers	3
Field officers	4
Rubber Development Officers	1
Smallholders	2
University students	6
NDT students	3

Mr E B Fernando, Mrs T H P S Fernando, Mrs B I Tennakoon and Mrs D Wijeratne covered the practical aspects of the above programmes, while all the staff members extended their fullest cooperation in educating students from universities, technical colleges and schools on disease scenario of the rubber tree.

Grants received from external agencies

Received a grant from Sri Lanka Council for Agricultural Research Policy CARP/12/497/370 to cover the costs of consumables, traveling, subsistence and labour for the project entitled "Identification of resistant genetic material for *Corynespora* leaf fall disease management". The investigators of this project are Dr C K Jayasinghe, Dr Miss W P K Silva, Mrs T H P S Fernando and Mr N Nishantha.

Junior research project entitled "Possibility of the popularization of *Oidium* susceptible high yielding clones with the predicted climate change" was awarded to Mrs T H P S Fernando from the Ministry of Environment and Natural Resources. Dr C K Jayasinghe was appointed as the supervisor of this project.

Advisory visits

Client	No. of visits
Plantations	12
Small holdings	3

GENERAL

The wintering was uniform. Weather conditions during the refoliation period were not conducive for propagation of *Oidium heveae*, the causative agent of Oidium leaf fall. However, late wintering clones namely, RRIC 121 and PB 260 showed secondary defoliation in few locations due to the wet weather experienced in the latter part of the wintering season. A moderate leaf fall was detected due to the spread of the pathogen, *Phytophthora* spp. in all rubber growing districts towards the end of the South West monsoon period. This situation was predicted in advance and an interim circular entitled "Phytophthora Leaf Fall and Bark Rot - 2003" was sent to the Director General, Rubber Development Department, Head of Advisory Services Department and all Plantation Management companies requesting them to be vigilant on possible tapping panel infection causing Bark Rot. Subsequently two press notices were released to "ලංකා දිනපත" and "Daily News" with the view of increasing the awareness on the disease and to educate the general public on the disease management.

Dr C K Jayasinghe and Mrs T H P S Fernando were awarded President's Research Awards in November 2003 in recognition of their innovations and contributions to the global advancement of science and human knowledge.

Distinguished scientists Dr K H Chee and Dr Sivakumaran from Malaysia spent three days from 30th June to 2nd July at the RRISL to study the *Corynespora* leaf fall disease (CLFD) incidence in rubber plantations. The objective of this mission was to evaluate a research project submitted to the Common Fund for Commodities by the authorities of South and South East Asia including the Head of Plant Pathology and Microbiology Department of the Rubber Research Institute of Sri Lanka.

Dr C K Jayasinghe was invited by the Food and Agriculture Organization of United Nations to attend the workshop for pest risk analysis (PRA) on South American Leaf Blight (SALB) and prepare the draft PRA on SALB with the view of justifying the regulations imposed under the APPC Agreement (Article IV, Appendix B). The workshop was held in Malaysia from 17th -21st November 2003.

Dr C K Jayasinghe attended the international workshop on coconut mite *Aceria guerreronis* held at Atria Hotel, Bangalore, India 5th to 7th April 2003 in the capacity of a member of the National Committee on Coconut Mite. Eriophyd mite of coconut, a microscopic insect detected for the first time in northern part of Sri Lanka in 1997 has now become a serious threat to the coconut industry. The main objective of Dr Jayasinghe's participation of this tour was to study the possibility of applying a biological control method using a fungal pathogen and propose a research plan to develop a successful mycoacaricide. The proposals were submitted to the Director, Coconut Research Institute and a report was sent to the Ministry of Plantation Industries.

LABORATRY AND FIELD INVESTIGATIONS

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

Screening of fungicides against Corynespora cassiicola

Spraying programmes were continued at three locations namely; Lagos Division of Payagala Estate, Salawa Estate and Kuruwita sub-station during the refoliation period. The fungicides, dithane, topsin and soluble sulphur were used. This experiment will be terminated during the year 2004 (C K Jayasinghe and C Wijeratne).

Screening of fungicides against Rigidoporus microporus

A series of new experiments was initiated to screen various phenolic compounds and herbal extracts against *R. microporus* with the objective of developing an economical fungicide in managing white root disease (C K Jayasinghe, K E Jayasuriya and D Wijeratne).

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

In vitro screening of clones against *Corynespora leaf fall*

Experiments were conducted to explore the possibility of developing a laboratory screening technique to detect expand CLFD tolerance in recommended and potential clones. All the experimental techniques were based on an introduction of a standard spore suspension on to the detached leaves of different *Hevea* genetic material. Observations revealed that there is no positive correlation between the observations made under laboratory conditions and actual field resistance (C K Jayasinghe, W P K Silva, N Nishantha and N Dharmadasa: collaborative project with CARP).

Maintenance of nurseries established for screening purposes

A nursery at Kuruwita sub-station was established using all recommended clones (C K Jayasinghe, W P K Silva, T H P S Fernando and N Nishantha: Collaborative project with CARP).

Screening of recommended clones against *Phytophthora leaf fall*

Disease screening programme was launched towards the end of South West monsoon period as a moderate *Phytophthora leaf fall* was detected during the year 2003. The summary of the observations made during the survey is given in Table 1 (C K Jayasinghe and E B Fernando).

Field screening of recommended clones against secondary leaf fall caused by *Oidium heveae*

Though the *Oidium* infections did not reach epidemic proportions during 2003, 29 clones recommended in group I, II & III were screened against secondary leaf fall caused by *Oidium heveae*. Only two clones namely RRIC 121 and PB 260 showed 25-50% defoliation. Details of the survey are presented in the Table 2 (C K Jayasinghe, E B Fernando and T H P S Fernando).

Screening of progeny of the hand pollination programme - 1979

One hundred and fourteen plants of the above progeny was screened against CLFD as a response to a request made by the department of Genetics and Plant Breeding. Canopies of the 31 plants showed mild to severe symptoms (C K Jayasinghe, W P K Silva and N Nishantha).

Screening of rubber clones using scopoletin

As conventional detached leaf technique was not successful in screening rubber clones against CLFD, initial studies were carried out to make use of scopoletin for screening purposes. Extraction technique was perfected and crude extracts of clones RRIC 100, RRIC 121, RRIC 102 were tested for the presence of scopoletin using thin layer chromatography. Experiment is in progress (W P K Silva, C K Jayasinghe and P Pieris).

Table 1. *Phytophthora* leaf fall disease severity on recommended and potential clones
(Observations have been made during a moderate epidemic year, 2003)

Clone	Disease severity (score)	Clone	Disease severity (score)
1. RRIC 100	Mild	18. PB 260	Resistant
2. RRIC 102	Mild	19. BPM 24	Resistant
3. RRIC 121	Severe	20. RRISL 204	Severe
4. RRIC 130	Resistant	21. RRISL 208	Severe
5. PB 217	Resistant	22. RRISL 218	Resistant
6. PB 28/59	Resistant	23. RRISL 220	Resistant
7. RRIC 117	Resistant	24. RRISL 221	Severe
8. RRIC 133	Mild	25. RRISL 222	Severe
9. RRISL 201	Severe	26. RRISL 226	Severe
10. RRISL 203	Severe	28. RRIM 712	Mild
11. RRISL 205	Resistant	29. PR 255	Resistant
12. RRISL 206	Resistant	30. RRII 105	Resistant
13. RRISL 211	Severe	31. PR 261	Resistant
14. RRISL 215	Severe	32. RRIM 712	Severe
15. RRISL 217	Resistant	33. PB 86	Severe
16. PB 235	Resistant		

Resistant: no defoliation or upto 5% defoliation; Mild: 6-25% defoliation;
Severe: 26-75% defoliation; Very severe: 76-100% defoliation.

Note: (a) Table presents the general reaction of the particular clone to *Phytophthora* infection. However, this could vary slightly depending on the micro climatic variations of the clearing.

(b) Disease score for certain clones (specially gp III) was given after examining only few sites as mature clearings of these clones are limited.

Development of molecular markers to identify Corynespora leaf fall resistant clones

DNA extraction method was optimised to obtain good quality DNA from *Hevea* leaves. Disease free leaf samples were collected from RRI clonal trials established in Kalutara District. Several leaf stages were used and the mature leaves were found to be the most suitable stage for extraction, due to the less latex content. DNA was extracted from 10 *Hevea* clones susceptible to *Corynespora* leaf disease and 10 resistant clones. DNA samples were digested with restriction enzymes EcoRI and MseI. Then MseI and EcoRI adapters were ligated to DNA. Thereafter preamplify the DNA with primers homologous to the adapters. Experiment is in progress to carryout the AFLP technique. (W P K Silva, C K Jayasinghe, N Nishantha, A Jayakody, E H Karunanayaka - Collaborative project with Colombo University partially funded by CARP).

Table 2. Results obtained from Field screening of recommended clones against secondary leaf fall in the year 2003 (observations of a mild year, 2003)

Clone	Disease severity	
	Level of infection on leaves* Disease severity (score)	Defoliation
RRIC 100	Mild	No
RRIC 102	Mild	No
RRIC 121	Mild	25-50%
RRIC 130	Mild	0-25%
PB 217	Mild	0-25%
PB 28/59	Mild	0-25%
RRIC 117	Mild	0-25%
RRIC 131	NA	
RRIC 133	Mild	0-25%
RRISL 201	Mild	0-25%
RRISL 202	Mild	0-25%
RRISL 203	Mild	No
RRISL 205	Mild	0-25%
RRISL 206	Mild	0-25%
RRISL 210	NA	
RRISL 211	NA	
RRISL 215	Mild	0-25%
RRISL 217	Mild	0-25%
PB 235	Mild	0-25%
PB 260	Mild to moderate	25-50%
BPM 24	Mild	0-25%
RRISL 200	NA	
RRISL 204	Mild	0-25%
RRISL 208	NA	
RRISL 218	NA	
RRISL 220	NA	
RRISL 221	NA	
RRISL 222	Mild	0-25%
RRISL 225	NA	
RRISL 226	NA	
RRISL 227	NA	
GPS 1	Mild	0-25%
RRIM 712	Mild to moderate	0-25%
PB 255	Mild	0-25%
PR 255	Mild	0-25%
PR 305	NA	
RRII 105	Mild	No
RRISL 2000	Mild	0-25%
RRISL 2001	Mild	0-25%
RRISL 2002	NA	
RRISL 2003	NA	
RRISL 2004	NA	
RRISL 2005	NA	
RRISL 2006	NA	
PR 261	Mild	0-25%
RRIM 600	Mild	No

* A range is given depending on sites NA – Data not available as mature clearings are not available

Survey on Corynespora leaf fall disease incidence in Sri Lanka

An island-wide survey was launched to detect the *Corynespora* leaf fall disease resistance in all potential and recommended rubber clones. Severe leaf fall was observed in clones RRISL 200, RRISL 202 and RRISL 208. Survey is in progress and a new protocol will be developed to screen clones against CLFD and analysis will be carried out accordingly during 2004 (C K Jayasinghe, W P K Silva, T H P S Fernando and N Nishantha: collaborative project with CARP).

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

Biological control of white root disease

Basal medium (T₁₀) containing *Trichoderma* sp. (Tr₃) has been evaluated at field level during this period. Initially, the proliferation rate of *Trichoderma* fungus in soil was tested by adding 500g of the T₁₀ preparation into soil around rubber plants. *Trichoderma* colony forming units (cfu) in soil after 6, 12, 16, 20, and 24 weeks was counted by extracting 10 g of soil, subsequently using dilution plate technique. Table 3 shows the variation in the number of cfu in 10g of soil treated with T₁₀ and in untreated soil.

Table 3. Variation of *Trichoderma* population (colony forming units-cfu) in soil amended with T₁₀ preparation during a period of 6-24 weeks

	Initial no	6 weeks	12 weeks	16 weeks	20 weeks	24 weeks
Control soil	3.2×10^5	3.3×10^5	3.7×10^5	3.5×10^5	3.25×10^5	3.2×10^5
T ₁₀ soil	3.2×10^5	1.8×10^6	7.7×10^5	5.2×10^5	4.2×10^5	3.2×10^5

The success rate of the application of T₁₀ preparation against the white root disease infection was investigated using artificially inoculated rubber plants. Rubber plants planted in experimental beds at Dartonfield estate spacing 4' x 4' were equally inoculated with rubber root pieces which were naturally infected with *R. microporus*. Collar infection by *R. microporus* was recorded after 2 months of inoculation.

After 3 months from the inoculation, plants were singly inoculated with Tr₃ preparation as per 500g per plant by mixing with soil around the collar area. To avoid adverse effect from direct sun, the plants were equally thatched with removed cover crop debris. There were 30 treated plants and 10 untreated plants, which served as control.

Assessments have been taken after 2 months from the treatment and thereafter at every 1 months. Collar region was inspected in the early hours to avoid direct sunlight. A marking scheme previously described has been used to assess the severity of the disease infection on collar region. Table 4 describes recovery rates of infected plants from two successive trials (K E Jayasuriya and B I Tennakoon).

Table 4. Recovery rate (%) of white root disease infected plants treated with T_{10} preparation

Trial 1	No of plants	Disease rate	after 10 d	after 30 d	after 60 d
Treatment T_{10}	5	+3	100	100	100
	2	+2	100	100	100
	3	+1	66	100	100
Control	3	+2	-	-	-
Trial 2					
Treatment T_{10}	7	+3	85	100	100
	5	+2	80	80	100
	5	+1	100	100	100
Control	2	+3	-	-	-
	2	+2	-	-	-
	1	+1	-	-	-

Biological control of rubber nursery diseases

Different liquid media were tested to produce more philosophers of Tr_{21} to be used as introduced inocula on leaves (K E Jayasuriya and C Wijerathna).

Biology of common pathogens (BCP/90/1)

Alternate hosts for *Corynespora cassiicola*

- (a) A new isolate of *Corynespora cassiicola* was identified from embaralla (*Spondias pinnata*). The embaralla isolate was tested on several rubber clones and found to be pathogenic on rubber (W P K Silva, C K Jayasinghe and N Nishantha).
- (b) The pathogen *Corynespora cassiicola* was proved to be the causative agent of leaf and stem spots on *Paulownia* spp. (C K Jayasinghe, W P K Silva, N Nishantha and D Wijeratne).

Variability in cultural, reproductive characteristics and fungicide sensitivity of different isolates of *Botryodiplodia theobromae*

Botryodiplodia theobromae is an important pathogen responsible for causing maladies in young and mature rubber plants. With this background 14 isolates were collected from infected rubber plants to study the variability of these isolates. Experiments with respect to cultural and reproductive characteristics have been completed and investigations on fungicide sensitivity are in progress (C K Jayasinghe and N Dharamadasa).

Authenticatin of *Colletotrichum acutatum* and *Colletotrichum gloeosporioides* using molecular techniques

RAPD-PCR technique was employed to distinguish the two species. Amplification products were scored and genetic similarities were computed and data were used to construct a dendrogram (Fig. 1). There were two RAPD groups

which represents the two species. These two groups were confirmed as *C. gloeosporioides* and *C. acutatum* by the fungicide sensitivity test. The polymorphic RAPD bands generated here can be used as identification probes to distinguish these two species. (W P K Silva, C K Jayasinghe, T H P S Fernando, A Jayakody and E H Karunanayake - Collaborative project with University of Colombo).

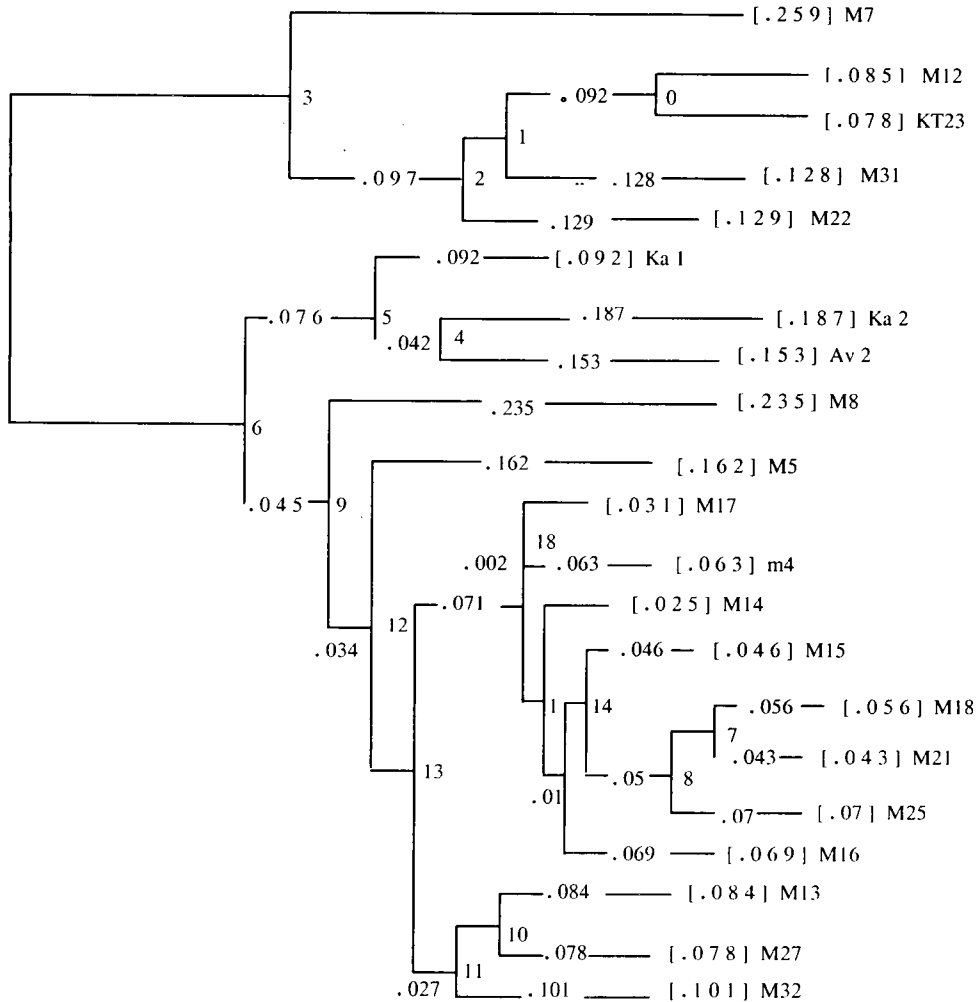


Fig. 1. Dendrogram generated from RAPD banding patterns from eight primers

Defense mechanism of rubber against leaf pathogen (DM/89/1)

Some defense related biochemical activities of selected rubber clones were investigated in view of building a relationship between hosts reaction and its level of tolerance against *P. meadii* infection. In *P. meadii* infected petioles of RRIC 100 which is tolerant to *Phytophthora*, the rapid synthesis of PR-proteins or their synthesis in high amplitudes was associated with significantly higher increasing activity of Phenyl alanine-Ammonia Lyase (PAL) enzyme during a 72 h period. These synergistic responsive reactions were related to the tolerance of RRIC 100 against *P. meadii*, while the levels of same reactions during infection of other *P. meadii* susceptible petioles such as RRIM 600, RRIC 121, PB 86 were significantly lower, during 72 h period. As another criterion for discriminating susceptible clones against pathogen, diluted serum test may be used. Germination of *P. meadii* zoospores was promoted by diluted latex serum (3.3% serum) from *Phytophthora* tolerant RRIC 100 and BPM 24 clones, while serum from susceptible clones such as RRIC 121, PB 86 and RRIM 600 did not promote. Therefore these criteria should be tested against other leaf pathogens such as *C. gloeosporioides*, *C. accutatum* and *C. cassiicola*. The level of soluble phenols in leaves revealed that in RRIC 100 leaves phenols were significantly higher than in PB 86 leaves, or in leaves from other clones, which are yet to be evaluated (K E Jayasuriya and B I Tennakoon).

Surveillance of pathogens in rubber plantations (MP/89)

First report of the natural occurrence of Cyindrocladium leaf spot disease of rubber in Sri Lanka

During the latter part of the year 2003 unusual leaf spot disease was observed from a two year old RRISL 206 clearing at Baduraliya in Kalutara District planted under Genetics & Plant Breeding Department. Disease symptoms consisted of numerous raised chlorotic pinhead size spots on mature leaves. Severely infected leaves became purplish brown. Under highly favourable weather conditions young rubber leaves infected with the fungus shriveled, blackened and fall off. A fungus reassembles *Cyindrocladium quinqueseptatum* was repeatedly isolated from such tissues on Potato Dextrose Agar.

Single spore culture of the suspected pathogen was sent to CAB International Mycological Institute, UK where it was authenticated as *Cyindrocladium quinqueseptatum* Boedjin & Reitsma and specimen culture was deposited in the IMI herbarium as IMI 391089. Subsequently, pathogenicity was proved and studies on morphology, biology and clonal susceptibility were commenced. This was the first report of the natural occurrence of *C. quinqueseptatum* on rubber in Sri Lanka (C K Jayasinghe, W P K Silva and N Nishantha).

MISCELLANEOUS

Poisoning of stumps to improve the methods of clearing of old stand during replanting

A critical trial was established at Gallewatta division of the Dartonfield estate to evaluate 3 treatments to enhance the decaying rates of old rubber tree logs left along in the field. The experiment comprised 75 old tree logs from an old plantation that will be uprooted in few years time.

Trees were cut at ground level using a chain saw and freshly cut surfaces were applied with 250 ml of 10% *a.i.* solution of either 2,4 D, or Glyphoset (10% *a.i.* dissolved in auto diesel). There were twenty-five tree logs serving as control.

Each treatment had 25 replicate tree logs, which were in statistically designed five blocks to minimize the variation of the effect of treatments due to the terrain. In addition, 30 tree logs in same five blocks were used to investigate the effect of ring-barking on the decaying rates, as this process is known to remove a considerable amount of sugar from root system (K E Jayasuriya, C K Jayasinghe, E B Fernando and P Pieris).

Eradication of white root disease in patches of immature, young or old mature rubber lands to increase the land use efficiency and productivity

The project was initiated in view of demonstrating and educating the rubber growers how to manage and suppress the white root disease incidence in infected patches. Information on availability of white root disease infected patches was gathered by requesting the data from the Plantation companies and sites were selected considering the resources available. It was initially decided to cover 375 immature, 375 mature young and 375 mature old trees to be treated. Therefore, initially four sites were selected from Kiriella and from 2 estates of Sapumalkanda group.

Immature infected trees were demarcated and treated with 1 lit. of 0.1% Hexaconazole solution around the collar with equally treating the adjoining healthy trees as well.

Mature young trees were similarly treated with 4 lit. of 0.1% solution. However, to facilitate absorption of the chemical, the dead cork layer was removed from the collar area before adding the chemical. Adjoining healthy trees were also treated similarly (K E Jayasuriya, C K Jayasinghe, E B Fernando and P Peiris).

SOILS AND PLANT NUTRITION

Lalani Samarappuli

SUMMARY

Use of rooted stem cuttings gave the highest establishment success of 78% and it was possible to introduce a successful method of planting for *Mucuna* in the field. Data revealed that the rate of fertilizer application may be reduced by half, at least until bud grafting, if compost is used at bag filling stage.

Leaf N, P, K and Mg contents of mature rubber leaves collected during the soil and foliar survey in the year 2004 indicated that fertilizer application should be continued uninterruptedly during the initial period of tapping, at least in the virgin panels commencing at the beginning of the mature phase and continue until 5 to 6 years prior to uprooting to ensure an efficient and cost effective fertilizer programme for mature rubber

The site-specific fertilizer recommendation programme for mature rubber provided fertilizer recommendations for 12,000 hectares in the estate sector. Under the land selection programme for planting rubber 200 hectares were surveyed. The Department analyzed approximately 2200 samples (8480 parameters) for outside organizations during the year.

DETAILED REVIEW

Staff

The Head of the Department, Dr (Mrs) Lalani Samarappuli was on duty throughout the year. Mr R S Dharmakeerthi, Soils Chemist returned in March after obtaining a PhD from the University of Guelph, Canada. Assistant Soils Chemist, Mr D N P Wickramasinghe continued his postgraduate studies in USA.

Experimental Officers, Messrs H D S P Perera, R Hettiarachchi, C Maheepala, S N Silva, P Karunadasa, U Mitrasena, A N Yakandawela, T B Dissanayake and V Edirimanne and Technical Officers, Messrs A Thevarapperuma, P R Puhambugoda, J A S Chandrasiri and T Gunatilleke and the English Stenographer Mrs L Rupasinghe were on duty throughout the year.

Seminars/Conferences/Meetings/Work-shops addressed

Officer	Subject	Organization
Lalani Samarappuli	An estimation of C sequestration in rubber plantations under Sri Lankan conditions	Institute of Biology
Lalani Samarappuli	Response of plantation crops to applied potassium in Sri Lanka	Post Graduate Institute of Agriculture
Lalani Samarappuli	Integrated potassium nutrient management in rubber	International Potash Institute/National Fertilizer Secretariat (NFS)
Lalani Samarappuli	Potassium status of rubber growing soils in Sri Lanka	International Potash Institute/NFS
Lalani Samarappuli	Impact of climate change on productivity of rubber, adaptation measures and role of rubber plantations as a mitigation option - Progress made in the project	Ministry of Environment and Natural Resources
Lalani Samarappuli	Soils and Plant Nutrition Department's Research Programme	Scientific Committee Meeting, RRI

Seminars/Conferences/Meetings/Work-shops attended

Officer	Subject	Organization
Lalani Samarappuli	C Trading for new rubber plantations	Rubber Cluster/Ministry of Enterprise Development and Investment Promotion
Lalani Samarappuli	Working Group on Organic Fertilizers	Sri Lanka Standards Institution
Lalani Samarappuli	Scientific Committee Meeting	Rubber Research Institute
Lalani Samarappuli	Fertilizer distribution in small holdings	Ministry of Plantation Industries

Training programmes

Client	No of programmes
Plantation Executives	03
Estate Managers	08
Field Officers	03
Estate Workers	03
Rubber Development Officers	04
Smallholders	02
University Students	06
NDT Students	02

Advisory visits

Client	No of visits
Plantations	15
Smallholdings	06

LABORATORY AND FIELD INVESTIGATIONS

Soil fertility management

Mulching

In this experiment, mulching was continued with and without chemical fertilizer during mature phase. The incorporation of 5kg rice straw per tree was done as mulching treatment. Test tapping was done to assess the latex yield (Lalani Samarappuli, U Mitrasena and T Gunathilaka).

Ground cover management

New cover crop species

The experiment on *Mucuna bracteata* in comparison with *Pueraria*, was continued. The effect of growing *Mucuna* on the girth of rubber plants in Ratnapura district and on soil aggregation and MWD of aggregates are given in Tables 1 and 2, respectively (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 1. Effect of growing *Mucuna* on girth of rubber at five years after planting

Species	Girth (cm)
<i>Pueraria phaseoloides</i>	44.1 ^A
<i>Mucuna bracteata</i>	47.6 ^B

Table 2. Effect of growing *Mucuna* on soil aggregation and MWD of aggregates

Species	Aggregation (%)	MWD (mm)	
		Dry sieving	Wet sieving
<i>Pueraria phaseoloides</i>	52.8 ^A	1.30 ^A	0.70 ^A
<i>Mucuna bracteata</i>	61.9 ^A	2.62 ^B	1.21 ^B

Another experiment was initiated at Main division, Payagala estate to study the establishment success of *Mucuna bracteata* stem cuttings. The treatments consisted of 2 different stem cuttings; with roots (P1) and without roots (P2). The effect of different treatments on establishment success is given in Table 3. Observations on flowering, pod formation and seed setting of *Mucuna* are given in Table 4 (Lalani Samarappuli, P Karunadasa, U Mitrasena, V Edirimanne, T Gunatilleke and S Chandrasiri).

Table 3. *The effect of different stem cuttings on establishment success*

Type	Establishment success (%)
Stem cuttings without roots	42
Stem cuttings with roots	78

Table 4. *The observations on flowering, pod formation and seed setting of Mucuna*

Type	Flowering (%)	Pod formation (%)	Seed setting (%)
Seedlings	100	92	83
Cuttings	46	08	00

At Sapumalkanda estate, Deraniyagala an experiment (SMC-GC/C/97/1) was started in a 1997 replanting to study the influence of *Wedelia trilobeta* (Arunadevi), on growth, nutrient enrichment and other desirable characteristics in comparison with *Pueraria*. Effect of this cover crop on leaf N and P contents of rubber plants are presented in Table 5 (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 5. *Effect of Wedelia trilobeta (Arunadevi) on leaf N and P contents of rubber plants*

Treatment	N content (%)	Status	P content (%)	Status
<i>Pueraria phaseoloides</i> + P	3.47 ^A	Medium	0.21 ^A	Medium
<i>Wedelia trilobeta</i> + P	2.10 ^C	Low	0.17 ^B	Low
<i>Wedelia trilobeta</i> + NPKMg (level 1)	2.91 ^B	Low	0.18 ^B	Low
<i>Wedelia trilobeta</i> + NPKMg (level 2)	3.02 ^B	Low	0.19 ^B	Low

(Means with same letter are not significantly different)

Phosphate fertilizers for cover crops

The field experiment, (SMC-GC/P/97/1) in Weniwella estate, Kegalle to study the effectiveness of Eppawela rock phosphate (ERP) as a source of P for leguminous ground covers, both creeping and bush/tree types were continued. The study consisted of three P treatments: no P, ERP and IRP and two cover types: *Mucuna bracteata* and *Flemingia macrophylla*. Effect of these treatments on tappareability of rubber plants at the end of six years from planting is presented in Table 6. The data seems to suggest that ERP can be used as the source of P for

Mucuna and *Flemingia* without any adverse effect on growth of rubber plants (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 6. *Effect of different sources of phosphate for Mucuna and Flemingia on the tappability of rubber plants*

Treatment	Tappability (%)	
	<i>Mucuna</i>	<i>Flemingia</i>
No P	63 ^A	68 ^A
ERP	74 ^B	76 ^B
IRP	76 ^B	80 ^B

(Means with same letter are not significantly different)

Planting practices for tree legumes

Field experiment (SMC-GC/TL/96/1), started to compare the efficiency of 3 systems of planting *Crotolaria micans* and *Flemingia macrophylla* as successful tree legume species that can be grown between the rows of rubber plants which could provide enough material for mulching, was continued. The treatments consisted of 3 planting practices; *Crotolaria micans* only, *Flemingia macrophylla* only and *Crotolaria* + *Flemingia*. Effect of these treatments on girth of rubber plants and leaf nutrient contents are presented in Tables 7 and 8, respectively (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 7. *Effect of different planting systems on girth of rubber plants*

Treatment	Girth (cm)
<i>Crotolaria micans</i>	46.0
<i>Flemingia macrophylla</i>	46.5
<i>Flemingia</i> + <i>Crotolaria</i>	47.1

Table 8. *Effect of different planting systems on leaf N and P contents of rubber plants*

Treatment	Leaf N (%)	Leaf P (%)
<i>Crotolaria micans</i>	2.12	0.13
<i>Flemingia macrophylla</i>	2.25	0.15
<i>Flemingia</i> + <i>Crotolaria</i>	2.36	0.15

Soil conservation and development of degraded lands

The survey started to categorize the rubber lands into 3 slope classes and to estimate their relative extents in rubber growing districts was extended to other rubber growing districts (Lalani Samarappuli and T Gunatilleke).

Weeds and weed control

An experiment was planned to study the performance of different weedicides on control of *Mucuna bracteata* in the field (Lalani Samarappuli, T Gunatilleke, U Mitrasena and A Thevarapperuma).

Another field experiment was also planned to study the control of different weed species by *Mucuna bracteata* (Lalani Samarappuli, T Gunatilleke, U Mitrasena and A Thevarapperuma).

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

Field experiments (SMC-Ag/F/88/3) at Nalanda estate, Ulpotha, (SMC-Ag/F/98/1) and (SMC-GC/C/99/1) at Bibile estate, Bibile, (SMC-Ag/F/99/1) and (SMC-Ag/M/99/1) at Nottinghill estate, Kahapathwela and (SMC-GC/TL/98/1) at Kumarawatta estate, Monaragala are in progress to study the soil moisture stress management with different soil management and fertilizer practices (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Mulching

Two field experiments at Bibile estate, Bibile and Nottinghill estate, Kahapathwela are in progress to study the effect of mulching on growth of *Hevea* plants. Girth at five years after planting is given in Table 9 (Lalani Samarappuli, P Karunadasa, U Mitrasena and T Dissanayake).

Table 9. *Effect of mulching on girth of rubber plants*

Treatment	Girth (cm)	Girth increment (cm)
No mulch	30.4 ^A	10.2
With mulch	32.7 ^B	11.3

Field experiment (SMC-Ag/M/99/1) is in progress at Nottinghill estate, Kahapathwela to study the effect of different mulching materials on growth of *Hevea* plants in a comparatively drier area. Treatments consisted of four mulching materials and a control; no mulching (M0), paddy straw (M1), coir dust (M2), paddy husk (M4) and green manure (M5). Girth at three and a half years after planting is given in Table 10 (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 10. Effect of different mulching materials on girth of rubber plants

Treatment	Girth (cm)	Girth increment (cm)
No mulch	38.5 ^A	8.1
Coir dust	41.4 ^B	10.0
Paddy husk	43.0 ^{BC}	10.4
Green manure	44.2 ^C	11.5
Paddy straw	44.3 ^C	10.7

(Means with same letter are not significantly different)

Ground cover management

At Kumarawatta estate, Monaragala an experiment was started in a 1998 replanting to study the performance of *Mucuna bracteata* in comparison with *Pueraria phaseoloides* under dry agro-climatic conditions. In the same experiment the effect of different planting practices of *Crotalaria micans* and *Flemingia macrophylla* as successful tree legumes under dry agro-climatic condition was also studied. Data on girth at five years after planting under two situations are given in Tables 11 and 12, respectively (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 11. Effect of growing *Mucuna* on girth of rubber at five years after planting

Species	Girth (cm)
<i>Pueraria phaseoloides</i>	32.6 ^A
<i>Mucuna bracteata</i>	36.7 ^B

(Means with same letter are not significantly different)

Table 12. Effect of different planting systems on girth of rubber plants at five years after planting

Treatment	Girth (cm)
<i>Crotalaria micans</i>	37.0 ^A
<i>Flemingia macrophylla</i>	39.8 ^{AB}
<i>Flemingia</i> + <i>Crotalaria</i>	42.4 ^B

Fertilizer practices for overcoming moisture stress

A field experiment (SMC-Ag/F/88/3) is in progress at Nalanda estate, Ulpotha to study the effect of different levels of potassium on growth and yield of *Hevea* plants in comparatively dry conditions. Although this experiment was continued girth measurements and test tapping were not done due to non-availability of transport facilities (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Two field experiments SMC-Ag/F/99/1 and SMC-Ag/F/98/1 are in progress at Nottinghill estate, Kahapathwela and Bibile estate, Bibile respectively, to study the effect of both potassium and mulching on moisture stress and growth of *Hevea* under three different agro-climatic conditions; comparatively intermediate and dry. Treatments consisted of two mulching techniques; no mulch (M₀) and surface mulching (M₁) and four potassium levels; half the recommended level (K₁), recommended level (K₂), one and half the recommended level (K₃) and double the recommended level (K₄). Girth measurements recorded in the different regions, intermediate and dry are given in Tables 13 and 14, respectively (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 13. *Effect of potassium and mulching on girth (cm) of rubber plants (1999 replanting) (intermediate region)*

Mulching	Level of K			
	K ₁	K ₂	K ₃	K ₄
M ₀	38.2 ^A	38.5 ^A	41.2 ^B	42.9 ^{BC}
M ₁	43.0 ^{BC}	43.5 ^{BC}	44.2 ^C	43.4 ^{BC}

(Means with same letter are not significantly different)

Table 14. *Effect of potassium and mulching on girth (cm) of rubber plants (1998 replanting) (dry region)*

Mulching	Level of K			
	K ₁	K ₂	K ₃	K ₄
M ₀	35.1 ^A	35.5 ^A	38.1 ^{AB}	39.0 ^B
M ₁	40.4 ^B	39.8 ^B	39.1 ^B	39.4 ^B

(Means with same letter are not significantly different)

Soil moisture requirement of rubber under different densities

An experiment (SMC-Ag/D/97/1) was started at Dorset division, Clyde estate to study the soil moisture requirement of rubber under different densities. Treatments consisted of four different densities; (i) 500 trees/ha [4.5m × 4.5m], (ii) 600 trees/ha [4.2m × 4.2m], (iii) 700 trees/ha [3.8m × 3.8m] and (iv) 800 trees/ha [3.5m × 3.5m]. Effect of different densities on girth of rubber plants at the end of six and a half years from planting and girth increment during the year is presented in Table 15 (Lalani

Samarappuli, P Karunadasa and U Mitrasena in collaboration with the Plant Science Department).

Table 15. *Effect of different plant densities on girth of rubber plants*

Planting densities	Girth (cm)	Girth increment (cm)
500 trees/ha [4.5m × 4.5m]	54.2 ^A	5.3
600 trees/ha [4.2m × 4.2m]	53.2 ^A	5.6
700 trees/ha [3.8m × 3.8m]	50.0 ^B	4.8
800 trees/ha [3.5m × 3.5m]	48.0 ^B	3.8

(Means with same letter are not significantly different)

Silt pitting for soil moisture conservation

The field experiment planned to study the effect of silt pits on the moisture conservation at Bibile estate, Bibile was continued (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Rubber as a system to mitigate climate change

Adaptability of rubber trees in capturing rainfall

This study was in progress at different localities of rubber growing areas. Fields of different ages were selected to represent different canopy levels and special devices were fixed to rubber trees to measure through fall, stem flow etc. Data on interception of rainfall by the canopy of a rubber plantation is presented in Table 16. This project was funded by the Ministry of Environment and Natural Resources (Lalani Samarappuli, Wasana Wijesuriya, R Puhambugoda, A Thevarapperuma and T Gunatillake).

Table 16. *Interception of rainfall, through fall and stem flow of a rubber plantation*

Component of rainfall	Mean percentage (cm)
Interception	19
Stem flow	2
Through fall	79
Total	100

Carbon sequestration in rubber plantations

A study was started to estimate the carbon sequestration in rubber plantations under Sri Lankan conditions to highlight it's potential in relation to carbon trading through carbon sequestration for purposes of sustaining rubber cultivation in the country. This study was continued (Lalani Samarappuli, Wasana Wijesuriya, V Edirimanna, A Thevarapperuma, T Dissanayake and S Chandrasiri).

Fertilizer use and plant nutrition

Fertilizers to nursery plants

Improvements to the fertilizer application and use efficiency in young budding nurseries

Municipal solid waste compost as a substitute for inorganic fertilizers

This experiment was initiated at the Dartonfield estate to investigate the possibilities of substituting chemical fertilizers, at least in part, with commercially available municipal solid waste compost and reducing the fertilizer application frequency in young budding nurseries. Statistical analysis on plant growth data up to bud grafting indicates that compost and fertilizer enriched compost used may not be agronomically effective substitutes for chemical fertilizers (Table 17). However, the rates of fertilizer application may be reduced by half, at least until bud grafting, if compost is used at bag filling stage at the rates used in this experiment (R S Dharmakeerthi, S N Silva and S Chandrasiri).

Table 17. *Effect of municipal solid waste compost on plant diameter (mm) at different times before bud grafting*

Treatment	Weeks after planting [†]		
	6	10	14
1. No compost, no fertilizer control	4.2 ^A	5.4 ^C	6.6 ^C
2. Current fertilizer recommendation	4.1 ^A	6.3 ^A	8.8 ^A
3. 1:5 soil-compost mixture	4.3 ^A	5.9 ^B	7.7 ^B
4. 1:5 soil-0.05% fertilizer enriched compost mixture	4.1 ^A	5.8 ^B	7.7 ^B
5. 1:5 soil-0.1% fertilizer enriched compost mixture	4.3 ^A	6.1 ^{AB}	7.5 ^B
6. 1:5 soil-compost mixture + ½ current fertilizer recommendation	4.5 ^A	6.4 ^A	8.4 ^A

[†] values in a column with the same superscript are not significantly different at $p < 0.05$

Slow-release fertilizers for young budding nurseries

An experiment was initiated at the Dartonfield Estate in 2003, in collaboration with the Polymer Chemistry Department, to develop a slow-release fertilizer for young budding nurseries and to determine its agronomic effectiveness. A mixture of coir dust and highly soluble N, P, K and Mg containing fertilizers were encapsulated with natural rubber during the development process. Either one or two of these encapsulated fertilizer blocks were placed in the soil at bag filling stage. Placement of two blocks of encapsulated fertilizer in the polybag was as effective as the current fertilizer recommendation, as indicated by the statistical analysis on the plant diameter

data before bud-grafting (Table 18) (R S Dharmakeerthi, N Liyanage, H N K K Chandralal, S N Silva, and S Chandrasiri).

Table 18. *Effect of encapsulated slow-release fertilizer on plant diameter (mm) at different times before bud grafting*

Treatment	Weeks after planting [†]		
	6	10	14
1. No fertilizer control	4.3 ^A	5.6 ^B	7.3 ^C
2. Current fertilizer recommendation	4.1 ^A	6.4 ^A	9.0 ^A
3. Two blocks of encapsulated fertilizer	4.5 ^A	6.0 ^{AB}	8.7 ^{AB}
4. One block of encapsulated fertilizer	4.2 ^A	6.3 ^A	8.1 ^B

[†] values in a column with the same superscript are not significantly different at $p < 0.05$.

Effect of continuous fertilizer application on bud grafting and scion growth

Four experiments were initiated at government rubber nurseries (*i.e.*, Egaloya, Welikadamulla, Meerigama and Karapinche) to determine the effect of fertilizer application during the period between bud-grafting and cutback on the grafting success and scion growth in nurseries raised by young budding technique. Following fertilizer treatments will be employed on 50 plants each, in all four nurseries under the normal nursery management conditions.

1. No fertilizer application from two-weeks prior to bud-grafting till four-weeks after cut-back (current fertilizer recommendation).
2. No fertilizer application from two-weeks prior to cut-back till four-weeks after cut-back.
3. Continuous fertilizer application at bi-weekly intervals.

These experiments are conducted in collaboration with the Plant Science Department (R S Dharmakeerthi, A M W K Seneviratne and S Chandrasiri).

Fertilizers to immature rubber

Different fertilizer sources

Dolomite as a source of Mg during the first year of planting

An experiment, is in progress at Pembroke division, Payagala estate in a 2001 replanting to study the feasibility of using Dolomite during the first year of planting. Girth measurements were done once in three months and a leaf nutrient analysis was also done twelve months after planting. Effect of different treatments on girth of rubber plants at the end of 2 years after planting is presented in Table 19. Although the data seems to suggest that dolomite can be used as the source of Mg during the first year of planting, a new experiment was initiated on the same subject at Nottingham

estate, Kahapathwala to confirm the results. Effect of same treatments on girth of rubber plants at the end of 2 months after planting is presented in Table 19 (Lalani Samarappuli, T Gunatilleke, U Mitrasena and P Karunadasa).

Table 19. *Effect of different treatments on girth of rubber plants in Pembroke and Nottingham experiments*

Fertilizer treatments	Girth (cm)	
	Pembroke	Nottingham
75g kieserite in 2 applications (Control)	17.1 ^A	10.3 ^A
25g kieserite + 75g dolomite	16.5 ^A	9.5 ^{AB}
50g dolomite + 75g dolomite	17.1 ^A	9.9 ^{AB}
75g dolomite only (planting hole)	17.2 ^A	9.7 ^{AB}
75g dolomite (planting hole) + 25g kieserite	16.8 ^A	9.6 ^{AB}
100g dolomite (planting hole) + 25g kieserite	15.9 ^A	9.6 ^{AB}
50g dolomite (planting hole) + 75g dolomite	16.2 ^A	9.8 ^{AB}
75g dolomite (planting hole) + 25g kieserite	16.2 ^A	8.5 ^B
100g dolomite only (planting hole)	16.2 ^A	9.5 ^{AB}
150g dolomite only (planting hole)	17.4 ^A	9.6 ^{AB}

(Means with same letter are not significantly different)

Foliar nutrients

A field experiment was started in 2000 replanting to study the effect of a foliar fertilizer; Humat 2000, on the performance of rubber plants. Effect of Humat 2000 on the girth of rubber plants at the end of three years is given in Table 20 (Lalani Samarappuli, U Mitrasena and T Gunatilleke).

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

Treatment	Girth (cm)
Normal recommendation (Control)	26.6 ^A
Humat foliar application	25.6 ^A
Humat soil application once a year	26.5 ^A
Humat soil application once in 2 years	26.4 ^A

(Means with same letter are not significantly different)

Fertilizer requirement for different cropping systems

Fertilizer requirement of rubber under different densities

An experiment (SMC-Ag/D/96/1) was started at Mucalana division, Sirikandura estate to study the fertilizer requirement of rubber under different densities. Treatments consisted of (a) Four different densities; (i) 500 trees/ha [4.5m × 4.5m], (ii) 600 trees/ha [4.2m × 4.2m], (iii) 700 trees/ha [3.8m × 3.8m] and (iv) 800 trees/ha [3.5m × 3.5m] (b) Three fertilizer treatments; (i) recommended level (F1), (ii) reduced level (F2) and (iii) 1st three years recommended level and thereafter reduced level (F3). Residual effect of different fertilizer treatments on yield of rubber was monitored (Lalani Samarappuli, P Karunadasa and U Mitrasena in collaboration with the Plant Science Department).

Another experiment (SMC-Ag/D/97/1) was also started at Dorset division, Clyde estate to study the fertilizer requirement of rubber under different densities with same treatments. Effect of different densities and fertilizer levels on tappability of rubber plants at the end of six years from planting is presented in Table 21 (Lalani Samarappuli, P Karunadasa and U Mitrasena in collaboration with the Plant Science Department).

Table 21. *Effect of different fertilizer and density treatments on tappability of rubber*

Fertilizer levels	Planting densities			
	500/ha	600/ha	700/ha	800/ha
Recommended level (F1)	96.0	90.5	68.3	58.8
Reduced level (F2)	98.5	87.5	62.3	47.0
1 st 3 yrs. Recommended level then reduced level (F3)	99.5	89.0	67.3	50.5

Nutrient requirement of rubber based cropping systems

No work was conducted due to unavailability of staff (Lalani Samarappuli, N Wickramasinghe, T Dissanayake and S Chandrasiri).

Application technique

Reduced frequency of fertilizer applications

Field experiment (F/Ap/95/1), started to study the effect of reduced frequency of fertilizer applications during the immature period on the growth of rubber plants was terminated and data are being statistically analyzed. Treatments consisted of (a) 25 applications/immature six year period (urea based), (b) 20 applications/immature six year period (SA based), (c) 19 applications/immature six year period (urea based), (d) 14 applications/immature six year period (SA based) and (e) 14 applications/immature six year period (urea based) (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Fertilizer use in mature rubber**Fertilizer application during mature stage on yield**

An experiment started at Hillcroft division, Mirishena estate to study the effect of fertilizer application during mature stage on yield was continued (Lalani Samarappuli and P Karunadasa).

Site specific fertilizer recommendation by soil and foliar survey programme**Improvements to soil and foliar survey programme****Estate sector**

Leaf N, P, K and Mg contents of mature rubber leaves collected during the soil and foliar survey in the year 2004 indicated that fertilizer application should be continued uninterrupted during the initial period of tapping, at least in the virgin panels (Table 22). Therefore, the policy and practice on fertilizer use in mature rubber should be by periodic tree monitoring at 3-year intervals by soil and leaf nutrient survey approach. This programme should commence at the beginning of the mature phase and continue until 5 to 6 years prior to uprooting to ensure an efficient and cost effective fertilizer programme for mature rubber (Lalani Samarappuli, V Edirimanne and A Thevarapperuma).

Table 22. Leaf nutrient contents of mature rubber leaves in different rubber growing districts

District	Status	Leaf nutrients (%)			
		N	P	K	Mg
Kalutara	5 th /6 th year	2.3	0.17	1.3	0.28
	A panel	2.4	0.21	0.8	0.32
Kegalle	5 th /6 th year	2.1	0.17	0.7	0.28
	A panel	2.2	0.18	0.8	0.32
Avisawella	5 th /6 th year	2.4	0.17	0.9	0.34
	A panel	2.7	0.19	0.8	0.25
Ratnapura	5 th /6 th year	1.9	0.16	0.5	0.26
	A panel	2.3	0.19	0.7	0.28
Galle/Matara	5 th /6 th year	2.3	0.20	0.7	0.27
	A panel	2.5	0.18	0.9	0.29

Smallholder sector

The fertilizer programme introduced to mature smallholdings in different rubber growing districts using leaf nutrient values of both smallholdings and surrounding estates was popularized by several training programmes conducted to both smallholders and extension officers (Lalani Samarappuli, V Edirimanne and T Gunatillaka).

Soil and foliar survey programme - Fertilizer recommendation

The site-specific fertilizer recommendation programme for mature rubber provided fertilizer recommendations for 12,000 hectares in the estate sector.

Nutrient requirement of new Hevea clones

P, K and Mg requirement of some new clones grown in the Kalutara region

Interactions of P, K and Mg on growth of three new high yielding *Hevea* clones (RRISL 201, RRISL 202 and BPM 24) were studied in a 3³ compounded factorial experiment. The trial was initiated in 1998 at Eladuwa estate. Plant girth and percentage tappareability was determined 5 years after planting. Statistical analysis revealed significant differences among P and K levels on both girth and tappareability at this age (Table 23). These differences were similar for all three clones tested. Girthing and tappareability at 5 years after planting have significantly increased when the P and K levels increased from 0.6 to 1.4 times the currently recommended levels but did not change further when the P and K levels increased from 1.4 to 2.2 times the currently recommended levels. There were no significant differences in girth and tappareability among the Mg levels (*i.e.* 0.6, 1.4 and 2.2 times the currently recommended levels). No significant nutrient interactions were observed under these conditions (R S Dharmakeerthi, Lalani Samarappuli and S N Silva)

Table 23. *Effect of P and K levels on girth and tappareability at 5 years after planting*

Level	Girth (cm) [†]		Tappareability (%) [†]	
	P	K	P	K
0.6	46.3 ^B	46.3 ^B	32.6 ^B	31.4 ^B
1.4	47.1 ^A	47.2 ^A	36.2 ^{AB}	37.2 ^A
2.2	47.5 ^A	47.4 ^A	40.6 ^A	41.0 ^A

[†] values in a column with the same superscript are not significantly different at $p < 0.05$.

Secondary and micro nutrition

The experiment started at Pallegoda estate to study the effect of three different sources of Sulphur on the performance of young rubber was continued. Girth measurements at six years after planting is presented in Table 24 (L Samarappuli, P Perera, S Chandrasiri and Chitra Maheepala).

Table 24. *Effect of different treatments on growth of rubber plants*

Treatment	Girth (cm)	
	RRIC 100	RRIC 121
Urea, IRP, MOP, Dolomite	53.9	54.7
Urea, IRP, MOP, Kieserite	54.5	53.3
SA, IRP, MOP, Dolomite	55.2	55.5
Urea, IRP, MOP, Dolomite, Epsom salt (level 1)	54.4	56.1
Urea, IRP, MOP, Dolomite, Epsom salt (level 2)	53.8	52.4
Urea, IRP, MOP, Dolomite, Epsom salt (level 3)	52.5	53.1
Urea, ERP, MOP, Dolomite, Epsom salt (level 1)	56.0	55.4

Organic fertilizers*Planting stage*

An experiment was started in Pembroke division, Payagala estate in a 2001 replanting to study the effect of application of different organic materials into the planting hole. Treatments consisted of; no organic manure, straw, poultry litter, cow dung, green manure, compost, coir dust, paddy husk, tea dust and saw dust. This experiment was terminated and results are being statistically analyzed (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Another two experiments were started in Pitiyakanda estate in a 2003 replanting to study the effect of application of different organic materials into the planting hole. In experiment 1, treatments consisted of; no organic manure (control), paddy straw, poultry litter, cow dung, green manure, EM treated compost type 1, EM treated compost type 2 and burned paddy husk. In experiment 2, treatments consisted of; no organic manure (control), EM treated paddy straw, burned paddy husk and coconut husk. Growth measurements at 3 months after planting in experiment 1 and 2 are presented in Tables 25 and 26, respectively (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 25. *Effect of different treatments on growth of rubber plants*

Treatment	Girth (cm)
Nil (control)	5.0 ^{AB}
Paddy straw	5.6 ^A
Poultry litter	4.7 ^{AB}
Cow dung	5.7 ^A
Green manure	3.6 ^B
EM treated compost type 1	5.3 ^{AB}
EM treated compost type 2	5.2 ^{AB}
Burned paddy husk	3.7 ^B

Table 26. *Effect of different treatments on growth of rubber plants*

Treatment	Girth (cm)
Nil (control)	3.3 ^A
EM treated paddy straw	3.4 ^A
Burned paddy husk	3.4 ^A
Coconut husk	3.3 ^A

Immature stage

Use of animal wastes

A field experiment (FPN-Org/An/01/1), is in progress at Pembroke division, Payagala estate to study the effect of poultry litter as an organic manure for rubber. Treatments consisted of (T1) No organic manure (control), (T2) Organic manure to planting hole + 1st to 6th year, (T3) Organic manure to planting hole + 2nd year + 4th year + 6th year (Level 1), (T4) Organic manure to planting hole + 2nd year + 4th year + 6th year (Level 2), (T5) Organic manure to planting hole + 3rd year + 6th year (T6) Organic manure to 3rd year + 5th year. Effect of treatments on girth at the end of two and a half years is given in Table 27 (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 27. *Effect of different treatments on growth of rubber plants*

Treatment	Girth (cm)
T1	18.3 ^A
T2	20.5 ^B
T3	20.4 ^B
T4	20.0 ^B
T5	20.4 ^B
T6	20.7 ^B

(Means with same letter are not significantly different)

Use of green manure

A field experiment, (FPN-Org/Gm/97/2) is in progress at Dorset division, Clyde estate to study the effect of plant materials as an organic manure for rubber. Treatments consisted of combinations of three sources of N *viz.* full inorganic (N1), ½ inorganic + ½ green manure (N2) and full green manure (N3) and three sources of K *viz.* full inorganic (K1), ½ inorganic + ½ straw (K2) and full straw (K3). The nine different treatment combinations were applied in a randomized block design with four replicates. Effect of treatments on tappability of rubber plants at the end of six years is given in Table 28 (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 28. *Effect of different treatments on girth (cm) of rubber plants*

Sources of N	Sources of K		
	K1	K2	K3
N1	80.1 ^A	82.9 ^A	86.9 ^A
N2	81.9 ^A	75.1 ^A	89.7 ^A
N3	82.8 ^A	81.4 ^A	74.1 ^A

(Means with same letter are not significantly different)

Refused tea and wood ash

A field experiment (SMC-Ag/M/97/1) is in progress at Sapumalkanda estate, Deraniyagala to study the effect of different quantities of refused tea and wood ash on growth of *Hevea* plants. Treatments consisted of three quantities of refused tea and wood ash /plant/annum; no refused tea (T₀), refused tea, level 1 (T₁), refused tea, level 2 (T₂), no wood ash (W₀), wood ash, level 1 (W₁) and wood ash, level 2 (W₂). Plant girth at six and a half years after planting is given in Table 29 (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 29. *Effect of refused tea and wood ash on girth (cm) of rubber plants*

Level of refused tea	Level of wood ash		
	W ₀	W ₁	W ₂
T ₀	44.3 ^A	46.4 ^A	44.4 ^A
T ₁	43.8 ^A	47.5 ^A	46.6 ^A
T ₂	48.32 ^A	45.3 ^A	41.8 ^A

(Means with same letter are not significantly different)

Use of sludge

An experiment was started at Payagala estate to evaluate sludge as an organic fertilizer for immature rubber. Residual effect of sludge applied during the immature period among the on yield of rubber is presented in Table 30 (Lalani Samarappuli, U Mitrasena, and T Gunatilleke).

Table 30. *Residual effect of sludge on yield of rubber plants*

Treatment	Yield (ml/t/t)
Without sludge	65.8
With sludge	63.4

Use of rubber factory effluent

The field experiment started at Eladuwa estate to study the possibility of using rubber factory effluent as a fertilizer was continued with data are being analyzed (Lalani Samarappuli, T Dissanayake and R Puhambugoda).

Organic rubber

An experiment is in progress to develop a sustainable and a commercially viable system for plantations as well as for smallholders to produce an environmentally, friendly new grade of rubber (organic rubber) to meet the increasing demand for "bio-market". Effect of different treatments on girth of rubber plants at the end of five and a half and six and a half years are given in Table 31 (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 31. *Effect of different treatments on girth of rubber plants*

Treatment	Girth after planting (cm)	
	5½ years	6½ years
Chemical fertilizer only	49.5	53.2
Organic fertilizer only	42.3	48.9

Rubber growing soils

Spatial variability of soil properties and the growth of rubber across variable landscapes

Spatial variability of growth of rubber:

An experiment was initiated to gather preliminary information on the spatial relationship of growth of *Hevea* plants in sloppy landscapes. Two lands were selected based on the slope of the land; one land with a mild slope of about 3% at RRISL substation Kuruwita and the other with a very steep slope of about 40% at Neuchatel Estate, Neboda. Changes in elevation and girth of rubber trees in these two fields were measured. The experiment is in progress (R S Dharmakeerthi, S P Perera, S N Silva and S Chandrasiri).

Management of diseases through fertilizer application

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

Corynespora leaf fall disease has been observed at various severity levels in new high yielding clones of RRISL 201, RRISL 202 and RRISL 217. The possibility of managing this disease by fertilizer application will be studied in this experiment. The severity of this disease was measured in RRISL 201 and RRISL 202 clones in the fertilizer experimental plots in the Eladuwa estate. Another experiment was initiated for these three clones in the 1997 clearing at RRISL substation, Kuruwita where three fertilizer levels (*i.e.* no fertilizer, current recommendation based on leaf analysis, and double the current recommendation) were started in June 2003. The disease severity in these plots was measured and the data is being analyzed. This experiment is being

conducted in collaboration with the Plant Pathology and Microbiology Department and the Genetics and Plant Breeding Department (R S Dharmakeerthi, C K Jayasinghe, D P S T G Attanayake, S N Silva and E A D N Nishantha).

Land selection and suitability for rubber cultivation

Improvements to land selection programme

This study was continued (Lalani Samarappuli, P Karunadasa, U Mitrasena, and T Gunatilleke).

Land selection programme for estate sector

Under this programme about 200 hectares of land was surveyed to find out the suitability for planting rubber (Lalani Samarappuli and all the staff of the department).

Analytical services and techniques

Analytical service

Routine chemical analysis of soil, leaf, latex and fertilizer samples collected for experimental and advisory purposes were carried out. Details are presented in Table 32.

Table 32. *Details of the analysis done during the year*

Source	No. of analysis				
	Plant	Soil	Fertilizer	Organic manure	Other*
Experimental	2,000	240	-	120	-
Soil and Foliar survey	8,000	-	-	-	-
Other Departments of RRI	24	06	-	40	76
Research Institutes	-	-	-	-	-
Rubber Development Department	-	-	-	-	-
Plantation Mgt. Companies	-	98	161	18	-
Other Private Companies	-	30	-	14	12
Total	10,024	374	161	192	88

* water/bleaching agents/chemicals/rubber

Analytical techniques

Work on preparation of a Laboratory Manual for the Soils and Plant Nutrition Department was continued.

BIOCHEMISTRY AND PHYSIOLOGY

G V Lakmali Nilmini

SUMMARY

Trials were continued to develop an economically feasible method to extract "Quebrachitol", a valuable biochemical from rubber serum simultaneously with the rubber production process.

Studies on biochemical changes associated with tapping panel dryness were continued. Further, colonial and seasonal variations of non-rubber constituents were studied.

Possible causes for variation in latex stability during and after wintering months were also studied. Results were compared with the results obtained from the artificially defoliated trees too.

Investigations on the impact of deviations in rainfall pattern on pollution in main rubber growing areas were continued.

Project on the effect of low temperature on metrolac reading was initiated.

Study on the effectiveness of coconut fiber media on biological wastewater treatment of rubber factory effluent was continued.

DETAILED REVIEW

Staff

Mr W M Thurul, Assistant Biochemist, resigned with effect from 01st of January 2003. Assistant Biochemist, Mrs G V L Nilmini was on duty through out the year. Mr P D J Rodrigo and Mr D Ramawickrama, Experimental Officers, were on duty through out the year. Mrs K V V S Kudaligama Wijesundera, Experimental Officer reported for duty on 28th of November after the maternity leave.

Research students

- Miss Jayani Gunasekera, undergraduate student from University of Kelaniya, successfully completed her vacation training under the supervision of Mrs G V L Nilmini.

Seminars/Conferences/Meetings/Workshops attended

Officer	Subject	Organization
G V Lakmali Nilmini	Effect of wintering on latex and raw rubber properties of <i>Hevea brasiliensis</i>	Ministry of Environmental and Natural Resources
K V V S Kudaligama	Effect of rainfall on the pollution problem associated with natural rubber processing factories	Ministry of Environmental and Natural Resources

Training Programmes

Client	Subject	No. of programmes
Assistant Managers	Wastewater management	01

LABORATORY AND FIELD INVESTIGATIONS**Extraction of quebrachitol from rubber serum**

Extraction of quebrachitol from rubber serum was continued (G V Lakmali Nilmini, K V V S Kudaligama, P D J Rodrigo and D Ramawickrama).

Biochemical studies of Tapping Panel Dryness (TPD)

This project attempts to identify possible causes for this physiological disorder. As an initial step studies were focused on biochemicals such as carbohydrates and proteins (G V Lakmali Nilmini, K V V S Kudaligama, P D J Rodrigo and D Ramawickrama).

Studies on non-rubber constituents present in latex

In order to investigate the clonal and seasonal variation of non-rubber constituents present in latex, this study was initiated with 4 clones, *i.e.* RRIC 100, RRIC 121, RRIC 130, and RRIC 102. Latex samples were collected from two replicates and were analysed (G V Lakmali Nilmini, K V V S Kudaligama, P D J Rodrigo and D Ramawickrama).

Effect of wintering on latex and raw rubber properties of *Hevea brasiliensis*

The research project funded by the Junior Research programme of the Climatic Change Enabling Activity (Phase II) Project of Ministry of Environment and Natural Resources was continued. This research project was focused on the variation of stability of the latex during the year. Latex samples collected from RRIC 102 and RRIC 121 were subjected to analyse of amino acids, phenols and technical properties

and the results were compared with the results obtained from the artificially defoliated trees (G V Lakmali Nilmini and L M K Tillekeratne).

Effect of rainfall on the pollution problem associated with natural rubber processing factories

The impact of deviation in rainfall pattern on the pollution problem associated with rubber processing factories was studied in main rubber growing areas. This project is funded by the Junior Research Programme of the Climate Change Enabling Activity (Phase11) Project of Ministry of Environment and Natural Resources (K V V S Kudaligama, Wasana Wijesuriya and W M Thurul).

Effect of low temperature on metrolac reading

This research project focuses on the development of relationship between metrolac reading and the temperature in order to minimize the effect of low temperature on metrolac reading.

This research project was initiated due to the anomalous metrolac readings obtained in rubber growing areas of the high elevation (G V Lakmali Nilmini, K V V S Kudaligama, P D J Rodrigo and D Ramawickrama).

Effectiveness of coconut fibre media on biological wastewater treatment of rubber factory effluent

This study was focused on improving the efficacy of Covered Activated Ditch System with Bio-brush media for the treatment of rubber factory effluent. Combination of different specific surface areas (SSA) and diameters of Bio-brush medium under different organic loading rates (OLR) were tested aiming to improve the treatment efficiency of Covered Activated Ditch System by selecting the best packing strategy of Bio-brush medium (Table 1).

Possibility of treating rubber factory effluent with low SSA of media was studied in order to reduce the cost of stationary media.

Table 1. COD removal efficiency of 10 cm diameter bio-brush media under different organic loading rates

SSA (m ² /m ³)	OLR (kg COD/m ³ /d)	COD removal efficiency (%)	Standard deviation
50	0.5	62	3.27
	1.0	77	0.72
	2.5	70	2.43
	3.5	56	2.10
100	0.5	68	2.06
	1.0	86	2.27
	2.5	74	1.03
	3.5	65	1.02
150	0.5	82	2.80
	1.0	87	1.26
	2.5	78	0.67
	3.5	82	1.05
200	0.5	91	1.81
	1.0	89	1.46
	2.5	82	0.93
	3.5	83	3.59
250	0.5	94	1.16
	1.0	90	0.74
	2.5	83	0.60
	3.5	82	0.84

Effect of inorganic nutrients and chemicals, used during processing on rubber factory effluent treatment was studied. Variation of chemical and microbiological parameters was monitored in covered activated ditch reactors (K V V S Kudaligama, W M Thurul, P A J Yapa and C K Jayasinghe).

ADVISORY SERVICES

A Dissanayake

SUMMARY

Several projects were identified and carried out at National level and Regional level to increase the productivity of the smallholder rubber industry in the country.

Improvement of the quality of RSS was identified as a priority project and a number of new processing centres were constructed, while a large number of substandard processing centres were refurbished to improve the quality of RSS produced in them. The staff of ASD was also involved in carrying out special projects viz; introduction of *Mucuna* as a new cover crop, and organizing and motivating farmers to apply fertilizer for mature plantations.

Priority was given to conduct farmer training programmes organized at village level in all regions, to improve the productivity of rubber plantations and to improve the tapper productivity as a solution for tapper shortage.

DETAILED REVIEW

Staff

Dr Anura Dissanayake, Head of the Advisory Services Department and three Regional Advisory Officers - Mr A H Kularathna (Rathnapura and Colombo Regions) Mr D D Dasanayake (Kalutara and Galle Regions), Mr G Gunawardana (Kegalle) and 31 Rubber Extension Officers were on duty throughout the year.

Dr Anura Dissanayake was appointed as the Chairman of the Thurusaviya Fund of the Ministry of Plantation Industries which effect from 8th July 2003.

Seminars/Conferences/Meetings/Workshops attended

Officer	Subject	Organization
A Dissanayake	Meetings of Board of Thurusaviya Fund under the Ministry of Plantation	MPI
A Dissanayake	Research and coordinating meetings in relation to INTEREST project	MPI/RRI
A Dissanayake	Meetings of institutional arrangements for fertilizer and plant distributions activities of the smallholder project	MPI
A Dissanayake	Rubber Stallholders Timber certifications programmes under the Forest certifications Stewardship Project (FSC)	EDB

ADVISORY

Officer	Subject	Organization
A Dissanayake	Meetings of the Plantation and smallholder subcommittee under the Ministry of Policy Planning.	Ministry of Policy Planning
A Dissanayake	Workshops on promotion of Eppawala Rock Phosphate use in Agriculture	MPI
A Dissanayake	Scientific Committee meetings	RRI
A Dissanayake	Meetings of the Rubber Sector Review meetings	MPI
A Dissanayake	Meetings of Monthly progress review in different regions	ASD
A Dissanayake	Workshops on RSS manufacturing, grading and marketing conducted for REOO and Thurusaviya Society Officials	Thurusaviya Fund

REOO and RAOO attended the followings

- Advisory visits on specific requests of rubber growers
- District and regional level coordinating meetings organized by other relevant officers
- Special meetings organized by the Thurusaviya fund on establishment of fertilizer dealerships, establishment of rubber marketing with the private sector rubber marketing organizations and rain guard fixing *etc.*

Study Tours/Training programmes

- Dr Anura Dissanayake was on a study tour in India with effect from 12.11.03 to 28.11.03 study the organizational, production and marketing aspects of smallholder rubber industry in India.

SERVICES

National level projects

Rehabilitation of substandard rubber holdings

The survey to estimate the current stand per hectare in immature holdings with the objective of using these results, to develop appropriate action plans to maintain the stand per hectare, with relevant authorities, was completed, for all districts including Monaragala.

A separate report including general suggestions and improvements of rubber holdings in the Monaragala district was prepared.

Nearly 326.79ha. of substandard rubber holdings were rehabilitated by REOO during this period (Table 1).

Table 1. *Acreage of substandard holdings rehabilitated*

Region	Acreage (Ha.)
Kegalle	33.20
Colombo/Gampaha	21.49
Galle	79.09
Kalutara	167.00
Ratnapura	25.20

Selection and maintenance of model rubber estates

A programme to select and maintain model rubber estates which comprise of properly maintained rubber plantations, cover crops', intercrops', use of rain guards', standard production units *etc.*, as per RRI recommendations, was completed in each REOO range. These model estates are closely supervised by REOO and used for training and demonstration purposes.

Promotion of use of ERP mixtures

16 smallholdings were selected jointly by the Lanka Phosphate Limited and ASD in the Kalutara region and demonstrations plots were established. Fertilizer was distributed and display boards were fixed in each demonstration plot. This project is in progress.

Promotions of Fertilizer usage of mature and immature holdings

A special extension programme to improve the usage of fertilizer in both mature and immature rubber was conducted in collaboration with Thurusaviya societies in each REOO range (Table 2). REOO have encouraged farmers to apply fertilizer and helped in purchasing and distribution of fertilizer during the period.

Table 2. *Fertilizer distributed for mature and immature rubber*

	Kegalle	Colombo/Gampaha	Galle	Kalutara	Ratnapura
Mature (Ha)	207.9	100.89	253	215	178.25
Immature (Ha)	108.8	77.7	6	278.2	-

Soil conservation aspects

Growing Mucuna as a cover crop

Establishment of *Mucuna* as a new cover crop in selected smallholdings was successfully completed during the period (Table 3).

Table 3. *Introduction of Mucuna in small holdings 2004*

Region	Hectares
Kegalle	73.2
Rathnapura	43.4
Kalutara	33.41
Galle	3.75
Colombo/Gampaha	6.37

Promotion of other soil conservation aspects

Nearly 171.39ha. of rubber lands, which were substandard in soil conservation aspects, were rehabilitated by REOO during the period.

Control of diseases***Eradication of white root disease***

Farmer training programmes to train farmers on identification, control and prevention measures of white root disease were successfully completed.

Table 4. *White root infected holdings identified and treated by REOO*

Region	Extent of rubber lands treated
Kegalle	149.00
Rathnapura	131.00
Kalutara	80.20
Galle	19.50
Colombo/Gampaha	53.47

Production of good quality RSS

Under this project farmers were encouraged and trained to up- grade the quality of RSS in both private and group processing centers.

Following achievements were made during the period

- Construction of 138 new processing centers
- Refurbishment of 122 existing substandard processing centers
- Repair of 97 pairs of rubber sheet rolling units
- Arranging marketing facilities for 96 production centers
- Training programmes to update quality of RSS

REOOs assisted in selecting 20 suitable Thurusaviya Societies in-terms of their organization abilities, production efficiency and future performance

requirements *etc.*, for the distribution of rolling units, a project funded by the Thurusaviya fund.

School training programmes

A special educational programmes to enhance the knowledge on rubber cultivation and processing aspects prepared in line with the GCE O/L syllabus was conducted for O/L student in rubber growing regions. Programmes were conducted in following educational zones (Table 5).

Table 5. *School training programmes conducted in educational zones*

Educational zone	Programmes
Polgahawela Educational Zone	02
Kegalle	01
Rathnapura	01
Colombo	02

Categorization of smallholdings

Preparation of field monitoring methodologies and scoring sheets on adoption of RRI recommendation by smallholders during both mature and immature period were completed to evaluate the estates of smallholdings.

Improvement of tapper productivity as a solution for tapper shortage

Tapper training programmes organized by REOO at village level in all regions were successfully completed.

Table 6. *No of tapper training programmes conducted in regional level 2003*

Region	No. of tapper training programmes conducted	No. of farmers trained
Kegalle	17	170
Rathnapura	20	210
Colombo	04	80
Kalutara	39	300
Galle	20	150

Extension activities targeting the farmers in non traditional areas

The project funded by the Center for Poverty Alleviation (CEPA) on strategies for enhancing the productivity in the smallholder sector in non traditional rubber growing areas, continued. Awareness programmes for rubber smallholders were conducted in selected villages in the Monaragala district and a final report was submitted to the CEPA.

Interaction between the environment, society and technology (INTEREST)

Dissemination material in various forms, for researchers and farmers were completed. A meeting was held for preparation of dissemination materials with the foreign project counterparts.

Regional level projects

Different projects identified by RAOO and REOO on specific issues at regional level, covering a full range of field management practices, processing marketing and other related aspects were conducted successfully. Related activities were carried out to address following issues/problems.

1. Correction of incorrect latex exploitation practices
2. Unnecessary application of chemicals on tapping panels
3. Introduction of alternate firewood sources
4. Training programs on yield stimulation techniques
5. Introduction of mulching practices
6. Introduction of intercropping and establishment of tea-rubber mixed cropping systems
7. Tapper training programme for the plantation sector
8. Training programmes on rubber cultivation and processing aspects for Agricultural research and production assistants, attached to the Agrarian Services Department.

RUBBER TECHNOLOGY AND DEVELOPMENT

Dilhara Edirisinghe

SUMMARY

A Presidential (Merit) award was awarded to Mrs Manel Mahanama for the natural rubber (NR) latex based ornamental flowers and leaves developed by her.

Cast films out of uncompounded NR/polyvinyl acetate (PVAc) latex blends were prepared successfully and the physical properties were evaluated. Replacement of 13-15% of the NR latex with PVAc improves moduli and strength properties, significantly.

Good quality latex foam was produced out of NR/polychloroprene (CR) blends for flame resistant applications.

Work on the development of bio-degradable rubberized-coir pots was continued in collaboration with IDB.

Carbon black incorporated rubber sheets were prepared by a new technique with the aim of reducing energy consumption during processing. Physical properties of the tyre tread compounds prepared using these sheets were evaluated and compared with those of the treads prepared according to the conventional method.

An NR latex based adhesive for bicycle stickers, crepe rubber based non-toxic adhesive for surgical bandages/plasters, v-strap compound using a black colour dye, NR/EPDM blend compound for truck springs, NBR, CR and NR/CR blend compounds for engineering applications, rice-huller roller compound out of CR and a rubber compound suitable for dock fenders, were developed at the request of various parties.

Rubber models of skin lesions of leishmaniasis were produced out of NR latex and forwarded to the Faculty of Medicine, University of Colombo, for carrying out trials.

Effectiveness of some blowing agents on properties of micro-cellular shoe soles was evaluated on a request made by an industrialist.

Abrasion resistance of the tyre retreads produced by a tyre retreading company was improved at their request.

Moulded sheets out of PE/buffing dust/cotton fibre composites were prepared successfully.

A continuation on the work on Interpenetrating Polymer Networks (IPNs) had to be carried out on the advice of the authorities.

DETAILED REVIEW

Staff

Mrs D G Edirisinghe, Rubber Chemist was on duty throughout the year. Mrs M M Jayasuriya, Rubber Chemist continued her PhD project work at the RRISL during the year.

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

Miss D N Wickramarachchi, Research and Development Assistant and Mr A I Siriwardena, Technical Officer were on duty throughout the year.

Research students

- Mr S P Tissaverasinghe, a BSc (Chemical engineering) undergraduate from the University of Moratuwa underwent an in-plant training in the department. The title of the project is "Development of solvent based adhesives using different types of rubbers".
- Mr R Gobalarajah, a BSc (Materials engineering) undergraduate from the University of Moratuwa underwent in-plant training. The title of the project is "Development of NR/EPDM blends for outdoor applications".
- Miss Asha Ariyadasa, a NDT (Chemical engineering) student from the University of Moratuwa completed her in-plant training. The title of the project is "Some developments on latex/hot bitumen blends for road applications".
- Miss Nizreen Nizam, a BSc (Chemistry special) undergraduate from the University of Kelaniya underwent vacation training in the department. The title of the project is "Further developments of the latex based cement suitable for tyre retreading".
- Mr J M C N Jayatilleke, a BSc (Chemical engineering) undergraduate from the University of Peradeniya underwent an in-plant training. The title of the project is "Development of latex/carbon black masterbatches for sheet rubber manufacture".
- Mr S S Chandana, a BSc (Chemical engineering) undergraduate from the University of Peradeniya underwent an in-plant training. The title of the project is "Natural rubber/polychloroprene rubber blends for engineering applications".
- Mr Sasanka, a BSc (Chemistry special) undergraduate from the University of Colombo underwent vacation training on rubber products manufacture and instrumentation.

Seminars/Conferences/Meetings/Workshops

Officer	Subject	Organization
Dilhara Edirisinghe	Sixth sectoral committee meeting on "Chemical and polymer technology"	Sri Lanka Standards Institution
Dilhara Edirisinghe	Workshop on "Crepe rubber repositioning programme"	Rubber Cluster
Dilhara Edirisinghe and Madupani Jayasooriya	Technical seminar on "Rubber products testing for the export market"	Industrial Technology Institute

Training programmes

The staff of the department was involved in the following.

Client	Subject	No. of programmes
Extension Officers attached to the plantation sector (organized by the NIPM)	i. Composition of NR latex and effects of non-rubber substances ii. Demonstration on rubber products manufacture - 11 th Diploma course in Plantation Management	1
Students of the Plastic and Rubber Institute	i. Structure and property relationship of polymers ii. Compounding ingredients (latex) iii. Processing techniques (latex) - Basic course in Rubber Technology	1
Students of the Plastics and Rubber Institute	General properties of NR latex and latex technology - Diploma Course in Rubber Technology	1
Industrialists from the rubberized-coir industry (organized by the IDB, Peliyagoda)	Rubberized-coir manufacture	1
An officer attached to a rubberized-coir manufacturing company	Rubberized-coir manufacture	1
Low income receiving, Samurdhi officers (organized by the Ministry of Science and Technology, in connection with the divisional secretariat, Ratnapura)	How to overcome problems encountered during manufacture of rubber products	1
Undergraduates from the University of Kelaniya	Dipped products manufacture	1

The staff of the department was involved in conducting five practical classes for MSc (Polymer Science and Technology) students of the University of Sri Jayawardenapura.

Visits

Mrs D G Edirisinghe and Mr Warnajith Prasad made several visits to the Ceyesta factory at Maharagama in order to look into the problem of sagging of their rubberized-coir mattresses. Necessary advice was given on the quality of chemicals, compound formulation, preparation of chemical dispersions, spraying of latex, cure time and temperature, *etc.*

A report on "Rubberized-coir Manufacture" providing necessary advice on the problems encountered during the rubberized-coir manufacturing process was prepared and handed over to Ceyesta on request.

Furthermore, a report giving observations, comments and recommendations on the Rubberized-coir Manufacturing Process was forwarded to Ceyesta on a request made to the Chairman, RRB. This report was prepared after a factory inspection.

Mrs D G Edirisinghe, Mrs M K Mahanama, Mr P L Perera and Mrs H S Weeraman visited Ceylon Rubber Industries, Padukka on their request to look into the problems encountered during manufacture of balloons and to provide suggestions and advice on upgrading their testing laboratory.

Mrs Madupani Jayasooriya and Miss D N Wickramarachchi visited Bata Shoe Company, Ratmalana to attend to some problems encountered during manufacture of shoe soles.

LABORATORY INVESTIGATIONS

Latex technology

Natural rubber (NR)/polyvinyl acetate (PVAc) blends for dipped products

Work on this project initiated on a request made by Lalan Gloves (Pvt.) Ltd. was extended to study the physical properties of cast films produced out of blends of NR and PVAc latices in comparison to NR latex cast films (control).

A series of NR/PVAc blends was prepared by incorporating 10%, 13% and 15% of PVAc into NR latex. These blends were prepared according to different methods. The modulus at 100% elongation, modulus at 500% elongation and elongation at break values of these uncompounded blends prepared according to one of the above mentioned methods together with the properties of the control sample are given in Table 1.

Table 1. Moduli and elongation at break values of uncompounded NR and NR/PVAc cast films

	NR (Control)	90/10 NR/PVAc blend	87/13 NR/PVAc blend	85/15 NR/PVAc blend
100% Mod. (MPa)	0.27	0.33	0.44	0.57
500% Mod. (MPa)	0.36	0.34	0.85	1.44
Elongation at break (%)	870	988	830	725

Variation of modulus at 300% elongation with the composition of the blend is shown in Figure 1, while the variation in strength properties with the blend ratio is shown in Figure 2.

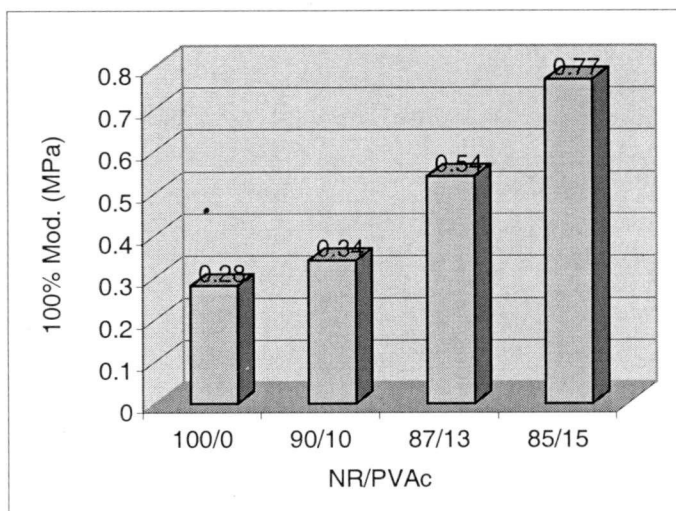


Fig. 1. Variation of modulus at 100% elongation with the composition of the blend

Results indicate that incorporation of 13-15% of PVAc into NR latex improves moduli, tensile strength and tear strength, significantly. However, there is a slight reduction in the elongation at break. Also, percentage retention of the above mentioned properties after aging the films at 100°C for 22 hours has been investigated. It was found that the percentage retention of the properties of the NR/PVAc blends after aging is greater than those of the control sample.

Furthermore, cast films out of compounded 87/13 NR/PVAc latex blends were prepared, successfully and the physical properties before and after ageing were evaluated (D G Edirisinghe, D N Wickramarachchi and P C Wettasinghe).

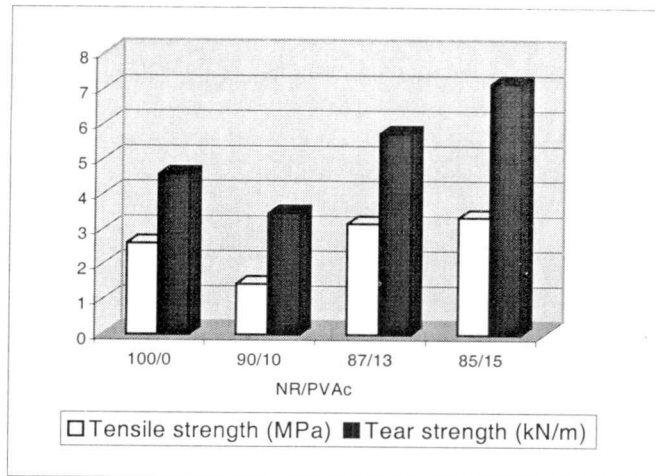


Fig. 2. Variation of strength properties with the composition of the blend

Latex foam out of NR/polychloroprene (CR) blends

Trials were carried out to produce foam rubber out of 90/10 and 80/20 NR/CR blends with the aim of increasing the flame resistance of NR latex foam products. This research was initiated on a request made by Mal *Hevea* Foam (Pvt.) Ltd. The foams produced were of superior quality. However, it was not possible to test the flammability of the foams produced due to non-availability of testing equipment (D G Edirisinghe and S I Yapa).

Bio-degradable rubberized-coir pots

Work on this project was continued in collaboration with IDB. Bio-degradability of coir and/or rubber was enhanced by using a special chemical agent. Optimum conditions for bio-degradability were identified. The change in tensile strength and other important properties of coir and/or rubber after subjecting to various experimental conditions were evaluated (M M Jayasuriya, P C Wettasinghe and D N Wickramarachchi).

Latex based adhesive for stickers

Few trials were conducted to develop an adhesive for bicycle stickers at the request of a small scale industrialist. One of the trials was successful and the technological knowledge on the development of this NR latex based adhesive was transferred to the industrialist (D G Edirisinghe and M K Mahanama).

Artificial flowers out of NR latex

Flower bouquet, head-dress and a table decoration using NR latex based flowers and leaves were made for the Presidential and National Awards Competition, 2003. Won a Presidential (Merit) award for the technique developed to produce NR latex based flowers and leaves (Manel Mahanama).

NR latex/carbon black masterbatches for sheet rubber manufacture

The main objective of carrying out this research is to minimize energy consumption during processing of rubber compounds. A series of NR latex/carbon black masterbatches was prepared according to different methods. Rubber sheets were made and the dispersion of carbon black in the NR matrix was analyzed at Loadstar Company using the instrument, Dispergrader 1000 NT, which consists of experimental histogram software. Dispersion of carbon black in the NR matrix of the sample was found to be 71-95%. This is an excellent retention.

Tyre tread compounds were produced using these rubber sheets. There was no significant difference between the physical properties of the tyre tread compounds prepared using the sheets produced with NR latex/carbon black masterbatches and those of the tyre tread compounds prepared according to the conventional method. In fact, it was interesting to note that the tear strength of the former was greater than that of the latter.

The advantages of the novel technique used to produce NR latex/carbon black masterbatches are that the carbon black dispersion can be prepared within a very short period. The power consumption is also less and easy to handle. Wastage of carbon black is also less and all of which facilitate rapid production of carbon black incorporated rubber sheets. Furthermore, there is no loss in physical properties of the samples made in that manner.

This process will be patented in due course (M M Jayasuriya, K E Jayasuriya, J M C N Jayatileka - University of Peradeniya, P C Wettasinghe, A I Siriwardena and D G Edirisinghe).

Development of rubber models of skin lesions of leishmaniasis

Trials were carried out to develop rubber models of skin lesions of leishmaniasis out of NR latex, on a request made by the Department of Parasitology, Faculty of Medicine, University of Colombo for the workshop on "Routine Laboratory Techniques in Diagnosis of Cutaneous Leshmaniasis". Trials were successful and about thirty rubber models were handed over to the Department of Parasitology for testing (D G Edirisinghe and M K Mahanama).

Dry rubber technology

Development of a non-marking compound for v-strap of rubber slippers

A request was made by D. Samson Industries to develop a non-marking compound for the v-strap of rubber slippers in order to eliminate the marking problem of their v-straps containing carbon black. Trials were carried out by replacing carbon

black with a black coloured dye. There was no significant colour difference between the v-strap compound containing the black dye and the compound containing carbon black. The physical properties of both the compounds are in accordance with the required values. The two formulations, one containing carbon black and the other containing the black dye were forwarded to DSI to carry out factory trials (D G Edirisinghe, Sarath Kumara, M K Mahanama and H N K K Chandralal).

Development of synthetic rubber compounds for engineering applications

A nitrile rubber (NBR) compound and a polychloroprene rubber (CR) compound suitable to produce two engineering components were developed on a request made by Salwathura Engineering, Boralessgamuwa (D G Edirisinghe, D N Wickramarachchi and H N K K Chandralal).

Blends of natural rubber (NR) and synthetic rubber

NR/ethylene-propylene rubber (EPDM)

A series of NR and EPDM blend compounds was prepared in order to formulate a suitable compound for a truck spring, on a request made by DSI. The blend compounds were prepared according to a single-stage mixing technique. The NR:EPDM ratio, the amounts of vulcanising agents and the oil content were varied in order to obtain the required values of physical properties. Visual observation of two of the above compounds and the resultant vulcanised sample indicated proper mixing of the two components in the blend. The physical properties of the 80/20 NR/EPDM blends; moduli, tensile strength, tear strength, hardness and compression set measured after ageing at 70°C for 22 hours were found to be in accordance with the required values (D G Edirisinghe, S Siriwardena, M K Mahanama and H N K K Chandralal).

NR/polychloroprene rubber (CR) blends

Since CR is an expensive synthetic rubber, trials were carried out to determine whether part of the CR in the compound developed for Salwathura Engineering could be replaced with NR. 30/70, 40/60 and 50/50 NR/CR blend compounds were prepared and the physical properties of the blend compounds together with those of the CR and NR compounds are given in Tables 2 and 3 (D G Edirisinghe, D N Wickramarachchi and S S Chandana - University of Peradeniya).

Table 2. Tensile properties of CR, NR and NR/CR blend compounds

	100% Mod. (MPa)	300% Mod. (MPa)	500% Mod. (MPa)	Tensile strength (MPa)	Elongation at break (%)
CR	2.5	7.3	13.6	18.7	554
30/70 NR/CR	2.1	7.4	18.4	20.7	538
40/60 NR/CR	1.7	6.4	14.7	17.2	560
50/50 NR/CR	1.3	4.5	11.4	19.6	645
NR	1.0	4.5	18.2	20.4	521

Table 3. Other physical properties of CR, NR and NR/CR blend compounds

	Specific gravity	Hardness (Shore A)	Tear strength (kN/m)	Compression set % at 70°C
CR	1.34	65	54.7	36.6
30/70 NR/CR	1.25	68	75.8	31.5
40/60 NR/CR	1.22	67	72.9	32.7
50/50 NR/CR	1.18	57	71.9	34.1
NR	1.04	45	41.9	11.4

Results indicate that there isn't a great change in physical properties when 30-40% of CR is replaced with NR. In fact, it is interesting to note that the tear strength of the blends show a positive synergism.

Evaluation of the effectiveness of blowing agents on properties of micro-cellular shoe soles

Effectiveness of two blowing agents on properties such as hardness, shrinkage and volume expansion of micro-cellular shoe soles was evaluated on a request made by Bata Shoe Company (Pvt.) Ltd. It was found that one of the blowing agents is effective in giving the desired properties of the micro-cellular shoe soles manufactured by the company (M M Jayasuriya and D N Wickramarachchi).

Development of a rubber compound for rice-huller rollers

A rubber compound for rice-huller rollers was prepared out of polychloroprene rubber (CR). The vulcanised rubber components were produced using the hydraulic press on a request made by the inventor of the newly designed rice-huller roller machine. The components were handed over to him in order to carry out trials and if successful, to introduce the machine to the paddy farmers. Work was initiated to develop the rice-huller roller compound out of a blend of NR and CR (D G Edirisinghe, S Siriwardena, M K Mahanama, A I Siriwardena and P L Perera).

Development of a rubber compound for dock fenders

Trials were carried out to develop a rubber compound suitable to produce dock fenders, on a request made by Piliyandala Rubber Products (Pvt.) Ltd. The dock fenders were required by the Ports Authority of Sri Lanka. The physical properties of the developed rubber compound were in accordance with the required values. The formulation was handed over to the above mentioned rubber products manufacturing company (D G Edirisinghe, A I Siriwardena, H N K K Chandralal and P L Perera).

Development of tyre tread compounds

A request was made by Lanka Tyre Retreaders (Pvt.) Ltd. to develop a tyre tread compound out of a blend of NR and reclaim rubber, with excellent abrasion resistance for the pre-cured retreading (cold) process.

Few NR/reclaim rubber blend compounds were prepared by varying the level of compounding ingredients and the technique of mixing. It was possible to bring down the abrasion volume loss of the tread compounds by about 100 mm³. The technology was transferred to the company. Furthermore, the company requested to develop a tread formulation out of a blend of NR and reclaim rubber to improve the abrasion resistance of the treads produced according to the hot process (D G Edirisinghe, M K Mahanama, P C Wettasinghe and A I Siriwardena)

Moulded sheets out of PE/buffing dust/cotton fibre composites

Blending PE, buffing dust and cotton fibre was carried out in the Brabender PL 2000 Plasti-corder on a request made by Encore Technologies (Pvt.) Ltd. The quality of the moulded sheets prepared using the above mixture was found to be excellent (S Siriwardena, D G Edirisinghe, M K Mahanama and A I Siriwardena).

Development of an adhesive for surgical bandages/plasters

Tas Medical Suppliers & Co. (Pvt.) Ltd. made a request to develop a non-toxic adhesive in the form of a paste for surgical bandages/plasters. A dry rubber compound with the required tackiness was developed out of crepe rubber without incorporation of any toxic ingredients. Conversion of the dry rubber compound into the paste form is in progress (D G Edirisinghe, S Siriwardena and D N Wickramarachchi).

Interpenetrating Polymer Networks (IPNs)

Writing up of the PhD thesis on the above project was continued throughout the year. Preparation of epoxidized natural rubber (ENR) and FTIR analysis of the same were carried out as further extensions of the project (M M Jayasuriya and D J Hourston).

Industrial extension

The following services were provided by the department during the year.

Service	Number of industries/institutions
Rubber compound testing	10
Rubber product testing	03
Testing of sole crepe	05
Testing of compounded/ pre-vulcanized latex	02
Preparation of rubber compounds	01
Preparation of compounded latex/pre-vulcanized latex	04
Ball-milling of rubber chemicals	01
Testing of miscellaneous items	02

In addition to the services rendered to the above mentioned industries, about twenty five entrepreneurs were provided with advice and assistance on setting up NR latex based cottage industries.

POLYMER CHEMISTRY

Nilmini Liyanage

SUMMARY

A patent was obtained for the manufacture of porous polymer profile by extrusion – sintering process Project, which was carried out by the Polymer chemistry department in collaboration with DSI Rubber Company is a major successful project executed by the department. This project work and field trials was continued during the year. Another project, which was also done in collaboration with TRI, is to produce waterproofing compound was also successful. In addition, various projects have been commenced already at the department and they are:

1. Development of an adhesive system for rubber to textile without adding resorcinol formaldehyde or vinyl pyridine was successful.
2. Positex/Bitumen mixture for waterproofing applications
3. Latex/ Carbon black masterbatches
4. Industrial waste organic matter based planting material for Horticulture and Agricultural industries
5. Waste Tyre Disposal Project

DETAILED REVIEW

Staff

Ms Champa Wellappilli, Assistant Rubber Chemist continued her postgraduate studies at University of Cardiff, from 28th April 2002, Ms Nilmini Liyanage, Assistant Rubber Chemist was on maternity leave from 27th August up to 30th December 2003.

Messers H N K K Chandralal, S S Warnapura, S L G Rangith. R Wijesundara, Ananda Samarakoon, Mrs Chitra Kuruppu and Mrs Indra Denawaka, Experimental Officers and Mrs Renuka Wijeratne, Clerk/typist, were on duty throughout the year.

Research students

The following students were trained in the department.

Miss G Ganeshan	- BSc engineering student
Ms Savida	- BSc engineering student
Mr Mahinda Tillekeratne	- MSc student
Mr Sarath Kumara	- MSc student
Mr P T Ithrees	- MSc student

Sixteen Polymer Technology MSc students of the year 2003 batch from Sri Jayawardenapura University followed their practical work from 18th July to 22nd August in the Department.

LABORATORY INVESTIGATIONS

NR protein allergy

Project on latex protein allergy supported by the NSF grant No RG/99/c/07 was continued. Gloves were prepared by applying ways and means, to reduce extractable proteins such as using Poly Vinyl Alcohol, ss-25 bleaching agent and fume silica *etc.* For each glove prepared as above, different leaching procedures were applied such as hot water leaching, NaCl leaching and teepol leaching followed by chlorination. Extractable protein levels of each set were measured and compared using the BCA enhanced protocol method.

Writing up of the MPhil thesis on the above is being continued up to end of the year (L M K Tillekeratne, W M G Seneviratne, Champa Wellappilli, S L G Ranjith, Kumudini Chadrasekera and Laleen Karunanayake – University of Sri Jayawardenapura).

Permeable hose for drip irrigation

By this process, porous tubes and mouldings can be produced from particulate matter with or without binder. It was able to produce a permeable hose by extrusion of mixture of Polyethylene powder and buffing dust. Pore size and water emitting rate could be adjusted by varying the ratio of buffing dust and polyethylene powder. Samples of the above were sent to Dartonfield estate, University of Peradeniya and Tea Research Institute for the evaluation of performance against the original product imported from Germany. According to the trials carried out at Dartonfield, it was found that the water-emitting rate of the tubes developed was comparable with the original product. Now they have requested a large batch for a nursery trial (Nilmini Liyanage, H N K K Chandralal and Ananda Samarakoon).

Rubber based adhesives

Development of an adhesive system for rubber to textile without adding resorcinol formaldehyde or vinyl pyridine was successful. A large batch was submitted to a factory in the free trade zone for a trial. Another project was started to investigate the possibilities of achieving equal bonding properties of Neoprene based adhesives available in the market, by blending different ratios of Methyl Methacrylate Grafted rubber and neoprene rubber. Peel strength of the above was checked for rubber to rubber and wood to wood bonding against commercially available neoprene based adhesives (Nilmini Liyanage and Chitra Kuruppu).

Positex/bitumen mixture for waterproofing applications

Project was continued in collaboration with TRI to produce waterproofing compound to apply on pruned tea bushes. Positex and cationically stabilized bitumen mixed in different ratios were subjected to storage life determination. Storage life of the mixture was improved for more than three months by incorporating several chemicals there. Group of scientists from the TRI visited to see the performance of the project. As the final product was meeting their requirements, a large batch will be sent to the TRI in due course for field trials (Nilmini Liyanage and Chitra Kuruppu).

Latex/carbon black masterbatches

Project was continued in collaboration with the University of Colombo to produce Natural Rubber Latex masterbatches using a novel-dispersing agent. In this project, skim serum was modified with papain and used as a surfactant in the preparation of the carbon black dispersion. It was concluded that retention of the black in the dry compound using the above surfactant is 97% and other physical parameters such as volatile matter and Mooney viscosity were in acceptable levels. Homogeneity of the dry compound was observed using scanning electron microscope. Research paper based on this was present at the SLAAS sessions this year

Aim of this project is to study the compounding properties of mill mixed rubber compounds and novel dispersing agent incorporated rubber compounds (Nilmini Liyanage, H N K K Chandralal, S S Warnapura, Indra Denaweeka and Dammika Dissanayake – University of Colombo).

Industrial waste organic matter based planting material for horticulture and agricultural industries

This project was continued with the collaboration of TRI. Previous work was completed using coir pith and sugar cane baggas at laboratory scale trials. TRI requested to produce larger size samples for field trials with a combination of coir pith, sugar cane baggas and tea waste. The objective was to find out optimum nutrient combination for tea seedlings. Further, a mould was designed and developed to produce large pellets following the instructions given by RRI officers (Nilmini Liyanage, H N K K Chandralal, Ananda Samarakoon and Keerthi Mohotti – TRI).

Waste tyre disposal project

The objective of this project is to explore the possibilities of the use of waste tyres to prevent sea erosion. Preparation of tyre tracks to be placed in seashore is in progress at the police mess Wellawatta. Mr H N K K Chandralal was appointed as the Officer in charge of the waste tyre disposal project.

Rubberized coir covered pellets as slow release fertilizer

A research was initiated to find out a method of binding the fertilizer into natural rubber thus forming a covering of rubber encapsulated fertilizer. A large number of fertilizer pellets were prepared and applied in the rubber nurseries at Dartonfield. Work is underway to assess the performance of the product (Nilmini Liyanage, H N K K Chandralal and Saman Darmakeerthi).

Patents

A patent was obtained for the manufacture of porous polymer profile by extrusion – sintering process (H N K K Chandralal, A H L R Nilmini, W M G Seneviratne and S M A Samarakoon).

Industrial extension

Company/Institution	Service
DSI	Product development
EDNA	Product development
Hanwella rubber	Rubber chemical analysis
Pro Flora	Magic coin development
CIC	Resin analysis
Water Board	Elastomer Analysis
SINWA	Chemical analysis

RAW RUBBER AND CHEMICAL ANALYSIS

L M K Tillekeratne and H S Weeraman

SUMMARY

The following activities were performed during the year:

- a) Testing, grading and issuing shipping certificates for all TSR produced in the country
- b) Testing and issuing quality certificates for different grades of raw rubber produced in the country for local industries and for shippers
- c) Testing and issuing quality certificates for latex
- d) Analysis of chemicals and water used in the rubber processing and rubber products manufacturing industry for purity
- e) Analysis of skim adulteration in raw rubber
- f) Recommendation of chemicals for the industry and analysing them for purity
- g) Testing of finished products such as
 1. Rubber gloves for sodium pentachlorophenate content
 2. Rubber content in vulcanized products
 3. Contaminations of metal ions in dipped products
- h) The following research project was in progress
Quality assessment of latex by monitoring the Volatile Fatty Acid (VFA) and Mechanical Stability Time (MST) parameters.

DETAILED REVIEW

Staff

The Director Dr L M K Tillekeratne over looked department activities through out the year. Experimental Officer, Ms H S Weeraman was in Charge of overall activities of the department.

Experimental Officers, Ms H S Weeraman, H V K Gamage, C Lokuge and Messrs L P Vitharana, Ms M Wijesekera, Messrs B Gunasiri, N Karunatilaka and W Vithanage, Development and Research Assistant Mrs P Perera and Clerk/Typist Mrs I Wijesinghe were on duty through out the year.

Instrument Technician, Mr L G P Lelwela, was on duty through out the year.

Research students

- Mr P Idriss, MSc student from the University of Sri Jayawardenapura, completed the laboratory analysis on the project “Use of rice bran oil as a stabilizer and preservative” for his MSc degree.
- K M D Silva from the University of Moratuwa completed the Laboratory analysis on the project “Quality improvement of centrifuged latex by addition of soap”.
- A student from the University of Jayawardenapura commenced the preliminary work on the project on variability of Mg content and Po_4^{---} content of field latex and the work has been done at Lalan Rubber Pvt. Ltd. who, provided funds from the project.

Training programme

Training programmes were carried out by the following officers/students in the field of latex testing and dry rubber testing.

A group of NDT students	-	University of Moratuwa
K A Sanjeewa Priyanka	-	Ceylon Rubber Industries, Arukwatta
R M Bandara	-	University of Colombo
D D P Perera	-	University of Jayawardenapura
A C A B Liyanage	-	Miyanadeniya, KU/Peradeniya
Husshani	-	Hanwella Rubber Mills (Pvt) Ltd
Geetha Nimali	-	Hanwella Rubber Mills (Pvt) Ltd
M D Y Milani	-	University of Colombo
S S Chandana	-	University of Peradeniya
J M C N Jayathilaka	-	University of Peradeniya
P Teranjan Kilhsin	-	Busan Dipping Ko Lanka
N Samanthika	-	Busan Dipping Ko Lanka
P Jayalatha	-	Busan Dipping Ko Lanka
Kelum Lasantha	-	Ansell Lanka (Pvt) Ltd

Visits

The confirmation of registration as a TSR producer was given to Le Ferne Laboratories, Getahetta, after the inspection visit made on 3rd September 2003 by H S Weeraman and H V K Gamage.

D G Edirisinghe, M K Mahanama, P L Perera and S Weeraman made an advisory visit to Ceylon Rubber Industries, Arukwatta.

Interlaboratory cross check 2003

Scheduled programme of annual cross check among the latex testing laboratories was not performed due to lack of funds.

LABORATORY INVESTIGATIONS

Production control by ash content in gloves

A number of samples were tested for ash content in order to stream line the production control system at Lalan Rubbers (Pvt.) Ltd.

Repositioning of crepe rubber

Nearly 700 samples were tested for all the TSR test parameters from each estate as a preliminary step to infer the statistical variability of each factory in order to maintain the quality of crepe rubber under the repositioning of crepe rubber programme initiated by rubber cluster. Out of all the parameters tested, a significant variation was shown by three parameters namely Dirt, PRI and VM. So more attention was paid to reduce the variability between the results of each parameters in these factories by organizing awareness workshops to educate the Managers and Field Officers (L M K Tillekeratne, G Seneviratne, S Weeraman, L Wanigatunga, V Gamage, C Lokuge, L P Vitharana, M Wijesekara, N Karunatilaka and W D Wimaladasa).

Calibration of latex tanks

Calibration of latex tanks were carried out at Glenross, Horana on a request made by the company in order to upgrade the quality of the latex produced by them (G Seneviratne, L P Vitharana and N Karunatilaka).

Evaluation of latex properties

Several latex samples were tested in order to evaluate the batch to batch variation of the properties of balloon compounds. Assistance and training were given to Ceylon Rubber Industries for setting up of a small scale laboratory at Arukkwatta (D Edirisinghe and M Mahanama).

Quality assessment of latex by monitoring the volatile fatty acid (VFA) and mechanical stability time (MST) parameters

Literature has been collected and locations were identified for the field experiments to be conducted. Preliminary investigations were performed in order to study the steps for which much attention has to be paid for quality assurance of latex (G Seneviratne, M Jayasuriya, L Wanigatunga, V Gamage, C Lokuge, P Perera, L P Vitharana and M Wijesekara).

Analytical services

Samples tested from each TSR factory during the year were as follows:

TSR factory	No of samples
Le-Ferne Block Rubber Factory, Getahetta	210
Sandhagiri Rubber Mills, Dompe	309
Total	519

Miscellaneous samples tested during the year are given below:

Raw rubber samples	1720
Latex samples	298
Chemical samples	71
Bleaching agent	131
Glove samples	156
Water samples	05
Total	2381

RAW RUBBER PROCESS DEVELOPMENT AND CHEMICAL ENGINEERING

S Siriwardena

SUMMARY

The Department provided advices and technical know how to the raw rubber processing factories in the country to improve the quality of raw rubber, quality consistency and to control the environmental pollution caused by the rubber effluent discharged by them. Eleven raw rubber factories were visited during the year in connection with quality concerns while Twenty five rubber factories and other industries were visited during the same period to provide solutions to the waste water disposal problems. Another major service provided by the department during the quarter was analysis of raw water or effluent water for quality as exemplified by the high number of such samples exceeding 100.

An investigation was carried out at the Ceyesta rubberized coir mattress-manufacturing factory to examine the cause for their quality problems. Recommendations were given and necessary training was also provided to their staff on the request made by the company. Interruption of supply of quality centrifuged latex, heavy energy losses and poor house keeping practices were identified as the main causes for the quality problems. Excessive labour has caused the high production cost.

A project funded by National Science Foundation and Energy conservation fund on Generation of bio - gas from skim rubber effluent was completed in this year. Some factors, which affect the efficiency of generation of biogas from the effluent water, were identified. The study carried out on the effect of metal ions on crepe rubber disclosed that there is no adverse effect on colour of the crepe even when the processing water contain up to 25 $\mu\text{g/g}$ of Mn^{2+} ions.

A project was conducted with the assistance of Research and Development centre of the Road Development Authority who provided testing facilities on the modification of bitumen with ground rubber from old Tyres (GRT).

DETAILED REVIEW

Staff

Deputy Director Research (Technology) continued to overlook the departmental activities throughout the year, before going on leave in the last quarter.

Dr Susantha Siriwardena, Rubber Chemist resumed duties on the 17th March after completing the PhD at the University of Science in Penang, Malaysia.

Mr Upul Ratnayake left for UK on 14th February to pursue postgraduate studies at the University of Loughborough.

Mr P H Sarath Kumara completed MSc in Polymer Science and Technology at the University of Sri Jayewardenepura.

Mr P P Jayasinghe, Development Officer was on duty throughout the year.

Messrs C D Senanayake and T A S Siriwardene, Mrs Shirani and Mrs Chandrika Nalini, Experimental Officers, Mr A K D Warnajith Prasad and Mrs V C Rohanadeepa, Technical Officers, Mrs L Ruckmanie, Store Keeper and Mrs Anusha Paranavithane, Typist/Clerk, were on duty throughout the year.

Industrial training students

- Miss G G Gayathri, BSc Chemical Engineering student from University of Peradeniya was trained from 03rd of February to 09th May
- Mr Sasanka Bandara, BSc Chemistry special student from Colombo University was trained from 16-27 June, 2003.
- Miss W M R C A Wijekoon, BSc Chemical Engineering student from University of Peradeniya was trained from 17th February to 09th May.
- Mr S P R Kanakarathne BSc Chemical Engineering student from University of Peradeniya was trained from 29th September to 19th December
- Miss S H U I de Silva BSc student from University of Colombo started her training on 22nd December and is being continued.

Seminars/Lectures/Workshops

Officer	Subject	Organisation
Dr W M G Seneviratne	Strain induced crystallization of NR.	University of Kyoto, Japan.
	Workshop on crepe rubber replanting programme organized by rubber cluster at the Hilton Hotel	Mr.Kip Tobon-USAID consultant.
	Two Director's meetings	NASTEC
	Two board Meetings and two Marketing committee meetings	Ceyesta.
	Three Management committee meetings and two educational sub committee meetings	Plastic Rubber Institute
	Served as a Technical Assessor for ISO 17025 quality systems for the chemical laboratory	Industrial Technology Institute.

Officer	Subject	Organisation
Mr P H Sarath Kumara	Held a demonstration for rubber farmers on the manufacture of good quality sheet rubber at Welihelatenne, Yatiyantota at a workshop	Advisory Services Department, RRI
Mr T A S Siriwardena	Held a demonstration for rubber extension officers on the grading of sheet rubber at Welihelatenne, Yatiyantota at a workshop	Advisory Services Department, RRI
Mr A K D Warnajith Prasad	Two demonstrations for rubber farmers on the manufacture of good quality sheet rubber at Ratnapura and Handapangoda in two separate workshops	Advisory Services Department, RRI

Advisory visits

The following estates and rubber factories were visited during the year in connection with factory development and quality improvement of raw rubber.

Vogan Rubber Factory	- latex shortage
Delkeith Rubber Factory, Badureliya	- discoloration of crepe rubber
Cetra Factory Horana	- advice on the production procedures
Arapolakande Estate	- defects in drying tower
Panawatte Estate	- discolouration of crepe rubber
Kiriporuwa Estate	- discolouration of crepe rubber
Razeena Estate, Akuressa	- advice on RSS Manufacture
Ellakande Estate	- manufacture of Lankaprene
Sunnycroft	- manufacture of Lankaprene
Atale Estate	- manufacture of Lankaprene
Delkeith Estate	- discolouration of crepe rubber

The following rubber factories and other industries were visited during the year to look into wastewater disposal problems and to gather information to propose suitable treatment methods and also for necessary advices to improve the efficiency of the existing treatment plants.

1. Lalan Rubbers, Warakapola
2. Dipped Products Ltd., Brahakmanagama, Kottawa
3. Kelaniya Service Station, Kelaniya
4. SRMEC Factory, Mawenella
5. Sunnycroft Estste, Waharaka
6. Vincit Estste, Waharaka
7. Elston Estste, Puwakpitiya
8. Siriniwasa Estste, Waga

9. Halpe Estste, Waga
10. Devalekanda Estste, Dehiowita
11. Talduwa Estste, Awissawella
12. Venigross Ltd, Weliweriya
13. Mackwoods Ltd, Ekala, Ja Ela
14. Panawatte Estate, Yatiyantota
15. Kiriporuwa Estate, Dehiowita
16. Ukwelkande Estate, Govinna
17. Ruwanwella Estate, Ruwanwella
18. Galatura Estate, Galatura
19. Paiyagala Estate, Dodangoda
20. Padukka Estate, Padukka
21. Udapola Estate, Polgahawela

Ceyesta rubberised coir mattress manufacturing factory

A detailed investigation was carried out at the factory covering areas from reception of raw materials to the packing of the products. It was found that the productivity of the factory is unsatisfactory due to excess labour, interruption of supply of quality centrifuged latex, heavy energy losses and poor house keeping practices. An interim report was submitted to the director board with a suggestion to recruit a competent person to look after the technical matters and management in order to rectify the above drawbacks and to improve the efficiency. A proper recording system was suggested to operate in line with ISO 9002 Quality Management System to have a better control of production (Susantha Siriwardena and Warnajth Prasad).

ISO 9000 Quality Assurance System

An internal Quality audit was conducted at the Dartonfield rubber factory. A management review committee (MRC) meeting was held at Board office at Ratmalana premises.

Deputy Director Research (Technology) along with Messrs P H Sarath Kumara and A K D Warnajith Prasad participated as invitees at the ceremony held at Busan Dipping Ko-Lanka Ltd. on the occasion of awarding the certificate of ISO 9002:1994 to them by the Sri Lanka Standards Institution.

Sample testing

Hundred and seventeen waste water samples, thirty six processing water samples and two miscellaneous samples were tested, from which seventy six certificates were issued to the clients on their request.

LABORATORY AND FIELD INVESTIGATIONS

Generation of bio - gas from skim rubber

Development of an efficient and cost effective treatment system for skim effluent and generation of bio - gas as a energy source project, jointly funded by National Science Foundation and Energy conservation fund was completed and the final report on the same was submitted.

As far as the treatment is concerned, following conclusions and recommendations could be made from the analysis of results of the study.

- Skim serum contains very high organic loads as well as higher percentage of sulphates when compared with effluents from crepe rubber processing. Therefore, microbiological treatment process employed to treat crepe rubber effluents should be altered for effluents generating from skim rubber processing.
- Optimum flow rate of the sulfate rich skim serum into the anaerobic digester should be adjusted to have 5 days retention in the digester compared to 3 days retention of crepe rubber effluents.
- COD removal efficiency is comparatively low at lower pH values. This was quite apparent with skim rubber effluents where serum has higher content of SO_4^{2-} .
- Highest removal efficiency of sulphate rich effluent was obtained at a loading rate of 4 kg COD/m³/reactor volume/day whereas it could be obtained for sulphate less effluent at a loading rate of 6 kg/m³/reactor volume/day.
- Low sulphate skim effluent could be treated more effectively using high rate anaerobic digester.
- Gas generation increased with COD loading rate of the anaerobic digester.
- Sulphate less skim serum produce higher amount of gas volume when compared with sulphate rich skim serum.

Analysis of bio gas generated by the anaerobic treatment could not be carried out due to the non availability of facilities for Gas-chromatographic analysis at the RRISL. Even though, GC Analysers were available at some Institutions and universities bio gas analysis could not be performed due to the non availability of standard gases and appropriate columns. The only place at which limited facilities were available for this purpose was the Ceylon Petroleum Corporation where only methane could be analysed.

Study of the effect of metal ions on crepe rubber

The project was continued this year too.

Studies showed that Fe^{2+} incorporated into latex with dilution water is converted to Fe^{3+} in crepe rubber manufactured.

Results of the analysis of fractionated bleached (FB) crepe and fractionated unbleached (FUB) crepe prepared incorporating Mn^{2+} with dilution water showed that the colour, the Plasticity Retention Index (PRI) and the Mooney viscosity were not affected when processing water contained up to 25 $\mu g/g$ of Mn^{2+} in processing water.

Similar studies of the effect of Cu^{2+} on the properties of crepe rubber will be investigated (P H Sarath Kumara, T A Sarath Siriwardena, A K D Warnajith Prasad and C Rohandeepra).

Modification of bitumen with ground rubber from old tyres (GRT)

The committee appointed by the ministry of Science and Technology to look into the problem of waste tyre disposal has identified the modification of bitumen with GRT for rubberisation of roads in Sri Lanka as one of the possible areas where discarded tyres could be made use of. A project was conducted with the assistance of Research and Development centre of the Road Development Authority who provided testing facilities. Several batches of samples were prepared incorporating ground rubber tyre (GRT) at different concentrations and varying the temperature and also the time of mixing. The samples were tested at RDA for penetration and ductility. Softening point was tested at RRI with an apparatus fabricated specially for this purpose.

Although the softening point and penetration were improved with the incorporation of GRT into bitumen, the ductility failed at all levels of incorporation of GRT. As the reason for this was thought to be due to the stress concentrations on GRT particles, the modified bitumen was filtered to remove undissolved/uninteracted GRT particles at a temperature of 140°C using a 60 mesh sieve taking into consideration that the particle size of GRT was more than 30 mesh size. The filtrate was again tested for softening point, penetration and ductility. Interestingly, there was no change in softening point compared with the control, but penetration and ductility of the asphalt deteriorated. Further trials will be carried out to improve the ductility of the modified asphalt (P H Sarath Kumara, H N K K Chandralal, W M G Seneviratne and A K D Waranajith Prasad).

Studies of migration of antidegradants through thick section rubber articles

Preliminary trials were conducted to ascertain the possibility of using FTIR techniques to quantitatively analyse the solvent extracts of the test specimens prepared. The project was initially hampered due to the breakdown of the FTIR spectrophotometer available at RRI. Samples were analysed using the newly installed FTIR spectrophotometer at the Chemistry Department of Sri Jayewardanapura University. The main constraint for the continuation of the project was lack of apparatus at the RRI laboratories.

A project proposal was forwarded to CARP for funding to acquire necessary equipment required to continue the project but not granted.

Plans are now underway to continue the project in collaboration with the Chemistry Department of Sri Jayewardenepura University using laboratory facilities at the university and employing a post graduate student (P H Sarath Kumara, D I R Denawaka and A K D Warnajith Prasad).

Latex quality standardization

A project was conducted to analyze the process variations and the quality of field latex on the final quality of centrifuged latex produced out of them. The objective of the project was to forward proposals to the industry to minimize the quality variations of centrifuged latex.

Ten centrifuged latex manufacturing companies were randomly selected for this study. Data collected from these companies with regard to the quality of field latex and for centrifuged latex were analyzed and their manufacturing procedures were studied using a check list which included factory details, steps in preservation of field latex, production procedure of centrifuged latex, procedure of chemical preparation and the amounts of chemicals used in each step. The analysis of data on quality parameters of field latex and centrifuged latex indicate that VFA is the most inconsistent quality parameter. It varies throughout the year from manufacturer to manufacturer and supplier to supplier. Other parameters are not highly variable. As far as the manufacturing procedure, the concentration and the method of preparation of chemical solutions and dispersions are concerned, all manufacturers follow the same procedures and methods. Nevertheless, the quality of the final product vary from one manufacturer to the other. The results also revealed that the main reason for the poor quality of concentrated latex is the poor preservation of field latex in the field. Other factors which affect the poor preservation of field latex were found to be the time between tapping and preservation, time of delivery of field latex, cleanliness of utensils and purity of water used for preparation of chemicals.

The following observations could be made, after analysing the data collected during the survey.

- a. Small holder field latex is inferior in quality to that of estate field latex.
- b. Most manufacturers of centrifuged latex (CL) do not pay attention to separate field latex which has a relatively higher VFA number for processing separately.
- c. Some Centrifuged latex manufacturers do not check the Mg^{2+} level in field latex before addition of DAHP, therefore correct amount of DAHP is not added which makes quality problems in product manufacturing.
- d. Mixing up of CL having high VFA with good quality CL with low VFA no is a common practice in the industry.
- e. During the periods when there is a short supply of field latex, the CL manufacturers tend to purchase latex from any source, irrespective of the quality.

RAW RUBBER PROCESS DEVELOPMENT

A report, was handed over to the ministry of science and technology, which included several proposals to improve the quality of centrifuged latex. Following steps were recommended for immediate implementation in order to solve problems in this industry.

- Conducting an awareness programme for the people who are involved in latex collection network and the production staff of the CL manufacturing industries
- Detailed study of the quality variation of field latex and CL under different conditions, to make appropriate recommendations.

(W M G Seneviratne and U M S Priyanka).

ADAPTIVE RESEARCH

S M M Iqbal

SUMMARY

Studies conducted on mature rubber-tea intercrops showed that the imposition of a root barrier between tea and rubber plants improved the productivity of tea when under low shade and evidence is presented that this improvement is based on an increase in efficiency of both radiation and water used by the intercropped tea. Another study in the rubber smallholder sector identified that three major factors influence the decision of farmers to intercrop rubber/tea, namely level and source of income and availability of suitable land. Feasibility of establishing rubber cultivation in the eastern province was also examined.

DETAILED REVIEW

Staff

Dr S M M Iqbal, Research Assistant in Agronomy returned to the institute on 08.08.2003 after completing the PhD study at Writtle College, University of Essex, UK. Dr S M M Iqbal was promoted to Senior Research Officer and designated as an Agronomist of this unit with effect from 27th October 2003. Mr K B A Karunasekara, Research Assistant was transferred to Genetics and Plant Breeding department with effect from 1st September 2003. Mr P P Jayasinghe, Mr A M A Perera, Mr R B Gunaratna and Mr W A D D S Wettasinghe Research Assistants and Mr E A T Senadeera, Experimental Officer were on duty throughout the year.

Seminars/Conferences/Meetings/Workshops attended

Officer	Subject	Organization
S M M Iqbal and A M A Perera	Press conference on rubber/tea intercropping	Media unit of Ministry of plantation industries
W A D D S Wettasinghe	Practical training programme on rubber plantation	School of Agriculture, Karapinche, Ratnapura
E A T Senadeera	Educational program on natural rubber industry for G C E (O/L) students	Civil Welfare Organization, Kegalle

Support services

Staff of adaptive research unit assisted in implementation of RRI recommendation pertaining to the agronomic activities at Dartonfield estate and Kuruwita sub-station RRISL (R B Gunaratne, A M A Perera and W A D D S Wettasinghe).

Advisory visits

Nine advisory visits were made during this year.

FIELD INVESTIGATIONS**Adaptive Research Programme*****Adoption level of RRI recommendations by the rubber smallholder sector***

Data analysis was in progress (S M M Iqbal, R B Gunaratne, W A D D S Wettasinghe, E A T Senadeera and A M A Perera).

Bee keeping in rubber smallholdings and plantations

After introducing the new colonies in smallholder sectors were unable to maintain their bee colonies due to the following reasons.

- Rain and drought conditions interrupted the feeding of the bees
- Difficulty to identify the wax moth infestation.

Colonies which were present in the estate sectors of Dartonfield and Sub-station Kuruwita were in progress. Arrangements were made to harvest the crop (W A D D S Wettasinghe and L M K Tillekeratne in collaboration with Training and Extension Division, Department of Agriculture, Peradeniya).

Expansion of rubber cultivation in the eastern province

The feasibility of establishing a project on rubber cultivation in the eastern province was examined by a multi-disciplinary research group comprising an ethnobotanist, an agronomist, a soil-scientist and a rubber clone specialist. Investigation on secondary data, interviews with key informants and farmers in the area, site visits and transect drives were used as the tools in this study.

Lands appeared to be not a limiting factor for the cultivation rubber in the area concerned and planting tree crops like rubber will uplift the livelihood of the poorest sector of the community. For the rubber cultivation in the Eastern province, the areas under the Intermediate zone initially targeted and the soils predominantly with Reddish

Brown Earth and Immature Brown Loams. Rubber cultivation started with six farmers as an adaptive research trial. Measures also taken to address the problems associated with dry spells and farmers' socio-economic needs were discussed (V H L Rodrigo, S M M Iqbal, R S Dharmakeerthi, K B A Karunasekera and A Nugawela).

Interplanting of rubber lands with tea

Productivity in rubber/tea systems (Kuruwita/TR 1)

A study was conducted at Kuruwita sub-station RRILSL with the objective of identifying the agro-physiological limitations to productivity in rubber-tea intercrops. The effect of intercrop spacing in combination with different levels of canopy shade was examined on intercrop yield and on a range of growth and physiological parameters. Analysis of the intercrop competition was achieved by inserting barriers between the crops to separate the root systems and effectively remove below-ground competition. It was established that while tea yields were reduced in intercrops compared to a sole tea crop, the overall productivity of the intercrop, measured as the land equivalent ratio (LER), was significantly improved. Little difference in yield was found in plots with relatively narrow (Rubber spacing 8ft × 27ft) or wide-spaced (Rubber spacing 8ft × 40ft) alleys (4 or 7 tea rows per alley) although crop growth rate (CGR) and light-dry matter conversion efficiency (ϵ) of tea were increased in the wider spaced plots. The imposition of a root barrier improved the productivity of tea when under low shade and evidence is presented that this improvement is based on an increase in efficiency of both radiations and water used by the intercropped tea. Root barriers had no effect on rubber yields. Chlorophyll *a* fluorescence measurements further showed that tea intercropped below a closed rubber canopy was protected from diurnal photoinhibition.

Another study was conducted with the objective of identifying the limiting factors that affect the agricultural decision-making process of rubber smallholders to intercrop rubber/tea in Sri Lanka. A rapid rural appraisal (RRA) was undertaken based on interviewing a sample of 90 smallholder farmers in the low country wet zone. Three major factors were identified that influence the decision of farmers to intercrop, namely level and source of income and availability of suitable land. A predictive model based on these factors developed through a correlation and logistic analysis. Detailed results were given in the PhD thesis of S M M Iqbal (2003) on "Factors limiting productivity and adoption of rubber-tea intercropping in the low country wet zone of Sri Lanka" (S M M Iqbal, A M A Perera and S Wettasinghe).

Productivity in rubber/tea systems (Agalawatta/TR 2)

The above experiment was in progress. Yields of rubber and tea were monitored by test tapping and test plucking respectively (S M M Iqbal and A M A Perera).

Productivity in rubber/tea system (Vogan estate/TR4)

Experimental details were given in the Annual Review 1998. Growth of the rubber plants was recorded. Test plucking was arranged to assess the treatments effect on tea yield (S M M Iqbal and R B Gunaratna).

Smallholder sector

Trials at Kegalle regions were continued. To minimize the excess shade of rubber canopy on tea, 25% of rubber foliage was reduced in these trials (S M M Iqbal and E A T Senadeera).

AGRICULTURAL ECONOMICS

J Edirisinghe

SUMMARY

A study on effect of climate change on rubber cultivation and seasonal behaviour of natural rubber prices of different markets in the world was carried out during the year. The Agricultural Economics unit was involved in the research on Interaction between Environment, Society and Technology (INTEREST) and Innovative Initiatives to address Poverty with the Biometry section and the Advisory Services Department of the Institute.

DETAILED REVIEW

Staff

Assistant Agricultural Economist, Mr A K B Naranpanawa was on study leave during the year continuing his postgraduate studies. Mr J C Edirisinghe, Assistant Agricultural Economist was on duty throughout the year and was reading for the Mphil degree in Agricultural Economics at the Postgraduate Institute of Agriculture (PGIA) at the University of Peradeniya, while on duty.

Services

Research support

Various cost - benefit analyses, sensitivity analyses were carried out on the request of other researchers.

Data base management

A data base on auction prices was continuously updated through the year.

Prices of Ribbed Smoked Sheets (RSS)

The prices of RSS continued to increase through out the year. Prices of all grades of RSS were above that of the previous year (2002). The prices showed an increasing trend through the year with minor oscillations owing to the seasonal nature of rubber production. The peak prices were observed in October -November period for all the grades and may be an indication that the rubber prices increasing further in 2004. However, the gap between the prices received in 2002 and 2003 showed a marginal decline towards the end of the year. This can be an indication of a slow down of the increase in prices. Therefore, though there will be an increase in prices in 2004, the indication is that it will not be as rapid as in 2003. Prices of all RSS grades increased by 48-50% from 2002 to 2003 (Fig. 1). The gap between RSS 1 and RSS 5 which was around Rs.9 at the start of the year declined to about Rs.7 at by December.

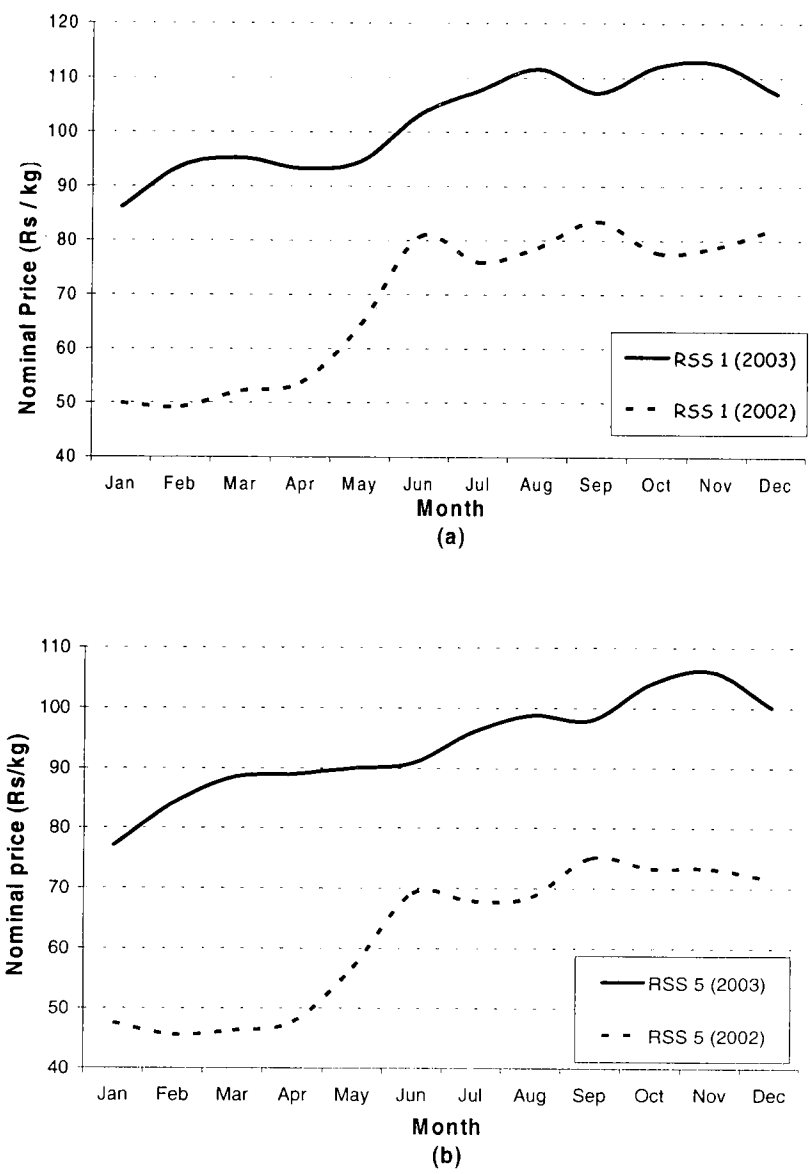


Fig. 1. Monthly averages of nominal RSS prices in year 2003 (a) RSS 1 (b) RSS 5

Prices of latex crepe

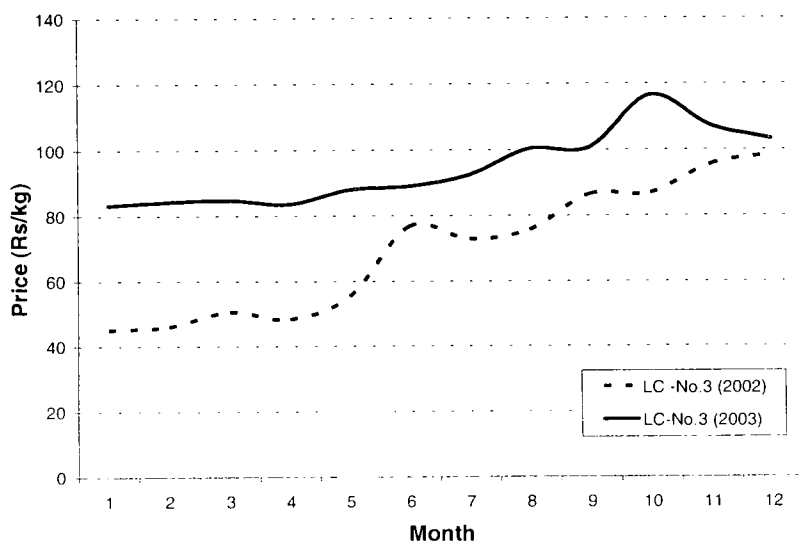
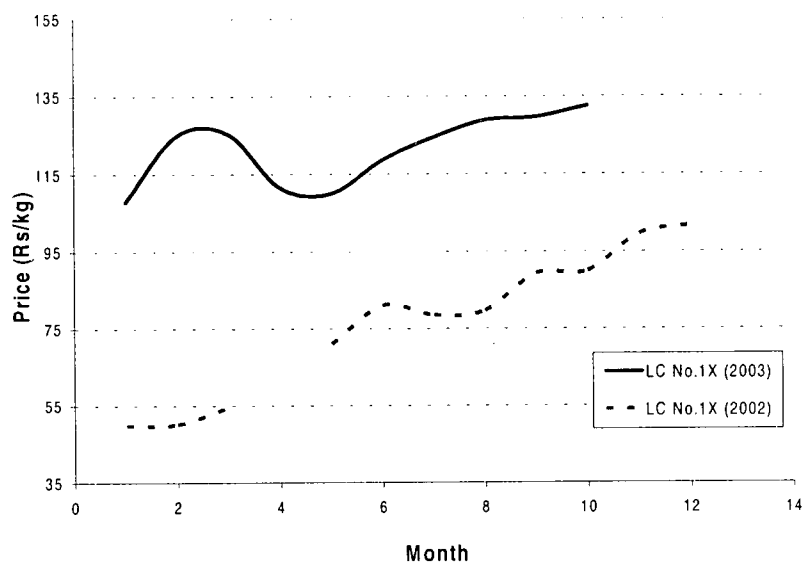


Fig. 2. Auction prices of Latex Crepe 1X and No.3 in the year 2002 and 2003

The LC prices behaved similar to that of the RSS prices during the year 2003. It is noteworthy that the prices in 2002 moved in a more brisk pace than that of 2002 (Fig. 2). Thus, if price trends within each year is compared, the increasing trend in 2002 is higher than 2003. This is shown by the reduced gap between prices of 2002 and 2003 towards the year-end. Thus, as in the case of RSS, the prices in 2004 will increase very marginally from that of 2003.

Quantities traded during 2003

The total quantities traded through the Colombo Auction are given in the Fig. 3. The majority traded through the auction was Latex Crepe (LC) grades. Though, production of RSS is high in the country, the amount traded through the auction seemed to be very low. It is about 8% of the total traded through the auction. However, the production of RSS in the country was 50,015 MT and total production of all crepe grades amounts to only 22,443 MT and TSR, latex and other grades accounted for 19,552 MT.

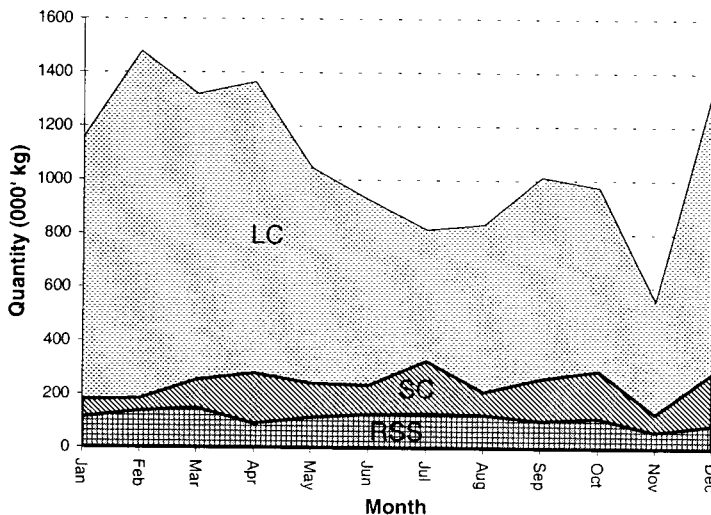


Fig. 3. Total quantities traded through Colombo auction in 2003

RESEARCH

Changing rates of interest, prices and cost to the climate with special reference to rubber cultivation

This study was funded by the Climate Change Enabling Activity (Phase II) project at the Ministry of Environment. The aim was to estimate the possible impacts

of interest rate and prices on the rotation length of rubber plantation and its impact on the environment.

Data on rubber yield were collected for the study from a questionnaire survey of 50 estates in the country. Data on CO₂ sequestration and valuation were obtained from secondary sources. The analytical methodology used in obtaining the optimum lifespan was through Faustmann formula, developed by Faustmann (1948).

The study reveals that the interest rate has a clear impact on rotation length. Higher the rate, lower is the rotation period. However, same cannot be concluded with the prices. Effect of prices is rather indeterminate and depends on the level of interest that prevails. The optimum lifespan at the current market interest rate *viz.*, 9.11% (Central Bank, 2002) was found to be 25 years (Fig. 4). This reduction of 5 years from the conventional uprooting costs Rs.609, 145.00 per hectare of land in terms of benefit foregone on carbon sequestration. At 10% interest, the increase in price by 25% would lead to a cost of Rs.410, 923 and a decline in price by 25% would lead to a cost of Rs.699, 977.00. Therefore, it was found that declining prices (at most interest rates) tend to extend the rotation length and the increases in prices tend to shorten the rotation length.

From this study, it has emerged that the monetary policies of the government (interest rate) have an indirect impact on management of renewable resources (rubber plantations). Hence, in drawing such policies these impacts also have to be taken in to consideration, especially, in the wake of global awareness on the effect of green house gases such as CO₂ and the mitigating policies like Kyoto Protocol that could favor developing countries like Sri Lanka. In addition it was also found that the private sector managing the rubber estates does not emphasize on the management of the full stand of trees (500 trees) until the time of uprooting. It was evident that the trees at harvesting almost halve what is originally planted. This not only reduces the yearly profits but also reduces CO₂ sequestration and affects the environment. In addition, it may hamper any hopes of deriving benefits out of Kyoto protocol or any future trading option that may develop due to the increasing concern over global warming resulting from emission of green house gasses.

In conducting the study it was clearly evident of the lack of quality data on carbon sequestration of rubber plants in the Sri Lankan situation. No major studies have gone into estimating carbon sequestration of rubber plantations for the full life span. Therefore, the study used the available data on estimating the carbon sequestration.

Table 1. Sensitivity analysis for changes in rate of interest and output price (LC No.3)

Nominal rate of interest (Real rate of interest)*	Price of LC No.3**	Rotation length of rubber stand (years)	Net benefit foregone on CO ₂ sequestration (Rs/ha)***
6% (Real rate = -2.3%)	25% increase	25	609,145
	10% increase	26	699,977
	Rs.110/kg	26	699,977
	10% reduction	27	688,100
	25% reduction	27	688,100
9.11% (Real rate = 0.81%)	25% increase	25	609,145
	10% increase	25	609,145
	Rs.110/kg	25	609,145
	10% reduction	25	609,145
	25% reduction	26	699,977
10% (Real rate = 1.7%)	25% increase	23	410,923
	10% increase	25	609,145
	Rs.110/kg	25	609,145
	10% reduction	25	609,145
	25% reduction	26	699,977
15% (Real rate = 6.7%)	25% increase	21	202,342
	10% increase	22	298,391
	Rs.110/kg	22	298,391
	10% reduction	23	410,923
	25% reduction	25	609,145
20% (Real rate = 11.7%)	25% increase	20	123,158
	10% increase	21	202,342
	Rs.110/kg	21	202,342
	10% reduction	21	202,342
	25% reduction	22	298,391
25% (Real rate = 16.7%)	25% increase	19	63,317
	10% increase	19	63,317
	Rs.110/kg	20	123,158
	10% reduction	20	123,158
	25% reduction	21	202,342

* The inflation rate was 8.3% (Central Bank, 2002)

** The average price of Latex Crepe No.3 in 2003 was used

*** Values are in present value at 10% interest rate

Carbon Cleaning cost of US\$ 100/ton of carbon was used

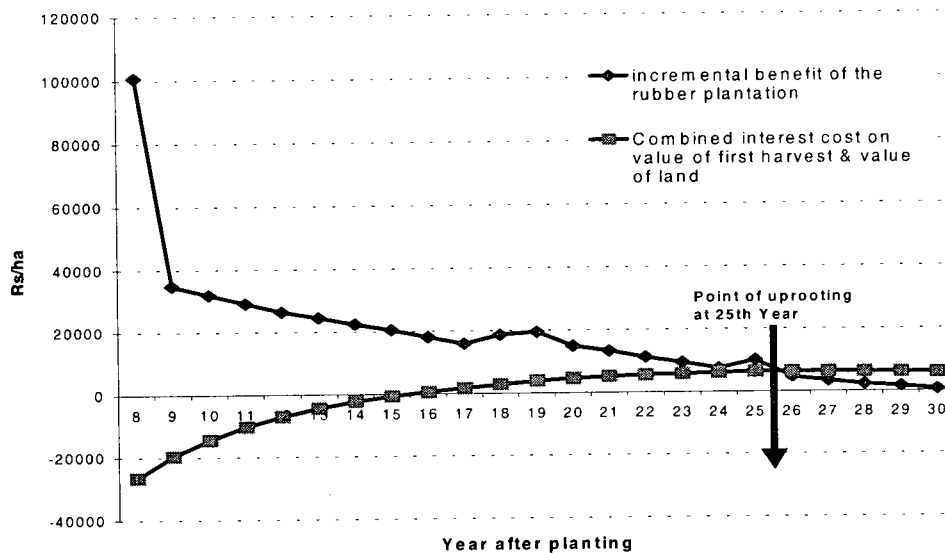


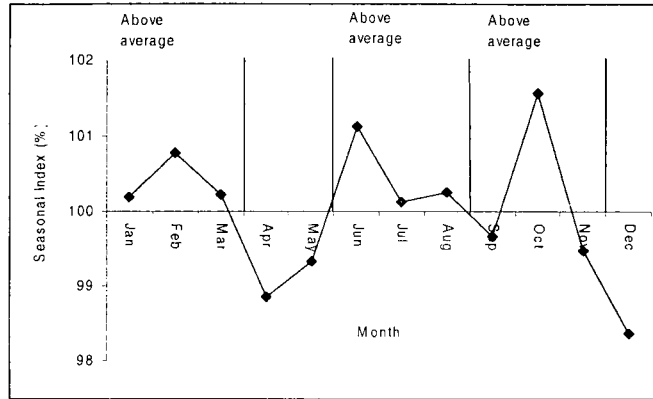
Fig. 4. Optimum time of uprooting when perpetual sequence of production periods is considered at current (2002) market (9.11% -Nominal) interest rate

The full report of the study was submitted to the Ministry of Environment (Jagath Edirisinghe, Shyama Ratnasiri - Wayamba Campus and A M T P Athauda - Wayamba Campus).

Seasonal behavior of natural rubber prices in different markets in the world

Prices play a key role in the profitability of an enterprise. This study attempted to investigate the seasonality in prices of rubber in different markets in the world. The market prices of New York, London, Singapore, Kuala Lumpur and Sri Lanka (Colombo) were studied (Fig. 5 & 6). The seasonal indices were calculated using the decomposition technique in time series analysis and data from 1980 to 2002 were used. Study of the seasonal indices reveals that there are considerable differences in seasonality of prices in different markets. The markets in the major consuming areas selected (New York and London) had differences in peaks and troughs achieved in a typical year. While Kuala Lumpur and Singapore prices are above average in the first half of the year, the Colombo price was above average in the middle and latter part of the year. The in-depth analysis of Colombo market shows that crepe grades of rubber have higher variability than the Ribbed Smoked Sheets (RSS). It was concluded that the timing of supply (storage) and use of technologies (rain guards) to curtail interference by rain is prudent, as it will increase yearly profits.

a)



b)

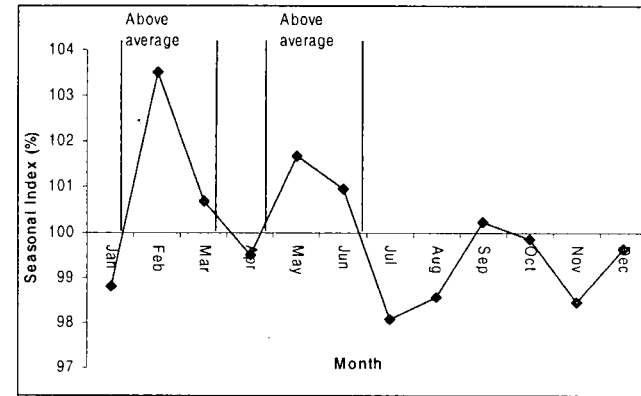
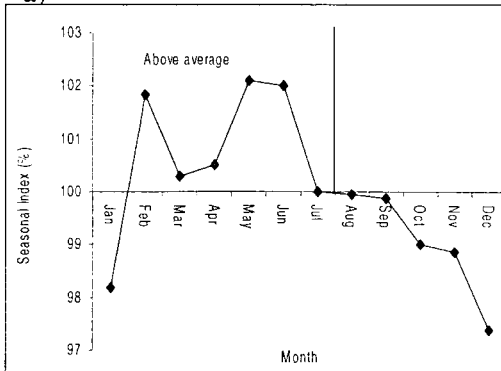
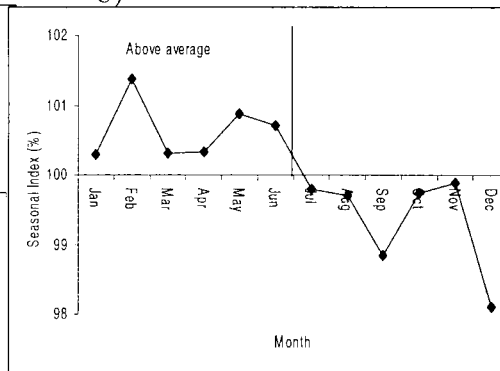


Fig. 5. Seasonal indices of prices of RSS1 in (a) New York & (b) London Markets

a)



b)



c)

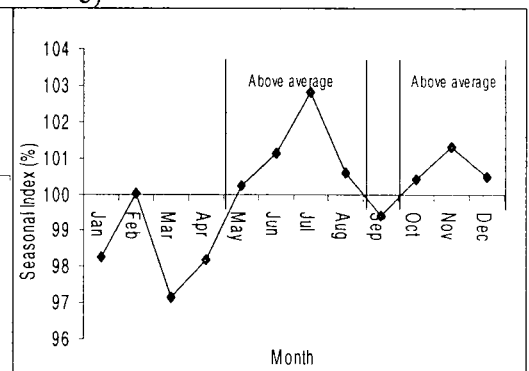


Fig. 6. Seasonal indices of prices of RSS1 in (a) Singapore (b) Kuala-Lumpur and (c) Colombo Markets

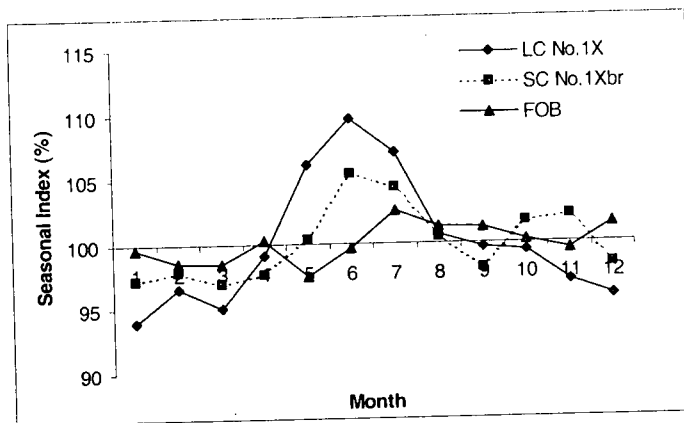


Fig. 7. Seasonal indices for Average FOB, Latex Crepe 1X and Scrap Crepe 1Xbr in the Colombo market (Jagath Edirisinghe and Keminda Herath)

Interaction between Environment, Society and Technology (INTEREST)

Agricultural Economics Unit was involved in the above project undertaken by the Biometry section of the institute. The full details can be found under review of the Biometry section (Wasana Wijesuriya, Anura Dissanayake, Mahinda Wijeratne - University of Ruhuna, Keminda Herath, Jagath Edirisinghe and Vidura Abeywardana).

Strategies for enhancing the productivity in smallholder units of non-traditional rubber growing areas in Sri Lanka

Agricultural Economics Unit was involved in the above project undertaken by the Advisory Services Department and the Biometry section of the institute. The full details of the study can be found under the review of the Advisory Services Department (Wasana Wijesuriya, Anura Dissanayake, Keminda Herath, Jagath Edirisinghe and Vidura Abeywardana).

BIOMETRY

Wasana Wijesuriya

SUMMARY

The services rendered to other Research Departments by the Biometry section involved providing necessary research support to the other Research Departments in various aspects; viz. experimental design, analysis and interpretation of results. Database and the meteorological station at Dartonfield were maintained satisfactorily. The personnel and project summary databases of the RRI scientists were updated.

Studies focusing on assessing the vulnerability of the rubber sector to climate change, developing appropriate statistical techniques for interpretation of data generated from surveys and participatory studies, designing frameworks and analysis to assess the sustainability of the smallholder sector and poverty related issues in the non-traditional rubber growing areas were among the main research concerns of the Biometry section.

DETAILED REVIEW

Staff

Ms Wasana Wijesuriya (Biometrician), Mr Keminda Herath (Assistant Biometrician), Ms Chintha Munasinghe (Experimental Officer) and Mr Vidura Abeywardene (Technical Officer) were on duty throughout the year.

Research students

- Mr. Nalin Sovis from the Faculty of Agriculture, University of Ruhuna submitted a report on "Use of appropriate statistical methods to analyze data generated from participatory rural appraisals." for the partial fulfillment of the BSc degree in Agriculture under the supervision of the Biometrician.

Seminars/Conferences/Meetings/Workshops attended

Officer	Activity	Organization
Ms Wasana Wijesuriya	Training on Mathematical programming under the Presidential Scholarship Programme	Rothamsted Research, UK
Ms Wasana Wijesuriya	Technical advisory committee of the Centre for Climate Change Studies (CCCS)	Department of Meteorology
Ms Wasana Wijesuriya	Second year review meeting of the INTEREST	The Energy and Resources Institute, Goa, India

Officer	Activity	Organization
Ms Wasana Wijesuriya	Scientific committee meeting	Rubber Research Institute
Mr H M L K Herath	Presented a proposal selected for funding under the junior research programme on climate change titled "impact of climate change on yield of rubber".	Ministry of Environment
Mr H M L K Herath	Presented the progress of the project 'impact of climate change on yield of rubber'.	Ministry of Environment
Mr H M L K Herath	Training on INFORM	Council for Agricultural Research Policy

Services

Statistical analysis and interpretation

Biometry section provided support to other research departments in designing of experiments, statistical analyses and interpretation of experimental results. Statistical assistance is also provided to undergraduate and postgraduate students working on their projects in various research departments (W Wijesuriya and K Herath).

Database management

a) Meteorological

The Dartonfield meteorological station was properly maintained and daily measurements were entered in the database. Monthly reports were prepared and sent to the Central Meteorological Station. These data were made available to researchers and Agrarian Service Centres (K Herath, C Munasinghe and V Abeywardene).

b) Management information

The personnel and project summary databases were updated for the year 2003. The collected information was transferred to CARP to be included in the database of National Agricultural Research System (NARS) (W Wijesuriya, K Herath and C Munasinghe).

RESEARCH

The following studies are in progress.

Interactions between the Environment, Society and Technology (INTEREST)

This project is funded by the European Commission and is being carried out in 5 different eco-systems in Asia. The Sri Lankan component is the smallholder sector of rubber. The following were carried out during the year under review.

I. Participatory studies were done in selected villages to identify farmers' perceptions in advance on needs and preferred media for dissemination in planning effective extension programmes. This study was focused on activities involved in immature and mature stages of rubber and preferred media for dissemination.

II. The INTEREST team organized one-day farmer workshops in the 3 villages. These workshops were planned according to the information collected in participatory studies during Year 1 and preference ranking exercises done in Year 2, focusing on individual awareness tests on general recommendations, tapping and processing aspects. Results of these awareness tests and the preference ranking studies were the basis for identifying the key areas for the awareness workshops.

The workshops in each village commenced with a brief introduction of the objectives of the workshop, which followed by a session to discuss how they fared in awareness tests. The participants were very keen to know their standard. The research team made use of this opportunity to present the correct answers to the questions displayed in awareness tests.

In the next session, the participants were involved in field demonstrations, which were organized in 3 groups, namely;

- General agronomic recommendations
- Tapping and
- Processing of rubber sheets.

Farmer participation in the workshops was very successful. The exhibition with live specimens, posters and banners to describe the whole process from field preparation to processing of rubber gained a lot of interest among the participants.

During the workshop, the participants had the advantage of viewing video documentaries addressing; field planting, fertilizer application and tapping. The officers of the Advisory Services, Soils and Plant Nutrition, Raw Rubber Process and Chemical Engineering Departments were involved as resource personnel in these awareness programmes.

III. The conceptual model produced including the issues of Environmental, Societal and Technological aspects was presented to the participants. With the intension of constructing a Bayesian Network (BN) the prior probabilities for the states of each issue and the conditionals were gathered in an informal discussion in all 3 villages. The conceptual model constructed in Year 1 was further improved using the indicators of sustainability identified during the Nepal workshop. An example done in one of the villages for the existing situation is given in Fig. 1. This network can be used to investigate the impact

of external pressures like; rubber prices, subsidies and skill upgrade on the sustainability of the system.

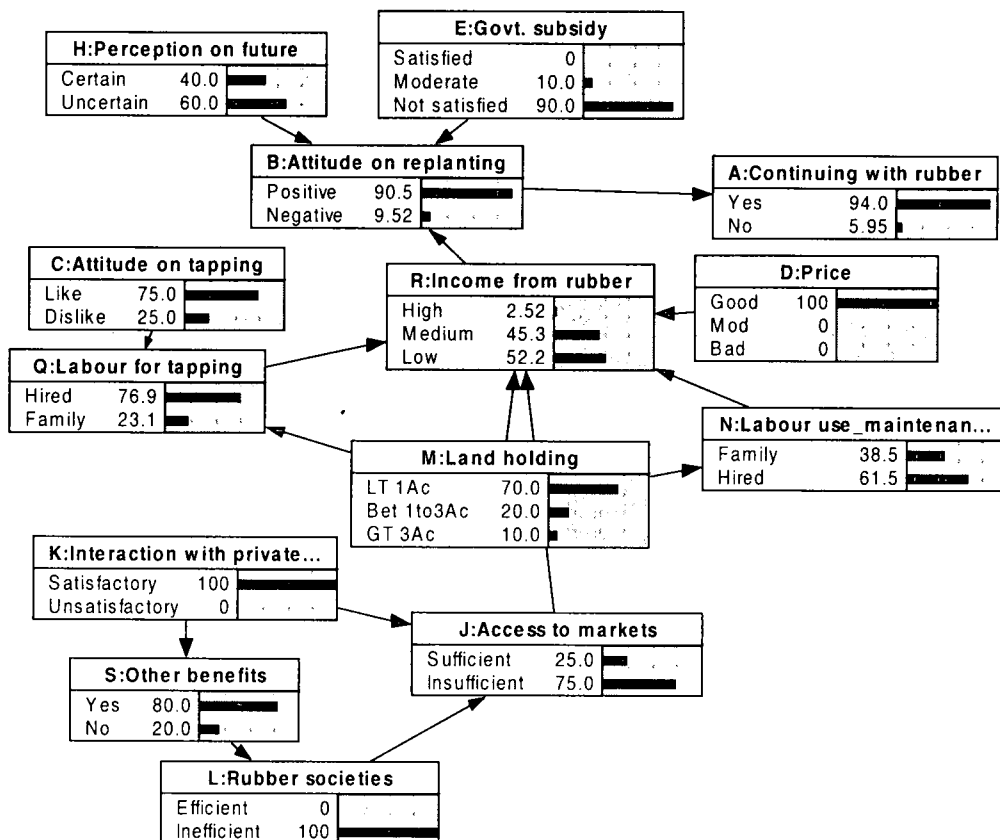


Fig. 1. Bayesian network describing the social, environmental and technological impacts on continuing with rubber cultivation in the Welihelatenna village (values given are probabilities [in the form of percentages] for each state for each node).

For the smallholder rubber sector in Sri Lanka, 5 different D-P-S-I-R frameworks were identified to describe the impact of different factors on the issues; substandard growth in immature rubber lands, low rubber productivity at local level, low membership in societies, poor quality of rubber produced and depletion of rubber extent which subsequently affect on the sustainability of the smallholder rubber sector. An example of the causes and effects, which affect on the productivity of smallholdings, is presented in Fig. 2 and the resulting network is presented in Fig. 3.

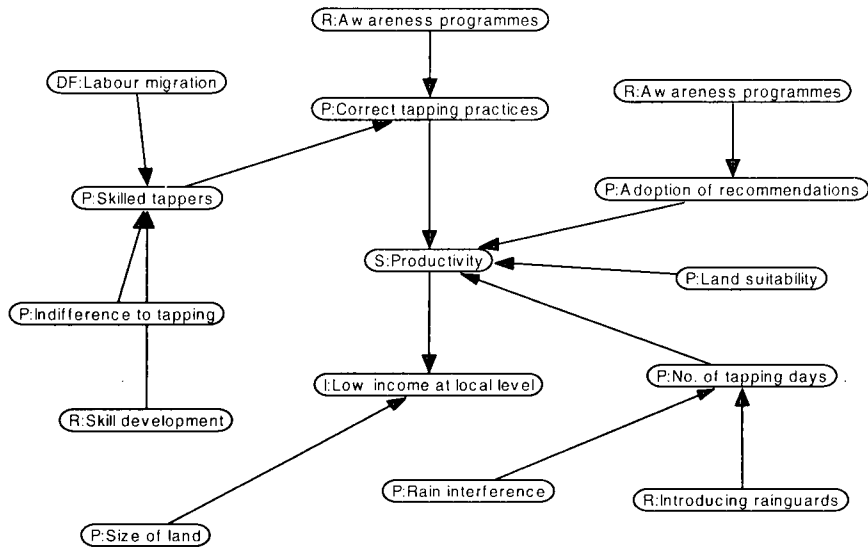


Fig.2. Cause and effect relationships on the productivity of the smallholder rubber units (DF:Driving forces, I:Impacts, S:State, P:Pressures and R:Responses of the system)

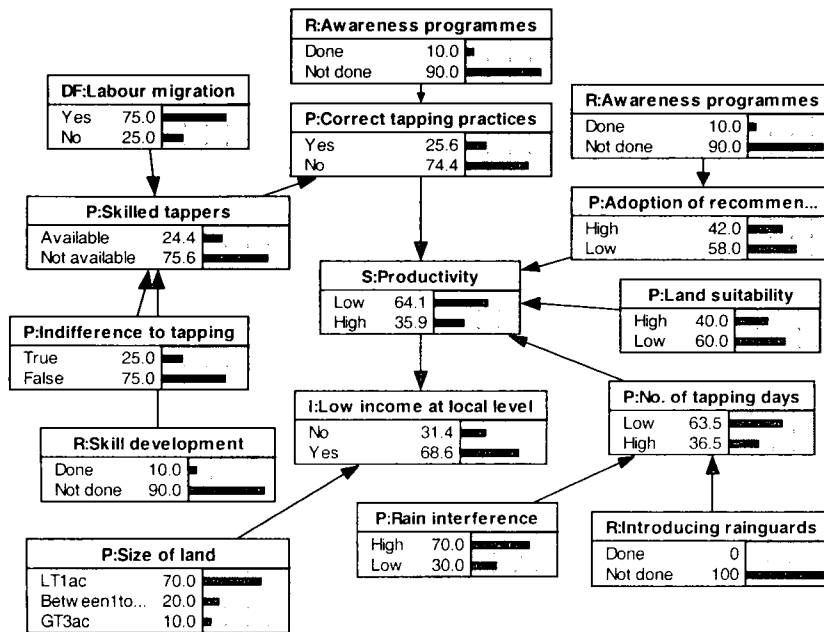


Fig. 3. Present situation in the Welihelatenna village (values given are probabilities [in the form of percentages] for each state for each node).

This network can be used to assess the impact of different responses on the productivity of the system.

IV. The questionnaire survey for the Year 2 was done on the same holdings on which the data were collected last year. Field evaluations were also done in immature and mature holdings. Data collection was done by the team with the help of the officers of Advisory Services Department of RRI. An appropriate database structure was done in ACCESS with several tables linked together. Data analysis is in progress.

V. Dissemination of results

a) ***For the general public***

The research team attended to the following addressing the importance of technical recommendations and the value of rubber plantations as a forest cover.

- Preparation of banners
- Preparation of posters
- Preparation of exhibits
- All project presentations, reports, databases and questionnaires are made available in the project home page:
<http://www.rothamsted.bbsrc.ac.uk/aen/interest/index.htm>
- 01 article to *Rubber Puvath* highlighting the use of participatory methods in the smallholder sector

b) ***For researchers***

- Publishing the findings of INTEREST was discussed in detail during the 2nd workshop in Goa, and the coordinator has arranged to publish them in a special issue of the journal, Agriculture, Ecosystems and Environment.
- The Sri Lankan team prepared several articles for publication in the journal and the bulletin of RRISL.
 - 01 article to the journal of Rubber Research Institute on the use of non-parametric statistics in participatory research
 - 02 articles to the Rubber Bulletin on adoption of technologies in the smallholder sector and use of Bayesian networks in participatory studies in the smallholder sector.
- All project presentations, reports, databases and questionnaires are made available in the project home page

(Wasana Wijesuriya, Mahinda Wijeratne (University of Ruhuna), D M A P Dissanayake, L M K Tillekeratne (Principal Contractor), Keminda Herath, Jagath Edirisinghe and Vidura Abeywardene).

Climate change studies funded by the Ministry of Environment

- a) Senior research programme: Impact of climate change on land productivity of rubber, possible adaptation measures and the role of rubber plantations as a mitigation option

This study is being conducted in collaboration with the Department of Soils and Plant Nutrition. The analyses and the preparation of the draft final report are in progress (L Samarappuli and W Wijesuriya).

- b) Junior research programme: Impact of climate change on yield of rubber.

The objective of this study is to relate rubber yield with meteorological parameters. Analyses and preparation of the draft final report are in progress (K Herath and W Wijesuriya).

Strategies for enhancing the productivity of smallholder rubber units in non-traditional rubber growing areas as an initiative to address poverty

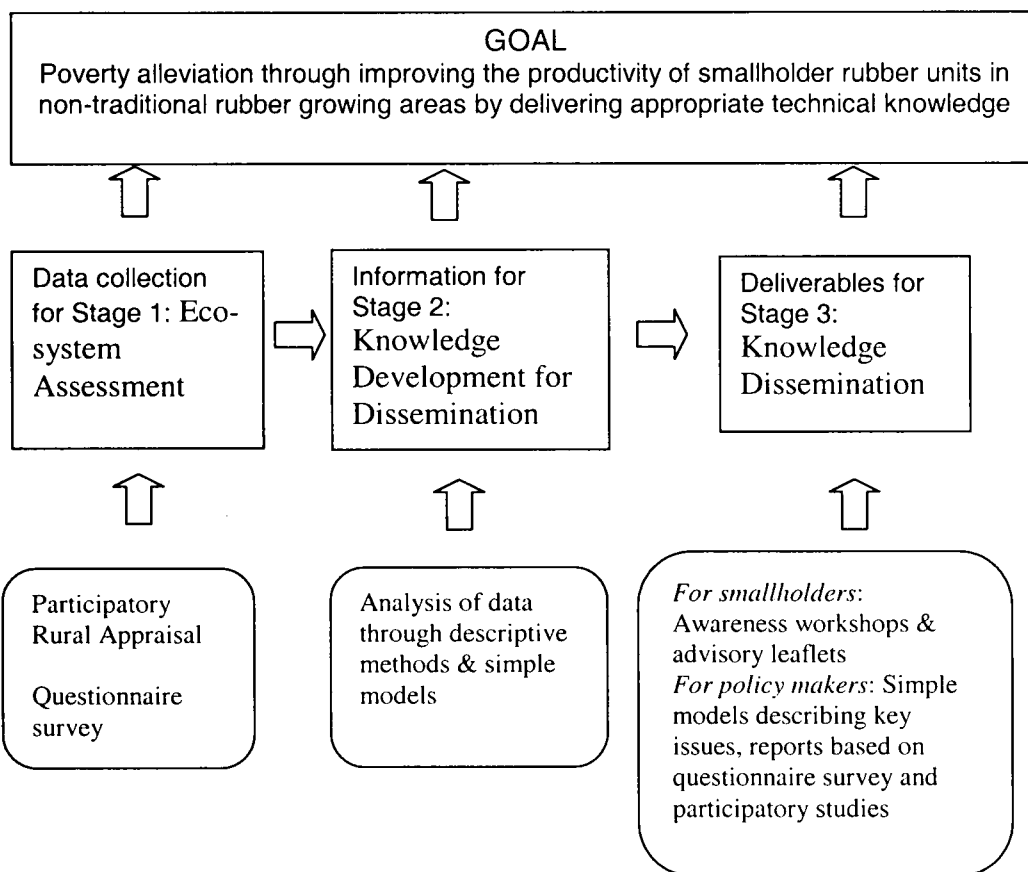
This project specifically looks into the aspects of identifying strategies for enhancing the productivity in non-traditional rubber growing areas. This will be achieved through the process;

1. understanding the resource availability in non-traditional areas for rubber cultivation
2. understanding and analyzing farmers' ecosystem practices in non-traditional rubber growing areas,
3. understanding the views and perceptions on the recommended technologies,
4. identifying the market constraints,
5. identifying the pressures between environmental policy, social challenges and technological innovation, and

based on these issues, the research team will develop a range of dissemination tools to deliver appropriate knowledge to the community, addressing how to manage rubber plantations in a profitable way.

The study comprises of 3 stages;

- Stage 1: Ecosystem assessment,
- Stage 2: Knowledge development and
- Stage 3: Knowledge dissemination.



Participatory Rural Appraisal (PRA)

The research team met the officers of the Moneragala RDD office and discussed the initial matters with the Assistant Director and Rubber Development Officers during early May 2003. During this discussion, the following sites (Table 1) were selected taking into consideration the number of smallholders in each RDO region and one village each was selected from each RDO region.

Table 1. Selected RDO divisions and villages in the Moneragala district

RDO Division	Village	Details
Monaragala	Tanwatta	Extent: 225 ha. No of Farmers: 125
Badalkumbura/Maligatenna	Karawila	Extent: 141 ha No of Farmers: > 100
Medagama	Polgahapitiya	Extent: 90 ha No of Farmers: 110
Bibile	Radaliyedda	Extent: 44 ha No of Farmers: 75

Questionnaire survey

A questionnaire survey was carried out in all the rubber growing areas to collect information on;

- a) Immature rubber lands
- b) Mature rubber lands, and
- c) Existing smoke houses.

The numbers of smallholdings surveyed in each RDO region are given in Tables 2 and 3. Table 4 gives a list of the number of smokehouse owners interviewed.

Table 2. *Number of immature smallholders surveyed in different REO ranges*

REO Range	No. of smallholders
Moneragala	30
Madulla	15
Badalkumbura	24
Bibile	13
Maligatenna	44
Medagama	37
Monarawane	2
Kotagama	4
Atale	30
Total	199

Table 3. *Number of mature smallholders surveyed in different REO ranges*

REO Range	No. of smallholders
Moneragala	30
Nannapurawa	02
Badalkumbura	15
Bibile	12
Maligatenna	58
Medagama	30
Monarawane	01
Kotagama	13
Atale	30
Wellawaya	08
Nikapotha	13
Total	212

Table 4. Number of smoke houses surveyed in different REO ranges

REO Range	No. of cases
Moneragala	30
Nannapurawa	2
Badalkumbura	8
Bibile	5
Maligatenna	15
Medagama	3
Monarawane	1
Kotagama	13
Atale	25
Wellawaya	5
Nikapotha	6
Total	113

Discussions with extension personnel

A SWOT analysis was done with the officers of the Rubber Development Department of the Moneragala district focusing on the potential for the rubber industry.

The following tables list the components of a SWOT analysis with scores for each item.

Rubber Industry in the Moneragala District: Strengths

Strengths	Marks out of 10
1. High land availability	8
2. More number of tapping days (low rain interference)	7
3. More number of people without a permanent income	5
4. High labour availability	4
5. More number of people with high tendency for agriculture	3
6. Low incidences of diseases	2

Rubber Industry in the Moneragala District: Weaknesses

Weaknesses	Marks out of 10
1. Low capital availability	8
2. Inefficient extension service	7
3. Low technical knowledge on rubber industry	6
4. Uncertainty on new technologies (unwillingness give up traditional approaches)	3

Rubber Industry in the Moneragala District: *Opportunities*

Opportunities	Marks out of 10
1. National requirement to increase the rubber production	8
2. Government sponsorship	7
3. High rubber prices	6
4. Being an opportunity to receive state owned lands for the landless people	5
5. Enthusiasm of people	4
6. Low availability of alternative crops	3

Rubber Industry in the Moneragala District: *Threats*

Threats	Marks out of 10
1. No proper market	7
2. Sugarcane plantations being a threat	5
3. Political interference	2
4. Natural hazards - such as fire	3

Data analyses of the questionnaire surveys are in progress. This study will end in July 2004 (Principal Investigators - Wasana Wijesuriya, D M A P Dissanayake; Team Members - Keminda Herath, Jagath Edirisinghe and Vidura Abeywardene).

LIBRARY AND PUBLICATIONS

S U Amarasinghe

SUMMARY

The prime objective of the library to provide promptly, appropriate documents to its clientele so as to gain knowledge to do research and study works efficiently.

The library attempts to fulfil this objective by collecting and disseminating information on natural rubber and related areas. The other responsibility of the section is maintaining, processing and publishing of Institute's regular publications such as Annual Review, Journal, Bulletin, Rubber Puwath *etc.*

DETAILED REVIEW

Staff

Mr S U Amarasinghe, Librarian and Publications Officer, Mrs Tilaka Danthanarayana (Colombo Office) and Mrs Ramani Amaratunga, Library Assistants and Assistant Publications Officers, Mr P M Prema Jayantha, Clerk/Typist and two Library Attendants were on duty throughout the year

Seminars and Workshops

Librarian and Publication Officer attended the following.

- The AGM of the Sri Lanka Association at Hotel Galadari
- Three AGRINET meetings at CARP office
- Govt. Librarians/School Librarians/Western Group meeting

Resource development activities

The book strength increased up to 5120. The library subscribed to a limited number of journals due to financial constraints and nearly 30 were received on an exchange basis.

Publications

The publications have been processed and published during the year.

RRISL Bulletin Vol.44 (2002)

Annual Report 2002

The processing work of the following publications was done during this period.

RRISL Journal Vol.85 (2002)

Handbook of Rubber: Vol.2 - Technology

SDI service

Twenty three articles were sent to various agricultural libraries at their request and vice versa 16 articles were requested for the benefit of RRISL library users. Ten literature searches based on *Hevea*/rubber were done using CD-ROM databases available.

Inter-Library co-operation activities

The computerized bibliographic data of the year 2003 were sent to the National Library and the CARP Library for compilation of the National Union Catalogue and Sri Lanka Agricultural Bibliography respectively.

Meanwhile, content pages of 36 journal titles were received on the request of the RRISL library and content pages of 12 titles were sent to AGRINET libraries.

DATONFIELD GROUP

J Perera

SUMMARY

The total extent of the Institute group of estate, known as Dartonfield Group comprising of Dartonfield division and Gallewatta division in Agalawatte and Nivitigalakele division in Matugama, is 331.88 hectares, of which 189.69 hectares are in bearing and 43.03 hectares in immature rubber, during the year under review.

A satisfactory crop of 190,117 kg was harvested representing a yield per hectare (YPH) of 1,002 kg and exceeded the annual crop estimate by 1.4%.

The cost of production C.O.P. for the year 2003 was Rs.57.16 which was an increase of Rs.2.91 in comparison to that of previous year and however, the group was able to secure a profit of Rs.51.19 per kg in the year, as against the profit of Rs.13.86 per kg in the year 2002.

Total profit revenue and sundry income for the year under review were Rs.9868973.47 and Rs.1,494,950.32 respectively, without capital expenditure. The main reason attributable for the remarkable escalation in profit, is due to favourable selling price of rubber in the market coincided with managerial initiatives. For the first time in the annals of Dartonfield group, the decision has been taken by the management to reward Workers and Staff who cooperated and committed with the management in securing such a large profit.

The average intake per tapper (IPT) of the group was 8.4 kg, an increase of 16% than in the previous year.

As a mean of overcoming the scarcity of tapper which made the group, in past years, fell short of crop targets, the tapping system of ½s d3 ET2.5%.Ba 1.6.4/Y, was introduced to Gallewatta division where 72% of group's crop is generated. This system was found to be effective in reducing vacant blocks to a large extent.

Weather Condition experienced during the year was not so conducive for tapping and harvesting of crop. Although a rainfall of 3,509.7 mm was registered - that is - 643.5 mm less than the previous year, it's skew distribution disrupted tapping and harvesting activities of the group.

DETAILED REVIEW

Staff

Subject to following changes, the group's staff remained as fallow during the year.

Mr Jehan Perera the Estate Superintendent, Mr K K P Gunawardena Senior Clerk, Mrs C Dissanayake, Mr A K D Wickramasinghe, Mrs S I K Pathirage, Junior Clerks, Mr D S K Ranaweera, Rubber Factory Officer, Mr W D D Senanayake Assistant Factory Officer, Mr S K S de Silva, Mr T Somaratne and Mr N L D Reggie, Field Officers and Mr H M Jayantha Premalal, Assistant Field Officer, were on duty throughout the year.

Mr J A Wimalasena, Field Officer attached to Gallewatte division retired in January after long period of service in Dartonfield group.

Mr N U V S Vijitha Kumara transferred to Kuruwita sub - station on a disciplinary matter.

The group cadre stood at the end of the year, made as fallow.

Senior Staff	01
Assistant Staff	18
Minor Staff	03
Total	22

Hectarage summary – Dartonfield group

A hectarage summary of Dartonfield group is given in Table 1.

Table 1. *Land distribution of the Dartonfield group*

	Dartonfield	Gallewatte	Nivitigalakele	Total
Mature areas	34.79	136.55	18.35	189.69
Immature areas	4.28	23.34	15.46	43.03
Budwood nurseries	6.54		1.25	7.79
Seedling nurseries	0.73		0.75	1.48
Uprooting areas			11.32	11.32
Abandoned areas		5.13	11.32	16.45
State land taken	0.27			0.27
Paddy/Deniya		1.22	1.22	2.44
Waste land	0.19	0.18		0.37
Earth slipped areas	3.01	1.26		4.27
Jungles	0.80		3.29	4.09
Rock /Streams	2.14	4.74	2.17	9.05
Buildings	18.67	5.07	7.79	31.53
Roads	2.92	6.86	0.32	10.10
Grand Total (Hects)	74.29	184.35	73.24	331.88

Crop

Total crop of 190,117 kg was harvested from an extent of 189.69 ha. during the year 2003. The crop harvested for the year was 103% of Season's estimated crop.

Table 2. *The YPH in the Dartonfield group from 1999 to 2003*

Division	Year				
	1999	2000	2001	2002	2003
Dartonfield	649	730	764	1218	1117
Gallewatte	713	828	890	815	1010
Nivitigalakele	858	885	657	754	613
Group average	728	820	838	879	1002
Group estimate	926	1093	901	943	989

The main reason for poor YPH in Nivitigalakele division is, because 55% of its mature extent has already been surpassed the economic life of rubber clearings.

Tappers productivity

The IPT of the three divisions in the group for last 05 years is given in Table 3.

Table 3. *The IPT division wise for the last 05 years in the Dartonfield group*

Division	Years				
	1999	2000	2001	2002	2003
Dartonfield	8.5	6.8	7.2	7.1	6.6
Gallewatte	7.5	7.2	8.0	7.8	9.8
Nivitigalakele	5.6	5.0	4.6	4.4	4.6
	7.7	6.9	6.7	7.6	8.4

Vacant blocks

Table 4. Vacant block recorded division wise in the Dartonfield group during the last 02 years

Division	No. of vacant blocks		Percentage	
	2002	2003	2002	2003
Dartonfield	285	147	15%	02%
Gallewatte	5057	1739	18%	11%
Nivitigalakele	1027	202	21%	07%
Total	6369	2088	19%	07%

Non availability of tappers to meet the need of required tappers that coincided with larger number of vacant blocks made the group unable to obtain harvestable crop of 17,539 kg. The income generally lost due to vacant blocks was Rs1,913,000.00 during the year.

Tapping cost

Table 5. A breakdown of Total tapping cost in Last 02 years

	Cost – Rs./Kg		
	2001	2002	2003
Tapping	16.62	17.78	17.17
Double tapping	0.50	0.67	-
Over Kg	0.88	0.73	2.74
Over time on field staff	-	-	0.06
Curing shed labour	0.03	0.09	0.08
Scraps	-	-	-
Kanganies	0.02	-	-
Incentive to F /Staff	0.02	0.08	0.09
Ethral application	-	-	0.27
Total	18.07	19.35	20.41

Rain fall

Total rain fall recorded at Dartonfield, Gallewatte and Nivitigalakele division amounted to 4,452.2 mm, 2,503.3 mm and 3,571.6 mm on 229,162 and 215 wet days, respectively during the year.

Table 6. Annual rainfall and wet days during last 5 years

	Years				
	1999	2000	2001	2002	2003
Rainfall (mm)	4903.9	3586.2	4144.5	4153.17	3509.7
Wet days	194	176	199	194	202

The highest rainfall of 561.6 for the season was registered in the month of May 2003.

Tapping days

Despite the rainfall recorded for the year 2003 was lowered by 644.1 mm than in the previous year, the number of normal tapping days was also the same when compared with last year. This was due to skew distribution of rainfall that led to loss harvestable crop.

Table 7. The number of tapping days, IPT and YPH for the Last 4 years

	2000	2001	2002	2003
1. Tapping days				
1.1 Normal	208	204	322	204
1.2 Late	13	17	15	24
1.3 Double	06	03	20	-
1.4 No - Tapping	144	144	111	137
2. IPT (Kgs)	6.9	6.6	7.2	8.4
3. YPH (Kgs)	820	838	879	1002

Rainguard area

In year 2003, an extent of 34.79 hectares was rainguarded in Dartonfield division enabling the division to secure 323 tapping days, of which 90 days were the out come of rainguarding. Moreover, the division has been harvested additional 10,027 kg of rubber as the result of rainguarding. The cost incurred for fixing a rainguard was Rs.13.68 per tree. The net income and profit made per hectare were Rs.54,775.00 and Rs.15,745.00 respectively.

Mature area/Profit per ha.

Table 8. Comparative statement of mature area profit/Hect.

	2000	2001	2002	2003
Mature area extent	185.69	189.17	186.59	186.59
Total profit (in million)	(1.40)	(0.11)	(2.27)	9.86
Profit/ha. Rs.	7580.79	594.87	12182.45	52026.85

Table 9. Labour rates and breakdown of cost of Production (Rs/Kg) for last 5 years

	2000	2001	2002	2003
1. Labour Wages	112.70	119.70	147.35	147.35
2. COP	49.20	48.90	54.25	57.16
2.1 Tapping	18.43	18.07	19.35	20.41
2.2 Manufacture	8.79	9.35	11.12	12.66
2.3 General charges	13.21	13.20	16.87	36.77
2.4 Upkeep	8.77	8.28	6.91	07.27
3. N.S.A	58.44	48.19	68.11	109.07
4. Profit	9.24	(0.71)	13.86	51.91

Intercropping area - Rubber and tea

An extent of 4.35 hectares was intercropped with rubber and tea. The total crop harvested from rubber was 4,550 kg and the total income achieved was Rs.496,268.50. Net profit made on rubber was Rs.236,190.50. The total crop of green leaves, harvested from the intercropped area was 21,402 kg and net profit made by

selling green leaves was R.122,126.89. The local net profit secured was Rs.358,317.39 and the profit made per hectare from this intercropping area was Rs.82,371.81. YPH achieved on rubber and tea was 1,046 and 1,055 kg respectively.

General

Total profit made on Dartonfield and Kuruwita Sub – Station for season 2003 Rs.14,704,577.11

Manufacture

Table 9. *Detail of crop manufactured during the year 2003*

Grade	Quantity	Grade %	Latex %	Scrap %
Crepe No .1	141384	81%	81%	
Crepe No. 3	32979	19%	19%	
Scrap Crepe No. 1	11443	73%		72%
Scrap Crepe No. 2	3995	25%		25%
Scrap Crepe No. 3	316	02%		03%
Smoke sheet No. 1	-	-		
Smoke Sheet No. 2	-	-		

Latex crop was continued to be manufactured as crepe rubber. Net sale average for the year was Rs.109.07. The out turn of crepe No.1 was 75%.

KURUWITA SUB STATION

S A R Samarasekera

SUMMARY

The mature and immature extents of the Kuruwita Sub station were 48.83 and 36.04 hectares respectively during the year under review.

A crop of 66,972 kg., an increase of 14,222 kg. over the estimated crop was harvested achieving 1,371.5 kg yield per hectare an increase of 13.8 kg over last year.

The average intake per tapper was 9.4 kg. The intake decreased by 0.2 kg. over last year.

The annual rainfall was 3981.0 mm with 107 wet days as against 2,743.2 mm with 70 wet days during the last year.

The cost of production and net sale average for the year were Rs.34.25 and Rs.83.12 per kg respectively. The profit per kg was Rs.48.87 and profit made for the year was Rs.3,272,921.64. The total profit inclusive of tea, cinnamon and sundry income was Rs.3,434,116.67.

DETAILED REVIEW

Staff

The Visiting Superintendent Mr Anusha S Perera over looked the activities of the Sub station throughout the year.

Mr S A R Samarasekera, Assistant Estate Superintendent, Mr D S Jayasinghe, Clerk, Mr J R C Jayalath, Assistant Field Officer were on duty throughout the year.

The estate carder stood at 06 at the end of the year made as follows.

Intermediate staff	- 01
Assistant staff	- 04
Minor staff	- 01

Hectarage

A summary of the hectarage is given in table 1.

Table 1. Land distribution (ha.) in Kuruwita sub station

Land type	Extent (ha)
Mature area	48.83
Immature area	36.04
Nurseries	.84
Tea revenue area	1.75
Paddy area	1.00
Buildings gardens and roads	9.13
Water tank	.01
Unsuitable for planting	2.00
	99.60

Rainfall

Rainfall figures for years 2003 and 2002 are given in Table 2.

Table 2. Rainfall (mm) distribution during 2003 and 2002

Month	Year	
	2003	2002
January	128.6	80.1
February	154.3	172.6
March	300.8	196.2
April	432.0	197.2
May	596.0	346.1
June	376.0	199.1
July	455.6	154.4
August	511.7	214.3
September	415.8	125.4
October	270.0	586.2
November	276.7	194.7
December	63.5	281.4
Total	3,981.0	2,743.2

Crop

A total crop of 66,972 kg was harvested from an extent of 48.83 hectares during the year. When compared with the estimated crop there is an increase of 14,222 kg at the end of the year.

Table 3. *The yield per hectare (Kg) recorded during each month during the year*

Month	YPH (Kg)
January	174.6
February	121.1
March	96.9
April	73.6
May	84.2
June	88.6
July	88.7
August	104.5
September	79.2
October	146.7
November	125.4
December	188.0

The yield data for the last five years is given in Table 4.

Table 4. *Yield per hectare records from 1999 to 2003*

	Year				
	1999	2000	2001	2002	2003
Estimated	740.7	855.0	867.2	819.0	1,080.0
Y P H	799.6	1,012.2	1,015.0	1,357.7	1,371.5

Tapper productivity

The average intake per tapper for the last 5 years is given in Table 5.

Table 5. *The average intake per tapper (Kg) for the last 5 years*

	Year				
	1999	2000	2001	2002	2003
Intake per tapper	9.2	8.6	8.6	9.6	9.4

Tapping days

When compared with last year there was a decrease in both normal and late tapping days (Table 6).

Table 6. *The number of tapping days for the last 5 years in Kuruwita Sub-station*

	Year				
	1999	2000	2001	2002	2003
Tapping days	210	240	224	289	248
1.1 Normal	182	195	193	252	226
1.2 Late	12	23	16	36	14
1.3 Double	(17)	(45)	(19)	(32)	(46)
1.4 Rain interference	16	22	15	01	08
No tapping	147	122	134	70	76

Tapping cost

The tapping cost of the estate has increased by 7% over the previous year.

Table 7. *A break down of total tapping cost for last 2 years*

Cost item	Cost/Kg (Rs.) and year	
	2002	2003
Tapping	14.42	14.67
Double tapping	.47	1.33
Kanganies	.02	.03
Over kilos	.68	.48
Scrap pay	.22	.36
Incentive to field staff		.09
Overtime on tapping	.11	.18
	15.92	17.14

Cost of production and profitability

The cost of production for the season was Rs.34.25 and N.S.A. Rs.83.12. The estate made a profit of Rs.48.87 per kilo (Table 8).

The cost of production has increased by Rs.1.22 per kg. when compared with the previous year.

Table 8. Labour rate (Rs.) and a break down of the cost of production (Rs./Kg.)

	1999	2000	2001	2002	2003
Labour rate	95.00	98.00	98.00	109.00	109.00
Total C.O.P.	31.11	36.49	34.02	31.94	34.25
Tapping	14.63	16.36	16.57	15.92	17.14
General charges	13.12	14.39	12.01	12.37	11.39
Upkeep	2.66	3.92	3.58	3.14	4.95
N.S.A.	36.96	49.75	46.68	53.93	83.12
Profit	5.85	13.26	12.66	21.99	48.87

Labour rate per day for the year was Rs.109/- plus an incentive of Rs.22/- per day depending on the out come.

Table 9. Comparative statement of the mature extent profit per kg. and profit per hectare

	Year				
	1999	2000	2001	2002	2003
Mature extent (Ha.)	40.50	43.25	43.83	48.83	48.83
Total profit (Ha.)	199,502.55	580,509.54	563,357.34	1,437,640.23	3,272,921.64
Profit/Ha. (Rs.)	4,925.99	13,422.18	12,853.24	29,441.74	67,026.86

During the year 2003 a profit of Rs.48.87 on a kilogram and Rs.67,026.86 per revenue hectare were recorded.

Tea

A crop of 25,806 kg was harvested during the year which was an increase of 3,887 over the estimated crop for the same period.

The cost of production and the net sale average for the year were Rs.18.03 and Rs.21.65 per kg. respectively. The profit per kg was Rs.3.62 and the profit made for the year was Rs.93,463.35.

Cinnamon

9,278 Cinnamon sticks were sold at the rate of Rs.6.31 per stick and an income of Rs.58,544.18 was generated during the year.

Replanting

The replanting programme for the year was completed and also one hectare of pepper was planted with rubber at the Sub station during the year.

Fertilizer

Fertilizer application for mature and immature fields were carried out as scheduled.

Nurseries

A young budding nursery and a stock nursery were established in the sub station during the year 2003.

Budwood nursery

The budwood nursery belongs to the estate was under proper maintenance.

Meteorological Summary – 2003 Dartonfield Station

Wasana Wijesuriya

The total annual rainfall experienced during 2003 was 4454 mm, a considerable increase in rainfall compared to the previous year (3619 mm) and long-term average (4160 mm). The distribution showed a considerable deviation from the usual bimodal pattern especially during the mid year dry period as shown in Fig.1.

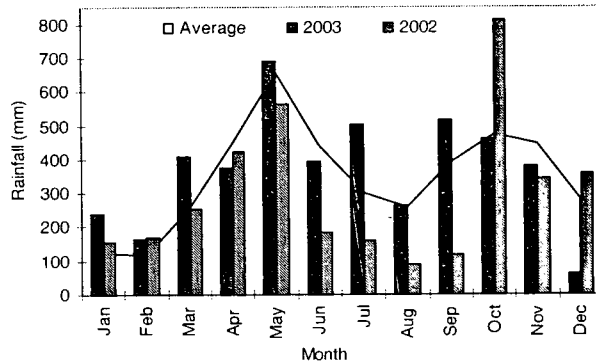


Fig.1. Monthly variation in rainfall

The rainfall in May was 690 mm, which was the highest recorded during this year. In May there was an unexpected flooding condition in the Agalawatta area due to heavy rains experienced on 6th May.

Fairly dry weather was observed during December of the year with the lowest rainfall of 60 mm, a deviation of 221 mm from the long-term average for this month. Rainfall observed during April, June, October and November were below when compared to long-term averages of these months.

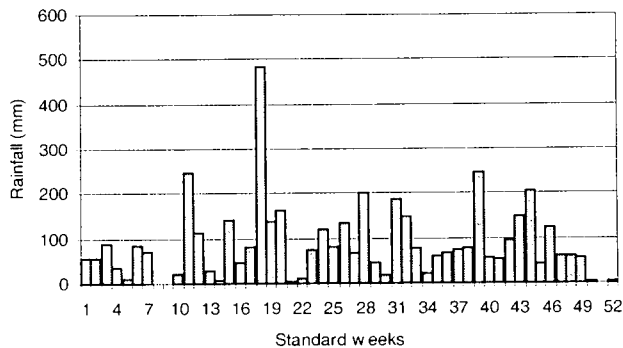


Fig. 2. Weekly variation in rainfall

The distribution of weekly rainfall is illustrated in Fig. 2. Seven dry weeks (a week having a total rainfall less than 10 mm) were observed during the year. The highest weekly rainfall was observed during the 18th standard week (early May), which coincided with the South West monsoon.

Start and end of monsoon rains

Frequency distribution of the onset of rains for both seasons is illustrated in Fig.3. The successful start of the rains occurred by 29th March and 08th September in 80% of the years (1964-2003) for South West (SW) and North East (NE) rains, respectively. For the year under review, SW rains commenced successfully by 12th of March, which is an early onset of rains, compared to the 80% expected. The onset of NE rains for this year could not be clearly identified.

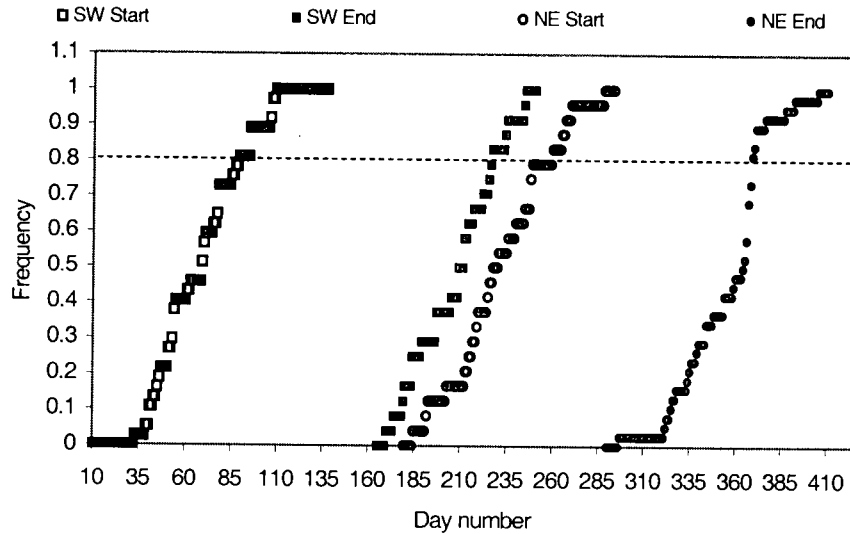


Fig.3. Cumulative probability of the start and end of rains in the two major rainy seasons at Dartonfield

According to Fig.3, rains have ceased generally by 14th August and 05th January for SW and NE rainy seasons, respectively (80% expected). For the year under review the cease of SW rains was not clear due to the continuous distribution of rainfall at Dartonfield. However, NE rains ceased by 23rd December, which can be identified as an early end for this rainy season.

The temporal variation in onset and ending of rains in SW and NE seasons are depicted in Fig. 4. In general, when compared to the period 1964 – 1980; the variability of the dates concerned is high during the recent years.

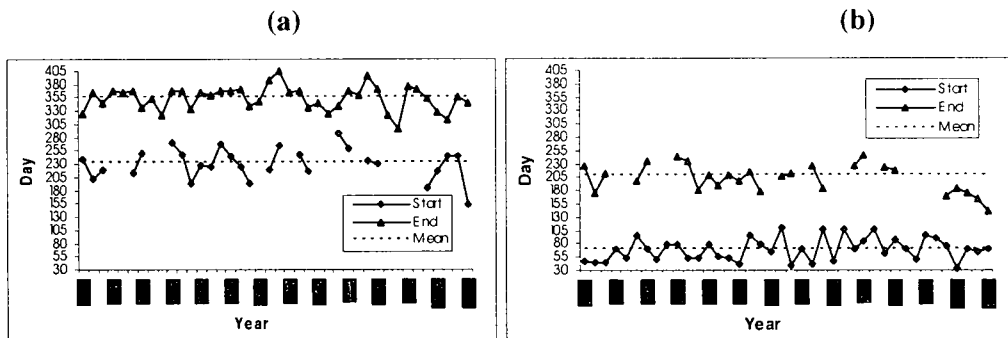


Fig.4. The start and the end of the SW rains (a) and NE rains (b) over 40 years

During the past 40 years, in 14 years, the end of SW rains and onset of NE rains could not be identified due to the continuous rainfall received at Dartonfield. The median length of the period for SW rains is 139 days whereas it is 122 days for NE rains. In year 2003, the length of rainy seasons could not be calculated due to the deviated rainfall pattern in the middle of the year.

The amount of rainfall and number of rainy days under low, moderate and high rainfall categories are listed in Table 1. Number of rainy days for the year was 229, equal to the long-term average. During March to October, rainfall events greater than 50mm per day were observed; at least once per month during this period. In May there were 5 such events. During the year under review there was a total of 21 days with rains greater than 50 mm per day compared to 15 events in year 2002.

Intensity of rainfall

In the year under review high intensity showers were observed during NE monsoon, whereas high intensity showers are generally common during the SW monsoon. This is a significant deviation of the usual rainfall pattern at Dartonfield. During the year, incidences of high intensity showers were more compared to last year. The highest rainfall intensity recorded was 265.6 mm/hr in May, but it lasted only for 15 minutes. For each month, the three highest intensities recorded, their duration, time of occurrence and the average intensity are presented in Table 2.

Other meteorological factors

Table 3 depicts the monthly values of some important meteorological observations together with averages for 1980 to 1992. Minimum temperature dropped below 20°C for 3 days only in December. The highest mean maximum temperature of 33.9°C was observed in March and December. The lowest mean minimum temperature of 21.1 observed in December. The lowest value for sunshine hours was observed in November due to overcast conditions resulted by unexpected heavy rains. The average morning RH was in the range of 62 to 93 %. The soil temperatures at 3 different depths are given in Table 4.

Table 1. Monthly variation of rainfall and rainy days in 2003

Month	Total rainfall (mm)	Average** (mm)	No of rainy days *	Avg.** Days	No. of days under each category			Evaporation (mm)
					0.3-2.5 (mm)	2.6-50 (mm)	>50 (mm)	
January	239.1	(121)	14	(10)	4	10		2.1
February	163.8	(116)	09	(09)	02	07		2.7
March	408.6	(252)	15	(17)	01	10	04	2.8
April	374.7	(449)	21	(21)	03	16	02	2.3
May	690.2	(659)	23	(24)	07	11	05	2.1
June	396.6	(440)	26	(24)	06	18	02	2.1
July	500.8	(299)	22	(22)	04	16	02	1.9
August	261.1	(257)	22	(21)	05	16	01	2.2
September	518.0	(391)	27	(22)	04	22	01	2.3
October	459.3	(476)	20	(22)	04	12	04	2.3
November	381.2	(448)	24	(20)	04	20	-	1.5
December	60.7	(282)	06	(17)	02	04	-	2.2
Total	4454.1	(4160.0)	229	(229)	46	162	21	26.5

* A rainy day is defined as a day with a rainfall ≥ 0.3 mm

** Average values for 1980-1992 are shown in parentheses

Table 2. Rainfall intensity recorded at Dartonfield meteorological station - 2003

Month	Date	Intensity (mm/hour)			Mean for the month
		3 highest records	Time of occurrence	Duration (min)	
January	17	35.2	17.30-18.45	75	9.07
	10	24.0	17.45-17.52	07	
	15	24.0	05.00-05.15	15	
February	11	35.7	16.45-17.30	45	7.49
	12	25.7	15.20-15.50	30	
	12	17.5	16.10-16.45	35	
March	20	30.0	14.15-15.40	90	4.74
	17	18.2	12.15-12.20	05	
	17	15.1	14.55-18.30	215	
April	14	24.9	17.20-18.15	55	7.26
	28	15.8	14.25-15.00	35	
	26	13.8	14.35-15.15	40	
May	05	265.6	08.45-9.00	15	14.77
	12	37.0	09.00-9.45	45	
	16	36.8	15.30-15.45	15	
June	04	40.1	10.00-10.25	25	7.89
	14	33.1	22.30-23.50	80	
	29	25.2	05.20-05.30	10	
July	15	62.4	19.40-19.45	05	6.96
	09	27.0	03.55-04.15	20	
	14	27.0	07.25-07.30	05	
August	05	38.4	12.30-12.35	05	8.24
	06	33.6	15.00-15.10	10	
	24	32.0	10.00-10.03	03	
September	01	61.7	11.15-11.22	07	9.14
	02	37.1	05.40-07.05	85	
	10	33.6	10.30-10.35	05	
October	27	59.5	14.30-16.00	90	11.67
	04	32.4	05.55-06.05	10	
	20	29.6	14.00-14.30	30	
November	14	40.0	15.00-15.45	45	7.11
	13	18.4	17.00-17.15	15	
	02	16.8	15.00-15.05	05	
December	26	14.4	21.05-21.10	05	8.4
	26	2.4	15.50-16.00	10	

Table 3. Variation of observed meteorological factors at Dartonfield - 2003

Month	(Latitude 6° 32'; Longitude 80.09 E Altitude 65.50mm)				Sunshine hours	Relative humidity (%)			Wind speed mean (K _{hr} ⁻¹)
	Temperature (°C)					9.00 am	No. of days 9.00>90%	4.00 am	
	Mean Max	Mean Min	Mean	No of days Min Temp<20					
January	32.8	22.1	27.5	-	4.7	82 (87)	21	76 (67)	1.5
February	33.7	22.7	28.2	-	6.6	82 (85)	14	68 (64)	1.7
March	33.9	22.4	28.2	-	6.0	88 (84)	20	71 (66)	1.7
April	33.7	22.9	28.3	-	5.3	91 (84)	14	83 (66)	1.6
May	31.9	24.2	28.1	-	4.9	93 (87)	18	79 (73)	2.0
June	31.0	23.7	27.4	-	4.9	91 (88)	22	82 (77)	2.0
July	31.1	23.6	27.4	-	4.1	89 (88)	28	84 (76)	1.9
August	31.2	23.6	27.4	-	4.1	90 (87)	26	74 (74)	2.2
September	31.3	23.3	27.3	-	4.7	90 (86)	23	72 (74)	1.9
October	31.9	22.8	27.4	-	6.2	91 (85)	17	77 (77)	1.7
November	32.4	22.5	27.5	-	3.8	90 (84)	17	83 (77)	0.8
December	33.9	21.5	27.7	3	7.0	91 (84)	07	77 (74)	1.4

** Average values for 1980 – 1992 are shown in parentheses.

Table 4. Soil temperatures recorded at different depths at Dartonfield - 2003

Month	09.00 hors				16.00 hors			
	5cm	10cm	20cm	30cm	5cm	10cm	20cm	30cm
January	26.6	25.9	26.9	27.8	33.4	31.4	29.7	28.2
February	27.3	26.5	27.4	28.3	33.7	32.1	30.4	28.9
March	27.8	27.1	28.2	29.0	36.2	34.0	31.9	30.0
April	28.8	28.0	28.6	29.3	35.3	33.6	31.8	30.3
May	27.7	27.1	27.7	28.2	32.6	30.9	29.4	28.5
June	27.9	27.2	28.1	28.8	33.5	31.9	30.4	29.3
July	27.5	26.7	27.5	28.3	33.6	31.3	29.6	28.7
August	27.5	26.8	27.6	28.3	33.9	31.9	30.2	28.9
September	28.2	27.0	27.8	28.6	34.0	32.3	30.4	29.3
October	28.1	26.7	27.3	28.1	33.8	32.0	30.4	28.9
November	27.3	27.1	26.9	27.5	31.4	30.5	29.5	28.2
December	27.2	26.2	27.2	28.1	35.9	33.7	30.9	29.2

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