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RUBBER RESEARCH INSTITUTE OF SRI LANKA

Annual Review 2004

Rubber Research Institute of Sri Lanka - Annual Review - 2004

Cover story

Wonders in nature: bee honey from rubber leaf glands

Rubber Research Institute of Sri Lanka

Annual Review – 2004

1 st January 2004 to 31 st December 2004

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L M K Tillekeratne, PhD (Aston)
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Dartonfield
Agalawatta

Board Office & Laboratories
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RUBBER RESEARCH BOARD OF SRI LANKA

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Mr Vas Gunawardena, Superintendent, Opatha Estate, Kahawatta
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Mr M R Fernando, Superintendent, Malaboda Estate, Matugama
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Provident Fund Committee
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Mrs L J C Perera, Secretary, Provident Fund Committee
Mr W B Herath, Senior Accountant (In attendance)
Mr H H Jayasinghe, Elected Committee Member
Mr W D Wimaladasa, Elected Committee Member

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Confidential Clerk/Stenographer	Mrs P Balasooriya

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RUBBER RESEARCH INSTITUTE OF SRI LANKA

STAFF

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Director	L M K Tillekeratne, BSc (Cey.), MSc (Aston), PhD (Aston), FI Chem C, FPRI, FNASSL
Deputy Director - Research (Biology)	R C W M R A Nugawela, BSc (SL), MSc (Lond.), PhD (Essex)
Acting Deputy Director - Research (Biology))	C K Jayasinghe, BSc (SL), MSc (SL), MSc (Agric) (Aust.), PhD (SL)
Deputy Director - Research (Technology)	W M G Seneviratne, BSc (SL), PhD (Sussex)

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Experimental Officer (Technical Officer to the Director)	K K Liyanage, BSc Agric (SL)

RESEARCH DEPARTMENTS

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Geneticist and Plant Breeder	Mrs S P Withanage, BSc Agric (SL), MSc (India)
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	I D M J Sarath Kumara
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Botanist	L S S Pathiratne, M I Biol, MSc (Reading), MPhil (SL)

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	M K P Perera
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	S N Silva
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Experimental Officers	E B Fernando
	D Ramawickrema
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	Mrs W C M Kuruppu, Dip. Rubber Tech. (PRI), Certificate Rubber Tech. (Moratuwa)
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	S L G Ranjith, Dip. Rubber Tech. (PRI)
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	Mrs C S Lokuge
	R S Wijesundera
	L P P Vitharana
	K R N Karunatilleke, Dip. Rubber Tech. (PRI)

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	W D Wimaladasa
Research and Development Assistant	Miss G M Priyanthi Perera, BSc (SL), MSc (SL)
Clerk/Typist	Mrs I Wijesinghe

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	Mrs D G Edirisinghe, BSc (SL), MSc (SL), MPhil (UK)
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	Mrs S I Yapa, Dip. Rubber Tech. (PRI)
	Mrs P C Wettasinghe
	P L Perera
Technical Officer	T A A I Siriwardene

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Rubber Chemist	S Siriwardene, BSc (SL), MSc (Australia),
(Principal Research Officer)	PhD (Malaysia)
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	E C D Senanayake
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Experimental Officer	Mrs H K D C S Munasinghe, NCT Polymer (Moratuwa), Dip. Rubber Tech. (PRI), Dip. Computer Science (IDM)

Experimental Officer	Mrs K V V S Kudaligama Wijesundera, BSc (SL)
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Research Assistants (Adaptive Research)	W A D D S Wettasinghe P P Jayasinghe, LPRI
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* On study leave overseas

RUBBER RESEARCH INSTITUTE OF SRI LANKA

DIRECTOR'S REVIEW

L M K Tillekeratne

Year 2004 was another good year for Natural Rubber (NR). Prices of all grades of NR prevailed above RS 100 per Kg. As a result the annual rubber production in the country has shown a slight increase. The total production of all grades was 97,000 MT this year, which is 5% higher than the production in the previous year. This increase could mainly be attributed to tapping areas that were abandoned earlier by both the small holders and the privately managed estates. Even when the rubber prices are predicted to be still higher by the economists and the international organizations like the IRSG, it is very sad to report that some of the plantations companies still continue to over exploit their revenue areas for higher crops in order to record quick profits without realizing that they will be able to generate more income in the future without overexploitation, as the rubber prices will continue to be at higher levels.

Tappers given two tapping blocks in many estates are still in the habit of tapping not only the block due to be tapped on that day; but also half of the block to be tapped on the following day. This is S2 d 1½ tapping at 150% intensity and not the universally recommended S2d2 tapping at 100% intensity. This short sighted policy would lead to unexpectedly high rate of Tapping Panel Dryness in our plantations which is one of the major causes for low productivity in our estates under RPC management. This problem is not heard among small holders in Sri Lanka. We believe that one of the causes for the exploitation in estates is the extra incentive payment for extra kilos of latex harvested by the tapper. But if the management is cautious about the bark consumption and the yield potentials of the tapping blocks, this sad situation could be avoided easily.

The RRI owned Dartonfield estate was able to recover extra 56 days of normal tapping without a single day of double tapping, due to the use of rain guards. The average number of normal tapping days in estates in Kalutara district this year was only 172 due to heavy rain that prevailed in the country at the beginning of the year. As a result of these additional tapping days the estate made an additional profit of Rs.24,400.00 per hectare over the revenue collected in all adjoining estates in the district. The results reported by Bogawantalawa Plantation and Kelanivalley Plantation from the use of rain guards is even more attractive than this. The chief executives of these companies must be congratulated for this achievement. They have not only recorded higher profits from this exercise to their companies; but also have disproved the unfounded fears and complaints some planters had about this new technology introduced by the RRI.

The cess on rubber exports came into effect from November this year. A cess of Rs.4 per a Kg was levied on every kilo of raw rubber exported from this period. In addition to that there is also a cess levy of 5% on all rubber products imported into the country. The total collection expected from these two cess components is about Rs.495 million per annum. Moreover with the introduction of cess on the rubber content of the end products manufactured in the country, this income is expected to rise up to Rs.600 million. All these funds are expected to be disbursed to both small holders and the RPC for the purpose of replanting rubber leaving aside a small percentage not exceeding 10% of the collection for the administrative costs of the Rubber Development Department, which is responsible for disbursing cess money for replanting in the rubber sector. This is the first time after over 15 years cess funds were given to replant estates in the corporate sector. Further, a fair amount of this collection is to be utilized for improving rubber factories in order to produce quality premium grades of raw rubber like Lankaprene. Centrifuged latex factories catering to the dipped products industry of Sri Lanka are also to be helped under this program. A sum of 25 million rupees is kept aside for purchasing equipment for the Technology Laboratory of the RRI, which will have an indirect benefit to the rubber plantation.

It is relevant to mention here with appreciation the decision taken by the Hon Minister of Plantation Industries and his ministry to reimburse 50% of the cost of fixing rain guards in 2005 by both the small holders and the corporate sectors out of the cess income.

The foundation for a new Sub Station of the RRI to help the rubber growers in Kegalle and Kurunegala districts was laid at the Narampotha Estate at Polgahawela by the Hon Minister of Plantation Industries Mr Anura Priyadharshana Yapa. This new substation started in this place on an extent of 40 hectare is expected to demonstrate to the rubber growers in these two districts mainly the performance of new RRISL clones, benefits of new inter crops developed for rubber while having a nuclear material bud wood nursery on all new clones introduced by the RRI. The Coconut Cultivation Board is planning to have a trial plot of Glirizedia in this substation for the purpose of utilizing the firewood produced for power generation in Gasifiers. Plans are also there to set up another similar sub station of the RRI at Monaragala to cater to the rubber plantation, in that area which is expected to be expanded in the future.

The Wellassa Rubber Company formed by the largest rubber products manufacturers and the RPCC jointly is expected to replant rubber in Bibile and Moneragala areas at the rate of 2000 hectares per annum on an out-grower basis, over and above the replanting target of the RDD. However, the total acreage replanted in this area in 2004 was insignificant due mainly to the acute shortage of plants in this area.

But, in the future a small percentage of cess funds will be made available for the RRI to do a thorough inspection of the rubber plants nurseries starting from the germinating beds and to recommend the quality of plants given out to all farmers in

the country. With this development RRI scientists are optimistic that the new clearings of rubber planted in the future will be much more healthy and also will have higher stands closer to 500 per hectare, and thereby will give yields not less than 1,500 Kg per hectare.

Total NR consumption in the world this year was 8,410 million metric tons, which is 41% of the total elastomer consumption that year. The highest consumer of NR in 2004 was also China, which consumed 1,630 million metric tons. Consumption of NR in USA that year was only 1,144 million metric tons, which is 17.5% less consumption compared to China.

Consumption of NR in Sri Lanka this year was 54,172 MT out of which, 24,998 Mt was used in latex form while the use of NR in dry form was MT. In order to meet the short fall, large quantity of NR have been imported from Asian countries in this year too. In order to curtail imports of NR in the future it is expected to plant 7,000 ha in the country next year, 2,000 ha of which will be planted in Monaragala.

OVERSEAS VISISTORS

Ms. Anita Westmon, Sweden
Ms. Isabelle Westmon, Sweden
Mr Orjan Westmon, Sweden
Dr Gerd Sylvester, Germany

GENETICS AND PLANT BREEDING

P Seneviratne

SUMMARY

The clone RRISL 203 continued to give high yields in Estate Collaborative Clone trials and arrangements are being made to encourage the use of this clone for commercial planting. Based on the promising commercial yields in the Estate Collaborative Clone trials, the clone RRISL 2001 was promoted from Group III to Group II and RRISL 216 was included in the Group III of the clone recommendation. Although RRISL 202 was removed and RRISL 201 and 217 were down graded in last year's clone recommendation, *Corynespora* incidences were not observed during this year and they continued to give high yields in Estate Collaborative Clone trials.

From the Small Scale Clone trials 38 new genotypes were selected from 1978, 1987 and 1992 hand pollination progenies, to test further in Estate Collaborative Clone Trials.

The analysis of 5th year girth measurements of the Genotype Environmental studies showed that the clones RRISL 215 and RRISL 217 were still maintaining their high stability over all the Environments with high mean performance.

The final fruit set success of the annual hand pollination programme was 3.96% from a total of 5027 pollinations. Out of this 465 seedlings were obtained.

The *Hevea* molecular biology work was restarted but showed a little progress due to non availability of research and technical staff. Nine polymophic RAPD markers between RRIC 100 and RRIC 103 were found and work continued on marker assistant selections to identify *Corynespora* resistant clones.

DETAILED REVIEW

Staff

The Head of the Department, Dr D P S T G Attanayaka, resigned from the Institute with effect from 21st January. Research Assistant, Mr K B Karunasekera, Experimental Officers Mr K W Rupatunga, Mr B M S G Peiris, Mr L S Kariyawasam, Mr I D M J Sarath Kumara, Technical Officers Mrs A K Gamage, 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. Mrs S P Withanage, Assistant Geneticist and Plant Breeder, was on maternity leave from 12th January to 24th May.

Assistant Geneticist and Plant Breeder Mrs S P Withanage, was promoted to the post of Geneticist and Plant Breeder with effect from 1st January. Mrs S P Herath Assistant Geneticist and Plant Breeder continued her postgraduate studies at the University of Nagoya, Japan. Dr (Mrs) P Seneviratne was appointed as the Acting Head with effect from 21.1.2004.

Research Students

- Ms Nadeesha Silva, a student from the Veslien Graduate College, Macon Geogia, USA underwent a training on aspects of preliminary screening of RRISL 200 and 2000 Series.

- Ms Malika Perera, a student from the faculty of Science, University of Ruhuna conducted a part of her research project on "Comparison of some biology & Morphological variation in *Phytopthora meadii* from different rubber clones with their genetic variation".

Meetings and Workshops

Officer	Subject	Organization
Mrs S P Withanage and Mr K B Karunasekera	Scientific Committee Meetings	RRI
Mrs S P Withanage and Mr K B Karunasekera	First Symposium on Plantation Crop Research	TRI, RRI, CRI
Mrs S P Withanage	National Policy on Biotechnology and Biosafety	
Mrs S P Withanage	Presented a paper on Performance of some seedling progenies derived by crossing of selected *Hevea* cultivars	TRI, RRI, CRI
Mrs S P Withanage	Presented a paper on Adaptability/Stability of different rubber genotypes for agro-climatic variability of Sri Lanka	Ministry of Environment and Natural Resources
Mrs S P Withanage	Presented a paper on Transfer of Rust Resistance from *Triticum aestivum* L. cultiva Chinese Spring to Cultivar WL 711 at the 16th annual congress	PGIA, Peradeniya.

LABORATORY INVESTIGATIONS

Molecular biology of *Hevea* GPB/MM/97

The laboratory work on *Hevea* molecular biology was continued with a little progress due to non-availability of funds and technical staff. Screening of polymorphism in recommended RRISL 200/2000 series clones and polymorphism between RRIC 100 and RRIC 103 were started by using RAPD markers.

FIELD EXPERIMENTS

Hand pollination (HP) programme – 2004 (GPB/BST/HP/01)

This year's hand pollination programme was carried out at Neuchatel Estate. The crosses attempted, the number of pollinations done in each cross, the number of pods harvested and seedlings obtained, in each cross are given in Table 1. The final fruit set success of the pollinations done during the year was 3.95%.

Table 1. *Details of 2004 hand pollination programme*

Cross	No. of pollinations	No. of fruits collected	No. of seedlings
RRIC 121 × RRIC 121	2391	4	4
RRIC 121 × PB 28/59	2636	195	461
Total	5027	199	465

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

Evaluation of hand pollinated progenies

Small Scale Clone Trials

The list of the Small Scale Clone Trials monitored by the Department to-date is given in Table 2.

Table 2. *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 14th year girth measurement of the promising clones are given in Table 3. Yield data relevant to the sixth year of tapping based on 9 test tappings are given in Table 4. The highest girth was obtained from clone 86-81 followed by 86-21 as previous year. The highest yield was obtained from the control clone RRIC 121 followed by the new clone 86-87. Based on the results, arrangements were made to establish estate collaborative trails with clones 86-87 and 86-10.

Table 3. *Mean girth (13th year) of promising H.P. clones*

Clone	Mean girth (cm) and DMRT grouping
86-81	88.44^{A}
86-21	81.87^{AB}
86-77	81.71^{AB}
RRIC 121	79.66^{ABC}
86-24	76.55^{BCD}
86-87	73.80^{CDE}
86-76	72.32^{CDE}
86-37	72.27^{CDE}
86-63	71.63^{CDEF}
RRIC 110	70.09^{CDEFG}

Table 4. *Mean yield of promising 1986 H.P. clones*

Clone	Yield (g/t/t) and DMRT grouping
RRIC 121	53.15^{A}
86 – 87	50.20^{AB}
RRIC 110	44.11^{ABC}
86-10	40.08^{BCD}
86-11	37.70^{CDE}
86-24	34.24^{CDEF}
86-81	33.14^{CDEFG}
RRIC 100	32.17^{CDEFG}

(S P Withanage, H P Pieris and K B Karunasekera).

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

Results of the Duncan's Multiple Range Test for 11th year girth are given in Table 5. Seven test tappings were done during the year. Mean yield of the high

yielding test entries of this trial in the 6th year of tapping is given in Table 5. Very high bark consumption rates were observed in this clearing. Arrangements were made to established estate collaborative trails from clones 87-372, 87-370 and 87-383 based on the proven results.

Table 5. *Mean girth and the results of DMRT of the 1987 H.P. selections*

Clone	Girth (cm) and DMRT grouping
RRIC 121	76.11^{A}
87-370	72.03^{A}
87-364	66.11^{B}
87-372	62.35^{BCD}
RRIC 102	61.48^{CD}
87-382	59.80^{DE}
87-375	59.31^{DE}
87-386	58.68^{DE}
87-369	55.94^{EF}
87-376	51.84^{E}

Table 6. *Mean yield and the results of DMRT of the 1987 H.P. selections*

Clone	Yield (g/t/t) and DMRT grouping
87-372	59.64^{A}
87-370	55.31^{AB}
87-383	54.14^{AB}
RRIC 121	52.04^{AB}
87-364	44.79^{BC}
87-382	40.29^{CD}
RRIC 100	39.09^{CD}

(S P Withanage, 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 5th year of BO-2 panel of each family are based on one test taping due to unfavorable weather *etc.* Progeny size, mean girth (16th year) and mean yield of the seedling families are given in Table 7.

Table 7. *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	07	78.71	28.57
RRIC 101 × GT 1	27	60.64	20.72
RRIC 100 × GT 1	47	84.27	53.61
RRIC 100 × RRIC 101	10	76.60	34.37
RRIC 100 × RRIC 110	08	81.87	39.62
RRIC 100 × RRIC 121	27	81.70	42.89
PB 86 × RRIC 121	14	78.03	24.25
RRIC 102 × GT 1	03	90.83	55.25
RRIC 121 × RRIC 110	24	76.95	30.71
RRIC 110 × RRIC 100	06	74.25	19.00
RRIC 110 × RRIC 121	02	66.00	5.5

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

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

The 11th year girth measurement was taken and the mean girth of clones were grouped using the Duncan's Multiple Range Test. Clones that are better than the control clones are given in Table 8. Mean yields and the DMRT grouping of some selected clones based on nine test tapings in the 4th year are given in Table 9 along with control clones.

Table 8. *Mean girth in cm of the 1988 HP progeny*

Clone	Mean girth and DMRT grouping
88-28	77.02^{A}
88-31	$72.53^{A\ B}$
88-16	$70.96^{A\ BC}$
88-32	$70.39^{A\ B\ C\ D}$
88-40	$67.20^{B\ CD\ E}$
RRIC 100	$63.77^{C\ DEF}$
88-15	62.61^{DEFG}
88-14	62.60^{DEFG}
RRIC 121	62.28^{DEFG}

Table 9. *Mean yield (g/t/t) of the 1988 HP progeny*

Clone	Mean yield and DMRT grouping
RRIC 121	36.80^{A}
RRIC 102	32.60^{AB}
RRIC 110	30.29^{ABC}
88-50	27.20^{ABC}
88-31	26.25^{ABCDE}
88-34	25.88^{ABCDEF}
88-14	25.81^{ABCDEF}
88-16	25.71^{ABCDEF}

(S P Withanage and L S Kariyawasam)

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

The trees of this trial are in fifth year of tapping. The family means of the 10th year girth measurements taken at 150 cm from the ground level and the yield based on five test tappings are given in Table 10. 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 as previous years.

Table 10. *Family means of girth and the yield of the 1992 HP progeny*

Family	Progeny size	Girth (cm)	Yield(g/t/t)
RRIC 100 × RRIM 712	46	64.02	29.84
RRIC 100 × PB 255	64	73.66	36.67
RRIC 100 × PR 255	48	62.76	31.32
RRIC 121 × PB 255	30	73.60	36.60
RRIC 102 × PB 255	22	66.76	22.18
BPM 24 × RRIM 712	5	58.00	20.88
RRIC 100 × PR 309	24	68.17	31.49
RRIC 121 × PR 255	8	59.22	27.35
RRIC 102 × PR 309	1	56.00	3.87
RRIC 121 × PR 309	3	60.25	34.51

(S P Withanage and K W Rupatunga)

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

The 5th year girth taken at a height of 120 cm is given in Table 11. Twelve H.P. selections show vigorous growth than control clones.

Table 11. *Mean girth in cm of the 1995 HP progeny*

Clone	Mean girth and DMRT grouping
95-55	59.73^{A}
95-50	58.61^{AB}
95-48	56.87^{ABC}
95-23	56.11^{ABCD}
95-51	55.84^{ABCDE}
95-45	55.58^{ABCDEF}
95-47	55.51^{ABCDEF}
95-33	$55.24^{BCDEFGH}$
95-29	$55.12^{BCDEFGH}$
95-18	$53.56^{CDEFGHI}$
95-53	$53.56^{CDEFGHI}$
95-40	$53.10^{CDEFGHI}$
PB 255	$53.10^{CDEFGHI}$
RRIC 121	$52.91^{CDEFGHI}$

(S P Withanage, I D M J Sarathkumara and K B Karunasekera)

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

Fifth year girth measurements of the experimental clones are better than the control clone RRISL 205 in both trials (Table 12). Girth measurements were taken at a height of 120 cm.

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

The forth year girth measurements were taken at 120 cm from the two trials. Some of the best HP entries of trail 1 and trial 2 are shown in Table 13.

Table 12. *Mean girth at 120 cm of the 1996 HP progeny*

Mean girth (cm) 96-1 trial		Mean girth (cm) 96-2 trial	
Clone	**Girth**	**Clone**	**Girth**
96-59	49.20^{A}	RRIC 121	45.21^{A}
96-31	45.64^{AB}	96-54	43.06^{AB}
96-15	44.40^{ABC}	96-37	42.00^{ABC}
96-17	44.20^{ABC}	96-44	40.92^{ABCD}
96-14	43.26^{BCD}	96-33	40.08^{ABCDE}
96-4	41.17^{BCDE}	96-53	40.03^{ABCDE}
RRISL 205	41.16^{BCDE}	96-36	39.83^{ABCDE}
		96-47	39.61^{ABCDE}
		96-45	39.37^{ABCDE}
		96-26	39.35^{ABCDE}
		RRISL 205	39.03^{ABCDEF}

(S P Withanage, H P Peris and K B Karunasekera)

Table 13. *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**
RRISL 205	45.73	97-62	42.07
91-29	44.30	61-63	41.40
91-5	43.58	RRISL 205	39.67
91-8	42.75	RRIC 121	38.66
91-19	42.40	91-55	38.58
91-34	42.40	97-58	38.50

(S P Withanage, K W Rupatunge and K B Karunasekera)

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

The forth year girth measurement was taken at a height of 120 cm. In both trials there were 9 HP entries performing better than the best control clone. The girth measurements of the best HP entries of both trials are shown in Table 14 (S P Withanage, T M S K Gunasekera and K B Karunasekera).

Table 14. *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**
97-2	43.33	97-68	49.63
97-19	42.71	97-55	41.86
97-32	42.13	97-48	40.40
97-26	42.00	RRISL 205	39.75
97-10	41.46		
97-25	41.40		
RRISL 205	41.40		

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)

Third 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. Girth of some of the best HP entries and control clones were shown in tables 15a and 15b.

Table 15a. *Mean girth of selected HP entries in cm of the 1998 HP progeny planted at Nivitigalakele Sub stations*

Mean girth(cm) from trial 98-01		Mean girth(cm) from Trial 98-02		Mean girth(cm) from trial 98-03	
Clone	**Girth**	**Clone**	**Girth**	**Clone**	**Girth**
98-88	30.90	98-129	29.39	98-204	28.71
98-180	28.15	98-132	28.90	RRIC 121	28.00
98-134	27.70	98-96	28.57	98-281	27.65
98-147	27.50	98-159	27.96	RRIC 130	27.15
RRIC 130	26.7	RRIC 121	27.80	RRISL 205	27.03
98-108	26.16	98-104	26.03	98-151	27.00
98-122	26.15	RRIC 130	25.65	98-157	26.56
98-119	26.06	98-97	25.59	98-126	25.93
RRIC 121	25.96	98-277	25.53	98-269	25.84

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.

Table 15b. *Mean girth of selected HP entries in cm of the 1998 HP progeny planted at Kuruwita Sub stations*

Mean girth (cm) of trial 98-04		Mean girth (cm) of Trial 98-05		Mean girth (cm) of trial 98-06	
Clone	**Girth**	**Clone**	**Girth**	**Clone**	**Girth**
98-230	23.78	98-58	25.65	98-19	25.14
98-276	23.71	98-68	24.80	98-154	24.79
98-219	23.40	98-80	24.50	98-30	24.71
98-98	23.31	98-51	24.43	98-223	24.42
98-89	23.06	98-73	23.60	98-15	23.16
98-11	23.06	98-62	23.23	98-23	23.07
98-25	22.68	98-41	23.12	RRISL 205	23.00
98-84	22.37	98-07	23.00	RRIC 121	22.76
98-236	22.31	98-71	21.90	98-18	22.75

(S P Withanage, H P Peris and K B Karunasekera).

The second year girth measurements were taken at a height of 120 cm. The HP entries have performed better than the best control clone RRISL 205 as shown in Table 16.

Table 16. *Mean girth of selected HP entries in cm of the 1990 HP progeny planted at Kuruwita Sub stations*

Clone	Mean girth and DMRT grouping
90-11	13.12^{A}
90-27	12.93^{AB}
90-28	12.35^{ABC}
90-10	12.25^{ABCD}
90-7	12.06^{ABCDE}
90-20	11.68^{ABCDE}
90-23	11.62^{ABCDE}
90-4	11.25^{ABCDEF}
90-21	11.18^{ABCDEF}
90-8	11.12^{ABCDEF}
90-19	11.06^{ABCDEF}
90-1	10.93^{ABCDEF}
90-29	10.87^{ABCDEF}
RRISL205	10.87^{ABCDEF}

(S P Withanage, H P Peris and K B Karunasekera).

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

Measurements of the second year girth were taken from each trial and the HP entries have performed better than the best control clone as shown in Table 17.

Table 17. *Mean girth of selected HP entries of the 1999 HP progeny planted at Kuruwita Sub stations*

Mean girth (cm) from trial 99-01		Mean girth (cm) from trial 99-02		Mean girth (cm) from trial 99-03	
Clone	**Girth**	**Clone**	**Girth**	**Clone**	**Girth**
99-73	12.00	99-265	12.18	99-78	14.64
99-71	11.81	99-210	12.06	99-166	12.87
99-81	11.75	99-157	11.62	99-230	12.62
99-55	11.68	99-167	11.56	99-247	12.57
99-48	11.56	99-242	11.50	99-195	12.56
99-42	11.56	99-137	11.42	99-63	12.56
99-61	11.50	99-272	11.14	99-201	12.56
99-64	11.28	99-197	11.14	99-44	12.43
99-43	11.25	99-159	11.06	99-131	12.42
99-72	11.12	99-196	10.87	99-92	12.37
99-95	11.12	99-47	10.87	99-105	12.21
99-52	10.93	99-194	10.81	RRIC 121	12.18
99-108	10.87	99-178	10.71		
RRISL 205	10.81	RRISL 205	10.68		

(S P Withanage, H P Peris and K B Karunasekera).

Evaluation of 2000 H.P. clones at Arappalakande (GPB/BST/HPS/00/01,02,03), Dalkeith estate (GPB/BS/HPS/00/04,05) and Nivithigalakele division (GPB/BS/HPS/00/06,07)

Arappalakande trial I (GPB/BST/HPS/00/01)

In this trial, progenies derived from 11 families are tested in three blocks. Each block contains 364 genotypes in completely randomized single tree plots. Data of the first year girth measurements are given with the families in Table 18a. DMRT grouping shows that there are no significant differences between families.

Table 18a. *Mean girth and DMRT grouping of families in cm of the 2000 HP progeny trial I planted at Arappalakande estate*

Family	Mean girth and DMRT grouping
BPM 24 × PB 235	10.26[A]
RRIC 121 × PB 260	9.73[A]
RRIC 121 × PB 235	9.70[A]
PB 260 × RRIC 121	9.52[A]
RRIC 121 × GP 36-147	9.50[A]
PB 235 × RRIC 121	9.48[A]
BPM 24 × GP 36-104	9.44[A]
BPM 24 × PB 260	9.18[A]
PB 235 × PB 260	9.17[A]
BPM 24 × RRIC 121	9.15[A]
PB 260 × PB 260	8.86[A]

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

Arappalakande trial II (GPB/BST/HPS/00/02)

In this trial a total of 258 genotypes derived from 10 families are tested in a completely randomized single tree plot experiment. Results of the first year girth measurements are given with the families in Table 18b. DMRT grouping shows that there were no significant differences between families.

Table 18b. *Mean girth and DMRT grouping of families in cm of the 2000 HP progeny trial II planted at Arappalakande estate*

Family	Mean girth and DMRT grouping
PB 260 × RRIC 121	9.96[A]
RRIC 121 × PB 260	9.94[A]
BPM 24 × PB 235	9.62[A]
RRIC 121 × GP 36-1	9.60[A]
RRIC 121 × PB 235	9.57[A]
PB 260 × PB 260	9.50[A]
BPM 24 × RRIC 121	9.29[A]
PB 235 × RRIC 121	9.01[A]
BPM 24 × PB 260	8.75[A]
PB 235 × PB 260	8.50[A]

(S P Withanage, K W Rupatunge and K B Karunasekera).

Arappalakande trial III (GPB/BST/HPS/00/03)

This trial contains 90 genotypes derived from a single family BPM 24 × PB 235 in a completely randomized design with four single tree plots per clone. Results of the first year girth measurements show that most of the genotypes have achieved over 8.00 cm (S P Withanage, I D M J Sarathkumara and K B Karunasekera).

Dalkeith estate trial IV (GPB/BS/HPS/00/04)

In this trial, 112 genotypes derived from two families (56 from each family) were planted in a completely randomized design with three single tree plots per clone. Results of the first year girth measurements show that 18 genotypes have achieved over 10.00 cm (S P Withanage, K W Rupatunge and K B Karunasekera).

Dalkeith estate trial V, GPB/BST/HPS/00/05

In this trial, 98 genotypes from two families (53 & 45) were planted in a completely randomized design with three single tree plots per clone. DMRT grouping from the first year girth measurements show that there were no significant difference between the two families (S P Withanage, I D M J Sarathkumara and K B Karunasekera).

Nivithigalakele division trial VII and trial VIII (GPB/BS/HPS/00/06, GPB/BST/HPS/00/07)

In trial VII, 46 genotypes from a single family with three single tree plots in a completely randomized design are being tested. In Trial VIII, 193 genotypes have been included from a single family with three single tree plots in a completely randomized design. Results of the first year girth measurements show that most of the genotypes have good girthing ability (S P Withanage, T M S K Gunasekera and K B Karunasekera).

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 of 13^{th} year girth and 7^{th} year yield obtained from this trial are given in Table 19.

Genotype Environment Interaction (G × E) studies (GPB/GE/98)

Analysis of variance of the sixth year girth showed highly significant differences in growth among clones, sites and the presence of significant genotype × environment interaction effect (Table 20). Table 21 shows the mean girth measurements and the variance of the clones in the eight sites under study.

Table 19. *Mean girth (cm) and yield (g/t/t) obtained from SRRP II clone trial*

Clone	Block I		Block II	
	Girth cm	g/t/t	Girth cm	g/t/t
PB 217	66.38	42.88	66.53	40.79
PB 235	70.19	54.23	66.63	43.08
PB 260	-		67.30	40.72
RRIM 712	58.70	38.52	58.80	39.43
PR 255	64.16	45.75	64.56	32.34
PR 261	64.73	37.55	64.90	34.79
BPM 24	59.01	36.01	59.31	39.03
RRIC 100	69.83	41.13	70.28	36.72
RRIC 121	72.70	36.51	78.82	47.04

(S P Withanage, B M S G Peiris and H P Peris)

Table 20. *The results of the analysis of variances*

Source	DF	Mean square	Significance
Clones	13	3152.89	***
Sites	7	3898.37	***
Clone × Sites	91	119.91	***

*** 0.1%

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

The 4th year girth measurement was taken. Table 22 shows the mean girth of each treatment, *i.e.* control monoclone plots and plots of Bi – and Tri - clonal mixtures.

Table 21. *Mean girth (cm) and the variance of the clones in each site*

Clone	Gane palla	Muwan kanda	Atale	Palm garden	Pelma Dulla	Badde Gama	Bibile	Sorana	Clone Mean	Variance
RRISL 201	52.52	54.97	54.57	46.91	54.33	56.30	42.32	55.05	52.15	24.05
RRISL 205	55.38	58.41	57.07	48.23	50.50	55.83	43.79	62.47	53.95	36.52
RRISL 206	48.55	54.75	56.47	48.78	51.11	55.60	45.12	56.96	52.17	19.32
RRISL 210	49.36	44.14	49.73	42.43	46.45	48.73	36.32	46.33	45.40	20.04
RRISL 215	45.93	48.38	47.34	42.65	49.11	49.29	38.53	48.28	46.25	14.27
RRISL 217	46.32	46.28	49.34	41.36	48.92	48.46	40.53	51.86	46.69	15.49
RRISL 218	46.50	51.42	53.91	38.71	47.44	53.66	39.47	54.55	48.06	40.40
RRISL 220	44.20	47.81	45.09	32.40	45.79	49.75	32.76	36.76	42.03	46.75
GPS 1	36.85	38.77	37.41	32.50	30.25	36.11	33.84	36.23	35.61	7.98
RRII 105	47.91	46.83	50.89	41.53	47.83	51.73	36.97	47.50	46.34	23.84
RRIM 712	41.41	43.67	43.18	31.36	43.14	46.00	34.47	32.41	39.22	33.12
RRIC 130	45.37	42.11	44.00	42.17	50.91	46.88	36.12	45.18	43.91	18.32
Heiken 2	38.73	45.57	44.05	32.92	42.15	41.80	36.64	38.05	39.98	17.44
PB 260	44.00	45.96	49.65	43.82	48.23	49.30	35.14	47.33	45.43	22.14
Site Mean	46.17	48.27	49.12	40.69	48.49	49.28	38.14	47.47	42.48	17.71

(S P Withanage, K W Rupatunga, I D M J Sarathkumara, H P Peris and K B Karunasekera).

Table 22. *Mean girth of each treatment*

Treatment	Mean girth (cm)
RRIC 133	46.08^{A}
RRIC 133/RRIC 121	45.07^{AB}
RRIC 121	44.90^{AB}
RRIC 102/RRIC 133	44.58^{AB}
RRIC 100/RRIC 102/RRIC 133	44.31^{ABC}
RRIC 102/RRIC 121	44.29^{ABC}
RRIC 100/RRIC 102	44.27^{ABC}
RRIC 100/RRIC 133/RRIC 121	43.89^{ABC}
RRIC 102/RRIC 133/RRIC 121	43.84^{ABC}
RRIC 100/RRIC 133	43.04^{BC}
RRIC 100/RRIC 102/RRIC 121	42.73^{BC}
RRIC 102	42.47^{BC}
RRIC 100/RRIC 121	42.41^{BC}
RRIC 100	41.67^{C}

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

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

Third year girth measurements were recorded from this trial and are shown in Table 23.

Table 23. *Third year girth measurements obtained from seedlings and budded plants*

Budded plants	Girth (cm)	Selected seedlings	Girth (cm)	Unselected seedlings	Girth (cm)
PB 86	35.94	RRIC 100	42.84	RRIC 121	41.89
RRIC 121	39.18	RRIC 121	37.27	PB 260	42.95
PB 28/59	38.78	PB 260	43.64	PB 86	39.51
RRIC 100	36.34	PB 86	41.27	RRIC 100	43.05
PB 260	41.20	PB 28/59	37.69	PB 28/59	36.61

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

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

Annual girth measurements were taken from all the trials. Table 24 shows the girth measurements of the current year with the information on planting.

Table 24. *Annual girth measurements recorded from ECTs*

Clone	Site	Year of planting	Girth in cm
RRISL 201	Tempo	1996	62.89
	Moralioya	1996	61.24
	Kuruwita	1994	64.00
	Salawa	1999	50.53
RRISL 202	Moralioya	1996	58.12
	Kuruwita	1994	56.58
RRISL 203	Kuruwita	1991	-
	Galawatte	1987	69.30
RRISL 204	Neuchatel	1997, b-I	51.78
RRISL 205	Pallegoda	1995	64.27
	Vogan	1997	68.5
	Neuchatel	1997,b-I	63.83
RRISL 206	Pallegoda	1995	57.24
	Vogan	1997	59.28
	Neuchatel	1997, b-I	56.33
	Salawa	1999	49.70
RRISL 211	Dartonfield	1994	62.88
	Siriniwasa	2001	28.46
RRISL 215	Salawa	1999	52.01
	Siriniwasa	2001	30.31
RRISL 217	Kuruwita	1995	53.45
	Vogan	1997	54.18
RRISL 218	Siriniwasa	2001	30.46
RRISL 220	Salawa	1999	46.76
RRISL 221	Salawa	1999	45.98
RRISL 223	Galawatta	1994	61.4
RRISL 225	Nivithigalakele	2002	21.65
RRISL 226	Salawa	1999	47.51
	Pallegoda	2000	-
	Siriniwasa	2001	26.04
RRISL 2000	Pallegoda	1998	54.45
	Nivithigalakele	2001	30.60
RRISL 2001	Pallegoda	1995	56.77
	Nivithigalakele	2001	24.77
GPS I	Pallegoda	1998	33.42
	Vogan	1997	-
	Nivithigalakele	2003	-
RRII 105	Pallegoda	1998	47.29
RRII 176	Pallegoda	2000	-
RRIC 133	Kuruwita	1995	68.70
	Salawa	1999	48.46

(S P Withanage, K B Karunasekera, K W Rupatunga, 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 third year commercial yield data obtained from the ECT trial planted at the Pallegoda estate are shown in Table 25. Yield per hectare per year for RRISL 205, RRISL 206 and RRISL 2001 were calculated on the basis of the tappable trees 450 and for 110 tapping days.

The estate yields obtained from RRISL 201, 202 and 217 of the Kuruwita ECT trial in the third year of tapping figures are given in Table 26. The clones RRISL 201and RRISL 202 have been tapped at 100% intensity while the clone RRISL 217 at 67%. The potential YPH of these clones are also shown in table 26.

The estate yields obtained for RRISL 201 and 202 at the Moralioya ECT trial in the third year of tapping are given in Table 27. These clones have been tapped at 100% intensity. YPH of these clones are also shown in table 27.

1st year yield data obtained for RRISL 201 of the Tempo division, Neuchatel Estate and RRISL 223 of the Dartonfield are given in Table 28. RRISL 201 trees have been tapped at 100% intensity and RRISL 223 at 67%.

The estate yields obtained for RRISL 203 at the Kuruwita Estate ECT trial in the 6th year of tapping are given in Table 29 (S P Withanage, K W Rupatunga, 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 25. *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	January	12	250	22.3	40	89.2	29.7
205	February	14	250	17.4	40	69.6	19.8
	March	15	250	18.6	33	61.3	16.3
	April	11	250	11.3	33	37.2	13.5
	May	9	250	9.3	34	31.6	14.0
	June	11	250	18.9	32	62.3	22.6
	July	11	250	20.7	33	68.3	24.8
	August	12	250	23.8	33	78.5	26.1
	September	8	250	13.9	34	41.2	23.6
	October	9	250	18.5	34	62.9	27.9
	November	8	250	16.8	34	57.1	28.5
	December	9	250	18.8	35	65.8	29.2
	Total mean	129				725	
	YPH*	**1112. 5**					
RRISL	January	13	215	29.5	40	118.0	42.2
206	February	13	215	17.8	38	67.6	24.2
	March	7	215	13.4	34	45.5	30.2
	April	7	215	7.3	34	24.8	16.4
	May	10	215	16.7	32	53.4	24.8
	June	11	215	21.7	32	69.4	29.3
	July	11	215	24.0	34	81.6	34.5
	August	12	215	26.0	34	91.0	35.2
	September	7	215	13.3	36	47.8	31.8
	October	9	215	17.7	34	60.1	31.1
	November	9	215	24.8	35	86.8	44.8
	December	9	215	24.2	34	82.2	42.5
	Total mean	118				828.2	
	YPH*	**1615. 9**					
RRISL	January	13	262	546	33	180.18	52.90
2001	February	9	262	310	30	93.00	39.40
	March	14	262	340	28	95.20	25.90
	April	11	262	186	28	52.00	18.00
	May	9	262	196	28	54.80	23.20
	June	11	262	271	28	75.80	26.30
	July	10	262	282	28	78.90	30.10
	August	11	262	298	29	83.40	28.90
	September	7	262	165	30	49.50	26.90
	October	9	262	242	30	72.60	30.78
	November	10	262	335	30	100.50	38.35
	December	15	262	549	30	164.70	41.90
	Total mean	129				1100.58	
	YPH*	**1611.0**					

* for 110 days of tapping and 450 tress per hectare

Table 26. *The third year commercial yields obtained for clones RRISL 201, RRISL 202 and RRISL 217 at 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	13	96	13	119	7	60
February	14	85	14	97	9	57
March	13	74	13	79	4	22
April	10	69	10	73	3	18
May	14	104	14	109	4	26
June	4	28	4	25	2	18
July	15	110	15	101	5	49
August	15	105	16	141	7	61
September	12	90	12	99	4	46
October	16	117	16	134	5	51
November	15	107	15	118	7	66
December	14	116	14	115	7	99
Total	155	1101	156	1210	64	573
YPH*		**1156**		**1267**		**1840**

* 110 days of tapping and 450 tress per hectare for RRISL 201 and RRISL 202 and for RRISL 217 number of tapping days was taken as 90.

Table 27. *The third year commercial yields obtained for Clones RRISL 201and RRISL 202 at Moralioya estate*

Month	RRISL 201 (No. of trees tapped 255)		RRISL 202 (No. of trees tapped 253)	
	No. of tapping days	Yield Kg	No. of tapping days	Yield Kg
January	13	76	14	89
February	11	54	10	47
March	9	49	9	46
April	6	41	6	37
May	3	19	3	20
June	6	39	8	53
July	9	53	9	52
August	16	102	17	110
September	4	32	4	25
October	8	54	10	63
November	10	73	11	78
December	15	101	15	96
Total	110	693	116	716
YPH*		**1222**		**1207**

- for 110 days of tapping and 450 tress per hectare

Table 28. First year *commercial yields obtained from clones RRISL 201Tempo division, Neuchatel estate and Clone RRISL 223 Dartonfield group*

	RRISL 201 (No. of trees tapped 213)		RRISL 223 (No. of trees tapped 300)	
Month	**No. of tapping days**	**Yield Kg**	**No. of tapping days**	**Yield Kg**
January	10	70.9	5	49
February	8	42.2	13	69
March	4	20.4	7	52.6
April	5	33.5	3	31
May	4	24.0	1	6
June	5	43.9	3	26
July	7	65.9	4	45
August	11	94.8	8	95
September	6	36.3	2	18
October	4	26.6	1	4
November	11	94.2	4	24
December	16	141.6	7	66
Total	91	694.3	58	485.6
YPH*	**1773**		**1130**	

* for 110 days of tapping and 450 tress per hectare for RRISL 201 for RRISL 223 number of tapping days were taken as 90.

Table 29. *The 6th year commercial yields obtained for Clone RRISL 203 at Kuruwita Sub-station*

	RRISL 203 (No. of trees tapped 325)	
Month	**No. of tapping days**	**Yield Kg**
January	14	147
February	13	96
March	8	49
April	9	59
May	12	89
June	13	101
July	13	99
August	13	99
September	11	72
October	14	91
November	14	124
December	12	101
Total	146	1127
YPH*		**1175**

* YPH was calculated for 450 trees and 110 tapping days

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

Third year girth measurements were taken from these trials (Table 30). All three clones planted under this programme showed vigorous growth.

Table 30. *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	31.70
			RRISL 203	31.06
	SRT/01/02	T A Bandula Kumara	RRISL 205	23.84
Homagama	SRT/01/03	D C Ratugama	RRISL 201	31.66
			RRISL 203	26.66
			RRISL 205	32.51

(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

Second year mean girth of the four clones obtained from three sites planted in the year 2002 are given in Table 31. The first year girth of the clones planted in year 2003are given in table 32. The site planted by Mr K C Gunathilaka is affected with frequent floods resulting a set back in plant growth. The damaged and weak plants were re-supplied.

Table 31. *Mean girth of the trials planted in 2002*

Site	Expt. No.	Farmer	Clone	Mean girth cm
Kalutara	SRT/02/02	R A Gunathilaka	RRISL 201	17.81
			RRISL 205	16.60
			RRISL 206	19.00
			RRIC 121	12.98
	SRT/02/03	K C Gunathilaka	RRISL 201	13.59
			RRISL 205	14.74
			RRISL 206	15.98
			RRIC 121	12.67
Ratnapura	SRT/02/04	A L D Jayasena	RRISL 201	11.32
			RRISL 205	12.37
			RRISL 206	12.15
			RRIC 121	9.62

Table 32. *Mean girth of the trials planted in 2003*

Site		Farmer	Clone	Mean girth (cm)
Kamburupitiya	SRT/03/01	T Wickramaratne	RRISL 201	10.0
			RRISL 205	8.88
			RRISL 206	9.18
			RRIC 121	9.91
Radawela	SRT/03/02	Piyadasa Sirisena	RRISL 201	8.51
			RRISL 205	7.71
			RRISL 206	7.35
			RRISL 121	8.10

(S P Withanage, K B Karunasekera, L S Kariyawasam, H P 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 Karunasekara, S P Withanage and T M S K Gunasekera).

New plantings

Estate/RRI collaborative clone trials

Two ECT trials were established in July at the Dorset division and Main division of the Clyde estate. One tapping task from each of the following clones were planted in these trials.

Dorset division (GPB/BST/ECT/04/01)

RRISL 223, RRISL 2000, RRISL 2001, RRISL 2002, RRISL 2003 and RRISL 2004

Main division (GPB/BST/ECT/04/02)

RRISL 207, RRISL 214, RRISL 2005 and RRISL 2006

PLANT SCIENCE

P Seneviratne

SUMMARY

Micrografting was done for one month and one year old embryo cultured plants of *Hevea* grown in different media using both clonal and seedling shoots derived from *in vitro* grown nodal cultures. Two months old *in vitro* grown micrografted shoots were re-cut in to nodal pieces and cultured on different media.

A uniform seedling population was raised from seedling individuals through rooted cuttings. A budgrafting experiment was carried out to see the effect of the position of the bud patch on budgrafting success and growth of plants, using uniform seedlings obtained through rooted cuttings. Budwood of clone RRISL 203 was used for this experiment.

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.

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 existed in both zones. As expected, the seed production was higher at field boundaries and lower in the center plots irrespective of the clone and the age category in both zones.

In a study on brown bast, 41 tapping blocks have been surveyed during the year. Collection of data from 75 tapping blocks of different clones and of different age categories was completed. According to the results, % TPD has increased generally with the advancement of the tapping panel from A to D. There was no clear clonal difference. Methodology development was done for the biochemical studies of TPD affected and healthy trees of rubber. Preliminary extraction procedures for the analysis of sugars were done.

Adoption of the LFT and its potential effectiveness to solve the negative effects of tapper shortage was assessed. The age distribution of tappers was examined to assess the future trends in tapper availability. Also, availability of casual labour was examined to consider the possibilities of training them for tapping.

In order to improve the easiness in fixing rainguard, a new system of fixing the polythene cover was developed based on the information gathered from the Rubber Research Institute of India. This system comprised with a strip of cloth together with the brushable type sealant. The system was tested in both Dartonfield estate and at Kuruwita substation and found to be superior compared to the traditional way of fixing. Also, semi skirt type rainguards with both high and low density

polythene were tested to facilitate situations where tappers have negative thoughts on rainguards. Low density polythene was found to be more suitable in this regards.

A field survey was commenced to investigate the socio economic conditions of rubber based intercropping systems. A financial evaluation at the smallholder farmer level on three widely used intercropping systems such as banana, tea and pineapple was the focus in this survey. Twenty farmers were interviewed by end of the year 2004.

The amount of carbon fixed on a sunny and a dull day was estimated as 8.65 and 7.0 gm^{-2}, respectively. On this basis, the annual rate of carbon fixed in the genotype RRIC 121 was 31.8 $MTha^{-1}$ whilst 12.21 $MTha^{-1}$ in RRIC 100.

Rubber trees in four sites comprising three genotypes, *i.e.* 28 and 30 year old RRIC100 in two sites, 11 year old RRIC121 and 30 year old RRIM600, were selected for the detailed assessment of timber volume. Two simple models were developed and lines were fitted based on two models to estimate timber volumes.

The growth in girth of rubber trees was highest in treatments having widest inter row spacing with single rows of rubber. Cinnamon bark yield was highest in wider inter row spacing treatments with rubber planted with paired rows. Those treatments with narrow inter row spacing gave low yields.

Advisory visits and training programmes on bud grafting, tapping and fixing of rainguards was done for both small holder and RPCs. Budwood of authentic materials were issued for the establishment of budwood nurseries. Nursery inspection was continued for productivity improvement. The management of all government nurseries, including the newly opened Moneragala nursery was taken back in August 2004 by the RDD. For the planting season in May-June, 575,000 plants were issued from these nurseries by the RRISL.

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 and Dr A M W K Seneviratne, Botanists, Mr N M C Nayanakantha and Mr N A A D Wickramarathna Assistant Botanists, Mr K A G B Amaratunga, Mr R P Karunasena, Mrs G A S Wijesekera, Mr S Wilbert, Mr U S Weerakoon, Mrs R K Samarasekera, Mr T U K Silva, Mr M N de Alwis and 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, Mrs D E Jayawardena and Mrs P D A H M A de Almeida, Clerk/Typists were on duty throughout the year.

Mr N A A D Wickramarathna left for his postgraduate studies at University of Alberta, Canada, on 01.09.2004.

Mr R P Karunasena was awarded a short training at the Rubber Research Institute of India, from 20 08.2004 to 12.12.2004.

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.

- Two students from the University of Colombo carried out tissue culture related work on rubber and *Paulownia.*

- Mrs E S Munasinghe, Research Assistant, continued her project on "Assessment on potential capability of carbon fixation in different genotypes of rubber" under the supervision of Dr V H L Rodrigo.

- Ms C Edusuriya from University of Ruhuna started her project on "*In vitro* micrografting in rubber, *Hevea brasiliensis*" with effect from 22nd April under the supervision of Dr (Mrs) P Seneviratne and Mr N M C Nayanakantha.

- Ms G R T S Senarathna from University of Peradeniya started her project on "A study on the variation of poly bagged seedlings and budded populations of rubber (*Hevea brasiliensis*) in a commercial rubber nursery" with effect from 24th May under the supervision of Dr (Mrs) P Seneviratne and Mr N M C Nayanakantha.

- Mr W A C D Gunatilaka from Advanced Institute Nawala, Veyangoda started his training on aspects regarding rubber nurseries with the supervision of Dr W Seneviratne, with effect from 6.04.2004.

- Ms R D Vidanapathirana, Research Assistant, continued her project on "Correct adoption of existing tapping systems to solve the labour related issues in both plantations and smallholder sectors of rubber industry" under the supervision of Dr V H L Rodrigo and Mr N A A D Wickramarathna.

- Mr S T G C de Silva, Research Assistant, continued his project on "Harvesting of *Hevea brasiliensis* genotypes introduced to areas marginal with regard to elevation" under the supervision of Dr A Nugawela.

Meetings and Workshops

Officer	Subject	Organization
Dr (Mrs) P Seneviratne	Scientific Committee Meeting	RRI
Dr (Mrs) P Seneviratne	The effect of quality of plants on the productivity of rubber	RRI
Dr V H L Rodrigo	Rainguard programme for 2005	RRI
Dr V H L Rodrigo	Research, what does it mean?	RRI
Mr W Karunatilaka	Rainguard application	RRI
Dr (Mrs) P Seneviratne	Meeting on rubber planting and nurseries	Ministry of Plantation Industries
Dr W Seneviratne	New Planting Programme at Moneragala	Ministry of Plantation Industries
Mr N M C Nayanakantha and Mr N A A D Wickramarathna	Two day workshop on "Scientific Writing"	CARP
Dr V H L Rodrigo	Two workshops in Senior Research programme on climate change	Climate Change Enabling Project
Dr V H L Rodrigo Mr C Nayanakantha, Mr N A A D Wickramarathna, Mr S T G C de Silva and Mrs E S Munasinghe	Workshop in Junior Research Programme on climate change	Climate Change Enabling Project
Dr V H L Rodrigo	Stimulation and Rain guarding	Horana Plantation (Ltd.).
Dr W Seneviratne	New planting programme	Land Ministry, Colombo
Dr P Seneviratne, Dr V H L Rodrigo, Mr L S S Pathiratna, Dr A M W K Seneviratne, Mr N M C Nayanakantha, and Mr N A A D Wickramarathna	First Symposium on Plantation Crop Research	TRI, RRI & CRI

Officer	Subject	Organization
Mr L S S Pathiratna	National Symposium on Medicinal Plants	Sri Lanka Conservation and Sustainable use of Medicinal Plants Project
Dr W Seneviratne	Directors meeting	CRI
Dr V H L Rodrigo, Mr N M C Nayanakantha, Mr N A A D Wickramarathna, Mr S T G C de Silva and Mrs E S Munasinghe	Report Finalization/ Dissemination workshop on Junior Research Programme	Ministry of Environment and Natural Resources

Training programmes

Client	Subject	No. of programmes
Plantation Sector	Tapping	03
Plantation Sector	Ethrel stimulation	02
RDD	In house budder training programme for Moneragala Nursery (22 budders)	01

Advisory visits

Client	No. of visits
Plantations	12
Smallholders	03

LABORATORY INVESTIGATIONS

Tissue culture

***Propagation of clonal* Hevea**

Micrografting was done for one month and one year old embryo cultured plants grown in different media using both clonal (RRIC 100 and RRIC 121) and seedling shoots derived from *in vitro* grown nodal cultures. Maximum successful graft intake was obtained with one month old *in vitro* grown seedling derived rootstocks compared to those with one year old stocks grafted with both the scion types (clonal and seedling). There was no significant difference in elongation of scions taken from both seedling and clonal materials and micrografted on to one month old stocks even after 6^{th} week from culture. The scions derived from *in vitro* grown nodal explants of clone RRIC 121 performed well in further elongation compared to that from the explants of clone RRIC 100 after one month from culture. Two months old *in vitro* grown micrografted shoots were re-cut in to nodal pieces and cultured on different media (N M C Nayanakantha, P Seneviratne and C P Edusuriya).

Micropropagation of other species

Mucuna bracteata

Mucuna seeds were cultured on different media according to a factorial combination of hormones in order to obtain multiple shoots. Axillary shoot elongation was continued with different hormone combinations (P Seneviratne and G A S Wijesekera).

Paulownia spp.

Seedling cultures were maintained by subculturing nodal explants of the seedlings on different media. Explants of leaves (petiole+half laminae) from about three months old *in vitro* grown seedlings were cultured on 25 different combinations of 2,4-D and BAP on MS media according to a factorial design. However, no direct shoot initiation occurred in any of the media but calli developed on some media. Most of the explants turned brown after about 7-10 days and dried. Nevertheless direct shoot formation occurred with leaf+laminae explants harvested from 10 month. seedlings maintained by repeated sub culturing of nodal explants.

Vegetative propagation of *Paulownia*

Field grown plants (both tissue cultured and plants brought from Parakaduwa nursery and planted in the field) were maintained by weeding and watering. Flowering occurred in most of those old plants after about 5-6 months from planting. *Corynespora* leaf disease was severe on mature leaves of most of the old plants. However, in some plants all leaves had been fallen due to *Corynespora* attack and only the stumps remained at the end of the year with no sign of sprouting (N M C Nayanakantha, P Seneviratne and G A S Wijesekara).

FIELD EXPERIMENTS

Clonal propagation

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

Field planted plants, produced from rooted cuttings were maintained in the field and annual girth measurements were taken.

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

Vegetative propagation through rooted cuttings was not successful up to now due to maturity factor associated with them. Budded plants of about 5 high yielding individuals are maintained as a bud wood nursery (P Seneviratne, G A S Wijesekera and R K Samarasekara).

***Phase change of* Hevea**

Growth, wintering and flowering were monitored of the seedlings planted in the field consecutively from the year 1991. Wintering occurred, in seedlings from year 1991 to 2000 and flowering was observed in trees from the year 1991 to 1997 as shown in Table 1.

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

Year planted	Wintering	Flowering
1991	√	√
1992	√	√
1993	√	√
1994	√	√
1995	√	√
1996	√	√
1997	√	√
1998	√	-
1999	√	-
2000	√	-
2001	-	-
2002	-	-
2003	-	-

(P Seneviratne and G A S Wijesekera).

Variation in budded plants

The uniform seedling population raised from seedling individuals through rooted cuttings was used for budgrafting experiment to see the effect of the position of the bud patch on budgrafting success and growth of plants. Budwood of clone RRISL 203 was used for this experiment.

As the age of the seedlings was different, though they are from the same plant, the results were not significant. Therefore, all the uniform plants of this experiment were cut back and the experiment will be repeated (P Seneviratne and G A S Wijesekera).

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

Plants with different root systems but of the same genetic make up, were maintained in the field. These plants were obtained by splitting the germinated seedling and by inducing roots on cuttings. Girth measurements of 4½ years old plants are given in Table 2.

Table 2. *Girth measurements of the* plants *of the same genetic makeup*

Girth of the seedling (cm)	Girth of the relevant cutting (cm)
49	44.5
47	33.5
3.1	46
46	18.3
25	19
19	49
31	42
35.5	57
32.5	20.5
33	40.5
Mean 34.9 (3.1)	37.03 (4.3)

Being seedlings they show a big variation in girth and therefore the values are not significantly different (P Seneviratne and G A S Wijesekera).

Rootstock nurseries

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

The mist was under repair during the seed fall period and hence experiments were stopped until it was properly installed.

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

A new set of polybagged plants were irrigated with the locally produced porous pipes in comparison with the existing Aqua Spa porous pipes system.

There was a significant difference in the mean diameter values of polybagged plants irrigated with the Aqua Spa system compared to that with the manual method (Table 3). However, the mean diameter values of the plants irrigated with the locally produced porous pipes were low in comparison with the control plants. The lower performance of the locally produced porous pipe system was mainly attributed with its poor porosity. The porosity was not uniform and at some places water drained out and at many places there were no sufficient porosity at all. As a result some plants had received excess amount of water and some received very little.

Table 3. *Monthly mean diameter measurements of polybagged plants irrigated with two micro porous irrigation systems and with a manual method*

Age (months)	Diameter (mm) in polybagged plants		
	Imported porous pipes	Locally produced porous pipes	Control
1	3.9±0.1	3.8±0.1	3.8±0.1
2	5.2±0.1	5.0±0.1	4.9±0.1
3	6.8±0.1	5.8±0.3	6.3±0.1
4	8.4±0.1	7.7±0.1	8.2±0.2
5	9.5±0.2	8.4±0.2	8.8±0.2
6	10.2±0.2	9.3±0.3	9.5±0.2
7	11.0±0.2	10.1±0.2	10.8±0.3
8	12.1±0.1	11.1±0.1	11.4±0.2
9	13.0±0.4	12.0±0.3	12.4±0.4

(N M C Nayanakantha and P Seneviratne)

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

The total number of seeds per hectare in the clone PB 86 and RRIC 100 in the Intermediate Zone in 2004 was slightly low compared to that in 2003 at both age categories (Fig. 1). However, in RRIC 121, there was a slight increase in seed production in 2004 compared to that in 2003. In Wet Zone, no considerable increase or decrease in the number of seeds per hectare was observed.

Phytophthora pod and leaf fall was higher in the intermediate zone in 2004 than in 2003. This was prominent in PB 86.

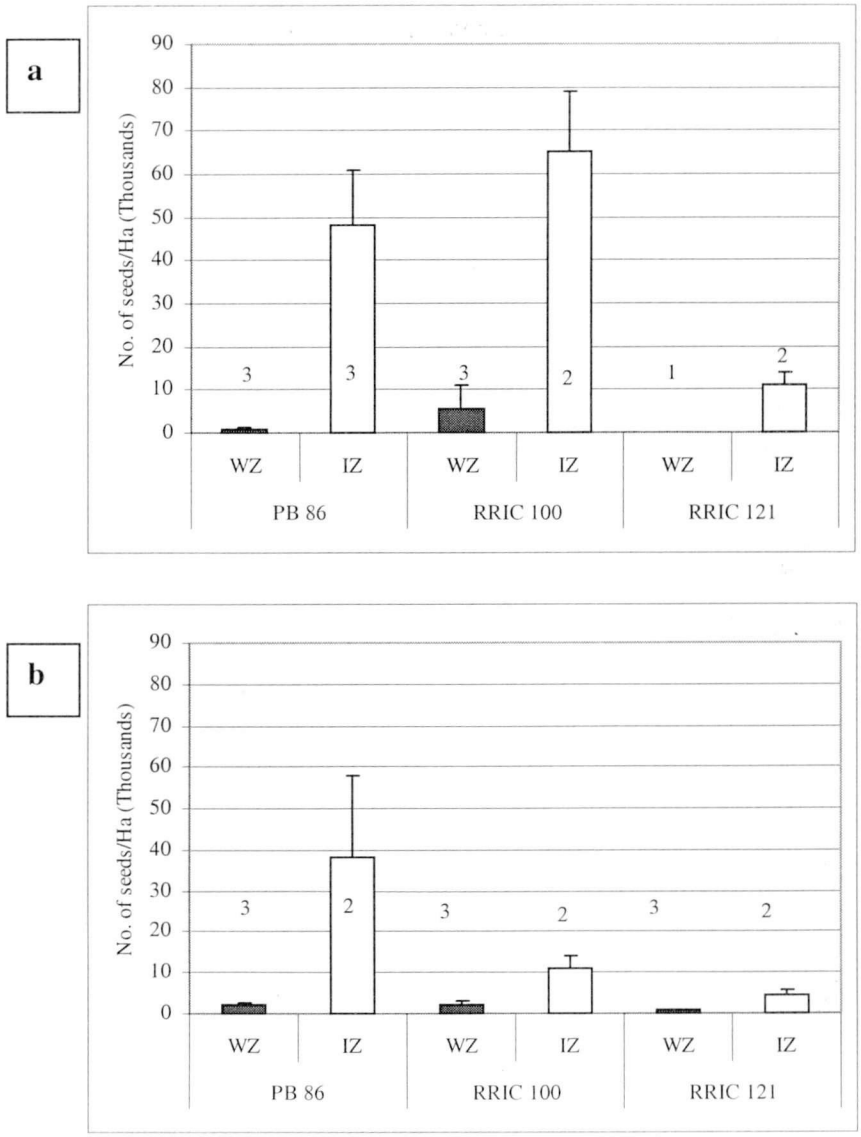


Fig. 1. Total seed production in each clone in all sites of the Wet Zone and the Intermediate Zone. WZ: Wet Zone, IZ: Intermediate Zone, **a**: Clones in 18-26 age category, **b:** Clones in 10-15 age category. Numerical on bars represent the number of sites in each Zone.

(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)

Monthly girth data were obtained from Culloden Estate (N M C Nayanakantha and P Seneviratne).

Budgrafting

Successive grafting - BG/1999/1 - Dartonfield

One budgrafting passage was completed during the year. Six passages have been completed by now (P Seneviratne and G A S Wijesekera).

Crown budding

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

Mean girth of RRIC 110 trees crown budded with RRIC 100, 102, 117, 130 and *H. spruciana* at Padukka estate are given in Table 4. As shown in table 4, RRIC 121 shows the highest girth in both clearings which is significant. *H. spruciana* being another species shows the lowest girth.

Table 4. *Mean girth of RRIC 110 trees crown budded with RRIC 100,102,117,130 and H. spruciana*

Menerigama Division

	H. Spurciana	RRIC 100	RRIC 102	RRIC 117	RRIC 121	RRIC 130
Mean girth (cm)	48.003	52.443	56.477	55.009	74.82	52.980
No. of plants	25	25	25	25	25	25
SEM (±)	0.805	0.997	1.680	1.022	1.250	1.015

Main Division

	H. Spurciana	RRIC 100	RRIC 102	RRIC 110	RRIC 117
Mean girth (cm)	53.788	50.092	53.069	66.33	53.237
SEM (±)	1.795	0.508	1.014	3.703	0.654

(P Seneviratne, S Wilbert and M N de Alwis).

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

Average yield for a period of one month during 2004 is given in Table 5. The girth of crown budded trees is less when compared with unbudded (not crown budded) trees owing to the set back after cut back.

Yield data shows some similarity in control RRIC 100 and trees with RRIC 100 as the canopy trees. The higher yields in trees, which were not crown budded is attributed to the higher girth (Table 5).

Table 5. *Average yield (volume) and girth (Number of tappings is given in brackets)*

Treatment	Mean girth in cm	Yield ml/e/t
1. Trunk – RRIC 121, crown – RRIC 100	63.24	140.7 (10)
2. RRIC 121 (Not crown budded)	87.96	270.6 (10)
3. RRIC 100 (Not crown budded)	84.80	293.0 (10)
4. RRIC 131 (Control)	61.30	111.41(16)
5. RRIC 100 (Control)	62.70	145.06 (15)

(P Seneviratne and S Wilbert).

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

Average yield and girth of RRIC 130 trees and crown budded trees with *Hevea spruciana* are given Table 6.

The yields of the trees with *H. spruciana crowns are very* poor when compared to the yields of RRIC 130. Though the girth is comparable the yield of RRIC 130 is about four fold showing the contribution of the canopy for the yield.

Table 6. *Average yields (volume) and girth (Number of tappings are given in brackets)*

Crown	Tree No.	Girth in cm	Average yield ml/t
	1	65.2	65.4 (13)
Hevea spruciana	2	65.9	72.7 (13)
	3	-	Formes
	8	77.3	82.1 (12)
	Mean	***69.46***	***73.4***
	4	49.5	60.4 (13)
	7	-	W/D
RRIC 130	9	86.2	501.9 (13)
	10	-	BB
	11	73.6	331.1 (13)
	12	-	
	13	83.9	339.2 (13)
	Mean	***73.3***	***308.15***

(P Seneviratne and S Wilbert).

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

Mean girth of RRISL 224 trees having different crowns are given in Table 7.

Table 7. *Mean girth of the trees with different crowns*

Crown clone/clones	Mean girth (cm)
RRIC 100	61.34
RRIC 100/*H. pauciflora*	68.5
RRIC 100/RRIC 121	64.94
RRIC 100/RRIC 121/*H. pauciflora*	64.47
H. paucflora	53.46
RRIC 121	59.025
RRIC 121/*H. pauciflora*	58.69

(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

Control treatment of all combinations continue to show the highest girth values owing to the continuous growth without any set back (Table 8). All pollarded and crown budded trees showed a girth increment of more than 10 cm. It is too early to comment on the performance of various combinations.

Table 8. *Mean girth of trees with different crown/trunk combinations*

Treatment	Trunk	Crown	Mean girth (cm)
1	PR 305	Control *	41.57 ± 0.09
	PR 305	RRIM 717	29.95± 1.08
	PR 305	Pollarded	41.24 ± 0.83
2	RRIM 717	Control *	42.05 ± 0.79
	RRIM 717	PR 305	30.06 ± 0.75
	RRIM 717	Pollarded	37.4 ± 2.44
3	BPM 24	Control *	38.41 ± 1.46
	BPM 24	PB 260	
	BPM 24	Pollarded	34.3 ± 1.88
4	PB 260	Control *	44.54 ± 2.17
	PB 260	BPM 24	29.99 ± 1.72
	PB 260	Pollarded	42.75 ± 1.75
5	RRIC 121	Control *	47.62 ± 1.63
	RRIC 121	RRISL 217	33.75 ± 2.28
	RRIC 121	Pollarded	42.27 ± 1.19
6	RRISL 217	Control *	43.21 ± 1.06
	RRISL 217	RRIC 121	35.25 ± 0.48
	RRISL 217	Pollarded	40.23 ± 0.81
7	RRIC 121	Control *	47.27 ± 1.29
	RRIC 121	RRIC 130	29.5 ± 2.84
	RRIC 121	Pollarded	48.28 ± 1.53
8	RRIC 130	Control *	49 ± 1.10
	RRIC 130	RRIC 121	31.95 ± 2.93
	RRIC130	Pollarded	46.42 ± 1.12

*Not crown budded

(P Seneviratne and L Zoysa).

Budwood nurseries

Budwood availability

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

These budwood nurseries were established in 2000 with new RRISL clones in order to provide authentic material for the establishment of budwood nurseries in private and Regional Plantation Company Nurseries.

Table 9. *Number of plants available from each clone*

Clone	BN/2000/DF	BN/2000/ Olikanda	BN/2002/ Olikanda
RRISL 200	11	7	
RRISL 201	31	11	-
RRISL 202	17	3	-
RRISL 203	30	18	-
RRISL 205	29	15	-
RRISL 210	18	-	-
RRISL 215	29	5	-
RRISL 217	44	98	-
RRISL 218	24	-	-
RRISL 219	18	-	-
RRISL 2000	-	-	120
RRISL 2001	-	-	82
RRISL 2002	-	-	40
RRISL 2003	-	-	83
RRISL 2004	-	-	53
RRISL 2005	-	-	52
RRISL 2006	-	-	25
Total	**251**	**157**	**455**

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

Nursery inspection

A total of 37 rootstock nurseries of private, RPCs and RDD nurseries were inspected as shown in Table 10.

Table 10. *The region wise distribution of nurseries inspected*

Region	No. of nurseries inspected		
	Private	RPC	RDD
Kalutara	1	4	2
Ratnapura	5	-	2
Kegalle	21	-	2

The budwood nurseries inspected during the year 2004 are given in Table 11.

Table 11. *Budwood nurseries inspected in different regions*

Region	No. of budwood nurseries		
	Private	Estate	RDD
Kalutara	-	4	2
Ratnapura	4	-	2
Kegalle	15	1	2

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

Rejuvenation of budwood nurseries

This experiment was started in 2004, with clone RRIC 100, 102 and 121 with the objective of getting the old clonal material rejuvenated through repeated grafting.

Two budgrafting passages were completed up to now, in the nurseries at Egaloya and Welikadamulla (P Seneviratne and G A S Wijesekera).

RRISL nurseries

Plants issued up to June 2004 from the nurseries established in August 2003, and the details of the nurseries of January 2004, are given in the table12. However, all 6 nurseries were taken over by the RDD with effect from July 2004.

Table 12. *Summary of the plant production for 2004 from government nurseries (plant issues are only up to June 2004)*

Nursery	2003 August Nurseries		2004 January Nurseries			
	Y/B	B/R	Y/B		B/R	
	Issued	Issued	Established	Expected	Established	Expected
Karapincha	15,988	50,000	241,000	175,000		
				(200,000)		
Meerigama	98,411	53,275	160,000	125,000		
Welikadamulla	143,365	43,030	197,000	150,000	20,000	15,000
Egaloya	87,000		215,000	175,000		
Gurugoda			(258,000)	180,000		
Moneragala			260,000	200,000		
Total	344,764	146,305	1,331,000	1,005,000	20,000	15,000
		491,069				

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

Planting techniques

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

Data collected annually have been reported in previous annual reports. However, the treatments tested are given in Table 13 along with the girth values for young buddings and polybags separately for 2004. With both types of planting materials, the treatment 1, *i.e.* those planted with the polybag continued to show the lowest girth. Though the control treatment showed the highest girth values, treatments 2, 3, 4 and 5 are not significantly different.

Table 13. *Girth and the girth increment of trees in different treatments (SEM values are given within brackets)*

Treatment	Young budding RRIC 121 1999 N/E	Polybags PB 260 1999 S/W
T1 - With the polybag	46.0	44.63
	(0.91)	(1.16)
T2 - Without the base of the bag	45.9	48.91
	(1.24)	(1.30)
T3 - Without the base of the bag but with 4 slits	46.52	48.38
	(1.29)	(1.62)
T4 - 4 slits only	47.26	47.8
	(1.27)	(0.85)
T5 - Bag removed as in the current Recommendation	48.2	51.71
	(1.38)	(1.89)

(P Seneviratne and U S Weerakoon).

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

Details of the experiment and the annual girth increments have been reported in the previous annual reports. As it is shown in Table 14 girth increment is satisfactory and the effect of the soil type is minimum.

Table 14. *The mean girth (cm), girth increment (cm) and SEM for the three types of planting holes*

Soil condition	Girth (cm)	Girth increment (cm)
Bad	32.05 (± 0.13)	13.33 (± 0.12)
Moderate	32.28 (±0.53)	13.32 (± 0.24)
Good	33.04 (± 0.17)	13.79 (± 0.15)

(P Seneviratne and L Zoysa).

Coppicing (CP/2002/1-N'Kale)

Shoot regeneration capacity of mature trees was tested by pollarding some RRIC 52 trees planted in 1972 at the height of 6" (30 years old clearing). The sprouting time varied from tree to tree and also the girth and the number of shoots produced showed a big variation. Further, the success rate was only 15% owing to the trees being very old. However, the trials conducted at Dartonfield and Galewatta in 2003 showed some positive results as far as the success rate and the girthing values are concerned. When 5-6 years old trees were cut at 12" and 18" the average girth of 25cm was observed (P Seneviratne and M N de Alwis).

Cultural practices during immature phase

Branch induction – CP/2001/1 – Pallegoda

Though the mean girth of the trees of which the branches were induced by the leaf cap was slightly higher they are not significantly different from the other treatments. However, for the mixed clones it is higher when compared to the control treatment (Table 15).

Table 15. *Mean girth of the trees for different branch induction treatments for the clone RRIC 121 and for the mixed clones. SEM values are given within brackets*

Treatment	Mixed clones	RRIC 121
T_1 - Leaf cap	62.74 (1.13)	63.33 (1.43)
T_2 - Leaves cut	59.20 (1.04)	60.54 (1.15)
T_3 - 3" long apex removed	60.9 (1.02)	62.82 (1.19)
T_4 - Control	59.39 (1.03)	62.12 (0.88)

(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 16. The growth parameters as indicated by mean girth, bark thickness and percentage trees in tapping have decreased with the increase of planting density. Hence, latex yield at individual plant level (g/t/t) was highest in the lowest density and it was vice versa in the highest density. However, percentage trees in tapping decreased slightly from the values recorded for 2003 due to the increased incidence of tapping panel dryness. The overall performance of RRIC 121 was superior to that of other clones, whilst it was lowest in RRIC 110, the clone affected by *Corynespora* leaf disease.

Table 16. *Effect of planting density on growth and yield parameters of rubber. In (a) plant girth (cm) and bark thickness (mm) at 150cm height and % trees in tapping, (b) tree yield (g/t/t) and estimated YPH (kg/ha/year)*

(a)

	RRIC 100				RRIC 110				RRIC 121			
Density	**Girth (cm)**	**Bark thickness (mm)**	**% Trees in tapping**	**Tappable trees/ha**	**Girth (cm)**	**BT (mm)**	**% Trees in tapping**	**Tappable trees/ha**	**Girth (cm)**	**BT (mm)**	**% Trees in tapping**	**Tappable trees/ha**
500	60.93	7.31	79.39	397	56.80	6.94	57.83	289	67.35	7.19	80.08	400
600	59.86	7.28	77.30	464	52.74	6.42	54.54	327	63.59	7.10	84.24	505
700	56.33	7.00	75.22	527	50.89	6.47	43.38	304	62.25	6.66	81.51	571
800	56.11	6.97	74.28	594	49.73	6.28	41.89	335	60.17	6.50	81.93	655

(b)

	RRIC 100		RRIC 110		RRIC 121	
Density (tree/ha)	**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	26.34	1547	27.90	1127	42.22	2510
600	25.98	1729	24.55	1067	34.89	2588
700	20.08	1559	21.71	956	31.43	2504
800	21.71	1873	22.61	1200	28.26	2782

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

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

Details of the experiment and the annual girth data have been reported in previous annual reviews. Effective trees of the block at N'Kale were remarked and arrangements were made to record yield data. Girth measurements at 5' height from the graft union are given in Table 17. Girth decreased with increasing planting density irrespective of the clone.

Table 17. *Mean girth (cm) of four clones for the four densities*

	C_1	C_2	C_3	C_4
T_1	72.29	73.46	75.12	67.65
T_2	70.28	72.06	72.55	67.36
T_3	63.97	67.12	67.65	61.31
T_4	61.72	65.36	58.04	60.51

C_1 - RRIC 100, C_2 – RRIC 121, C_3 – RRIC 133, C_4 – PB 260
T1- 350 t/h, T2- 425 t/h, T3 – 500 t/h, T4 – 575 t/h

(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

Exploitation continued throughout the year with over 25 tapping days in each month except in November (21 tapping days). Rains were mainly confined to the afternoons and tapping panels of the trees were apparently dry by following morning even without rainguards. RRIC 100 and RRIC 102 were tapped at ½ S d/2 system while RRIC 130 and PB 260 at ½S d/3 system as done in previous year. Latex volume and dry rubber content were recorded for each clone on daily basis. Initial flow rate and plugging index were monitored in ten trees of two growth categories i.e. at 45cm and 50cm girth, at monthly intervals. Dry rubber yield per tree per tapping (g/t/t), latex volume and girth were highest in clone RRIC 130. The dry rubber contents (DRC) were less in all four clones in this region and it was higher than the values recorded in the year 2003. RRIC 130 clone recorded the lowest DRC content in latex (Table 18).

Initial flow rate in all clones was higher than that in year 2003. The highest initial flow rate was recorded in clone RRIC 130.The plugging index is lowest in RRIC 130 and PB 260 (Table 18). The clones tapped at low frequency ½ S d/3 system recorded the highest g/t/t levels (Table 19).

Table 18. *Yield and growth performance of different* Hevea *clones*

Parameter	Clone			
	PB 260	RRIC 102	RRIC 100	RRIC 130
Yield (g/t/t)	33.45	23.75	26.95	43.30
Latex volume (ml/tree/tapping)	112.45	86.15	98.35	166.70
Dry rubber content (%)	28.20	28.45	27.35	26.40
Trunk girth (cm)	45.70	53.43	56.06	57.89

Table 19.*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	0.048	0.050	2.031	2.142
RRIC 102	0.051	0.056	2.012	2.032
RRIC 130	0.084	0.087	1.954	2.014
PB 260	0.046	0.054	1.607	1.525

(A Nugawela, V H L Rodrigo, G P Wijesinghe, K A G B Amaratunga and S Wilbert)

Exploitation

Testing a new Tapping Knife

This experiment was started in September 2003 at Galewatta to test the performance of a new tapping knife which has been made from high quality steel.

New tapping knives were distributed among nine tappers who are tapping virgin and renewed panels (Panel – A, B & C).

Shaving thickness and number of wounds were measured from randomly selected samples from each tapper. The measurements were taken regularly during the year (from Sept. 2003 - Sept. 2004) and data was summarized. It showed that shaving thickness of both the virgin and renewed panels which were tapped with new tapping knives was comparatively low. However, even with the new knife the average thickness was higher than the recommended thickness 1.25 mm. Number of wounds was also low. Results are given in Table 20 and figures 2-5.

Table 20. *Average shaving thickness of the trees tapped with the new and the normal knives*

	Average thickness of shaving (mm)								
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
Normal knife	2.0575	2.0125	2.06	1.995	2.015	2.06	2.015	2.14	2.07
New knife	1.8075	1.73	1.78	1.755	1.745	1.79	1.84	1.835	1.8175

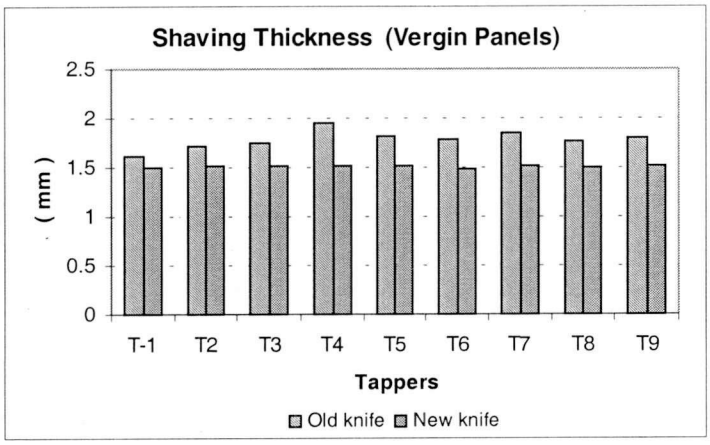


Fig. 2. Shaving thickness with the normal and the new knife of the virgin bark

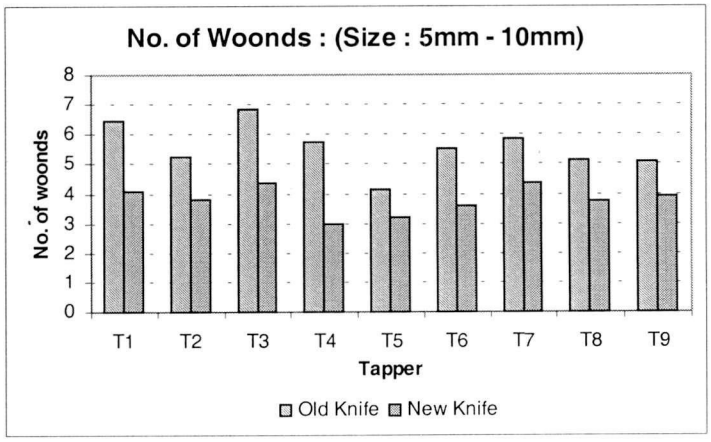


Fig. 3. Number of wounds on the virgin panels tapped with the normal and the new knife

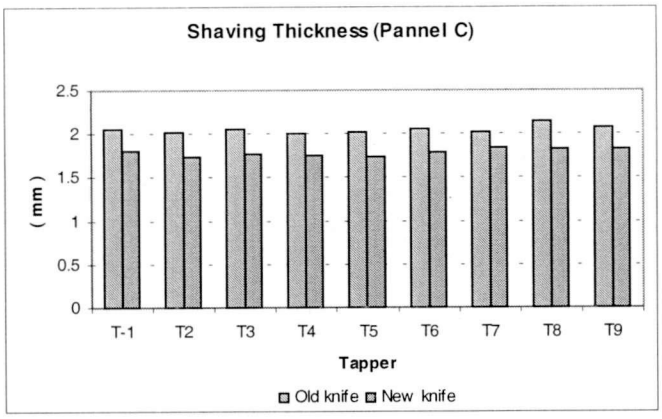


Fig. 4. Shaving thickness with the normal and the new knife of renewed bark

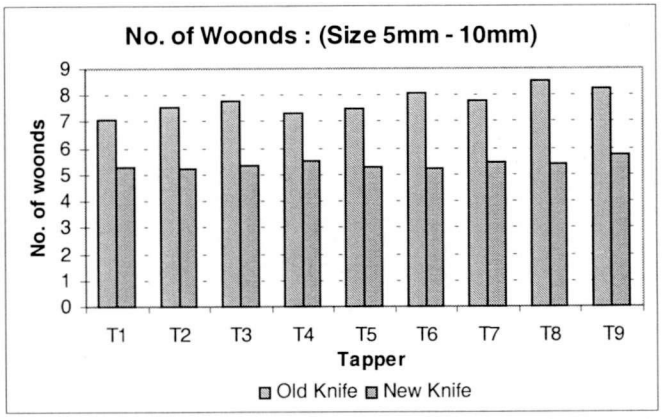


Fig. 5. Number of wounds on the renewed panels tapped with the normal and the new knife

(P Seneviratne, V H L Rodrigo and K A G B Amaratunga)

Girth at opening (TG/99/1)

Details of the experiment and the data collected over the years have been reported in previous annual reviews. Data for the year under review are given in Table 21. Highest girth increment for both tapped and untapped trees was recorded for the clone RRIC 121.

As shown in the table 22, highest dry rubber yield per tree per annum was also given by clone RRIC 121. In all treatments, G50 has given a higher yield than G40.

Table 21. *Mean girth increment of the treatments for all three clones under different tapping systems*

Clone	Tapping treatment	Mean girth increment (cm)					
		G_{40}	G_{45}	G_{50}	Mean for tapping treatment	Clone	Untapped
RRIC 102	½ S d/2	1.4	0.9	0.8	1.03		
	½ S d/3	1.0	0.84	1.7	1.18		
	½ S d/3 +Eth.	1.1	0.94	0.81	0.95	1.05	3.23
RRIC 121	½ S d/2	2.33	1.93	1.66	1.97		
	½ S d/3	1.95	1.8	2.16	1.97	1.87	4.16
	½ S d/3 +Eth	1.65	1.53	1.85	1.68		
RRIC 211	½ S d/2	0.84	1.03	1.21	1.03		
	½ S d/3	0.9	1.33	1.9	1.38	1.25	1.95
	½ S d/3 +Eth	1.1	1.9	0.99	1.33		

Table 22. *The yield per tree per year for the three clones under different tapping systems*

Clone	Tapping treatment	Yield (kg/tree /year)				
		G_{40}	G_{45}	G_{50}	Means for tapping treatment	Clone
RRIC 102	½ S d/2	6.03	5.54	6.55	6.04	
	½ S d/3	3.34	3.65	4.65	3.88	4.81
	½ S d/3 +Eth.	3.75	5.09	4.67	4.50	
RRIC 121	½ S d/2	5.66	4.90	5.74	5.43	
	½ S d/3	5.02	4.19	3.65	4.29	5.14
	½ S d/3 +Eth	5.91	5.52	5.71	5.71	
RRIC 211	½ S d/2	3.26	4.57	6.24	4.69	
	½ S d/3	2.31	3.34	3.42	3.02	3.74
	½ S d/3 +Eth	2.61	3.40	4.53	3.51	

(A Nugawela, V H L Rodrigo, K Gunasekera and R P Karunasena).

Low frequency tapping

Dartonfield 1988 replanting (LFT/2003-/1)

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

Details of the low frequency tapping systems and the stimulation schedule are given below (Table 23).

Table 23. *Tapping system and the stimulation schedule for the treatments*

Treatment	Tapping system	Schedule of stimulation (ET 2.5% Ba)
T_1	½ S d_4	January, May, June, July, August, September, October, November, December.
T_2	½ S d_6	January, February, March, April, May, June, July, August, September, October, November, December.
T_3	½ S d_2	No stimulation

Twenty trees were allocated for T_1 and T_2 treatments per clone. Daily latex yields were monitored using volumetric measurements of latex and metrolac reading for DRC% (Table 24).

No trees were specially allocated for T3 treatment and data were obtained from the estate crop book (N.B. ½ S d_2 is the common tapping system practised in estate).

Table 24. *Latex yield, number of tapping days, average DRC and the estimated YPH for different treatments*

Treatment	Clone	g/t/t	Tapping days/y	Estimated YPH/y (400 trees) (kg)	Average DRC (%)
T_1 -½ S d_4 2.5% Et	RRIC 130	73.27	65	1905.02	42
	RRIC 100	58.21	67	1560.00	32
T_2 - ½ S d_6 2.5% Et	RRIC 130	76.19	45	1371.42	44
	RRIC 100	63.59	51	1297.24	32
T_3 - ½ S d_2	RRIC 130	19.53	141	1101.50	38
	RRIC 100	13.73	153	840.28	34

Yield per hectare was greater in d_4 and d_6 treatments (Treatments 1 and 2) in both clones RRIC 130 and RRIC 100 with compared to that of d_2 treatment (Treatment 3) during the year 2004 (V H L Rodrigo, A Wickramarathne and R K Samarasekera).

Tapping panel drynes

Survey on tapping panel dryness (TPD/2002/01)

41 tapping blocks (250-300 trees per block) have been surveyed during the year. Collection of data from 75 tapping blocks has been completed up to the end of 2004. Summary of total and partial tapping panel dryness (% TPD), clone wise and panel wise, is given in Table 25. According to the results, % TPD has increased generally with the advancement of the tapping panel from A to D. There was no clear clonal difference observed.

Table 25. *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	9	7.1	5.1
	B	9	16.3	12.2
	C	7	17.7	8.7
	D	1	17.4	6
RRIC 102	A	2	4.1	2.3
	B	9	14.3	8.2
	C	-	-	-
	D	-	-	-
RRIC 121	A	8	1.9	2.3
	B	11	10.6	6.2
	C	7	11.9	7.3
	D	2	16.2	15.4
RRIC 130	A	6	5.9	4.2
	B	1	24.4	8.1
	C	3	8.2	7.7
	D	-	-	-
Total		**75**		

* Total TPD – Entire tapping panel is dry
Partial TPD – Part of the panel is dry

(A M W K Senevirathna, S Wilbert and S Wijesinghe)

Resting and continuous shaving on TPD trees (TPD/2002/02)

Experiments to find the effect of continuous shaving and resting of TPD affected trees were started in the surveyed 'B Panel' tapping blocks at the Dartonfield estate. These tapping blocks are monitored in two monthly intervals to investigate the changes (A M W K Senevirathna, S Wilbert and S Wijesinghe).

Continuous monitoring of TPD (TPD/2002/03)

Total of ten tapping blocks from each clone RRIC 100, 102, 121 and RRIC 130 and from five estates were monitored at three monthly intervals for the incidence of TPD (Table 26). Four tapping blocks were added to the total during the past 6 months of the year. It was difficult to find newly tapped blocks of RRIC 102 and

RRIC 130 clones because of the less abundance of these clones in plantations in Kalutara district.

According to the results, TPD percentages are comparatively high in clearings of RRIC100 (1995) and RRIC 130 (1996) at Ambetenna and Arappolakanda estates respectively. Total TPD percentage of 20.5% of RRIC 130 at Arappolakanda estate was extremely high probably due to the high intensity tapping (Table 26). Continuous monitoring also showed that % TPD incidence increase gradually with time and TPD first appears as a partial dryness of the tapping panel.

Table 26. *Percentage total and partial TPD trees of a tapping block of rubber being tapped in the first virgin panel, A*

Clone	Estate	Planting year	% TPD	
			Total	Partial
RRIC 100	Ambetenna	1995	7.3	3.9
	Culloden	1997	-	1.2
	Culloden	1998	-	-
RRIC 102	Ambetenna	1992	4.2	2.6
RRIC 121	Ambetenna	1996	1.1	1.1
	Culloden	1997	-	1
	Uskvalley	1996	1	-
RRIC 130	Arappolakanda	1996	20.5	9
	Culloden	1997	0.92	0.32
	Clyde	1997	0.26	0.26

* Total TPD – Entire tapping panel is dry
Partial TPD – Part of the panel is dry

In addition to these, tappers involved in the survey are being interviewed for the collection of local knowledge incorporated in TPD. Most of the tappers were in the opinion that high intensity tapping (daily tapping and double tapping in a day) and tapping on wet panels are the main causes for the high intensity of TPD (A M W K Senevirathna, S Wilbert and S Wijesinghe).

Biochemical analyses (TPD/2002/04)

Methodology development was done for the biochemical studies of TPD affected and healthy trees of rubber. Preliminary extraction procedures for the analysis of sugars were done (A M W K Senevirathna in collaboration with Biochemistry Department) CARP funded Project – 12/478/358.

Present status of labour availability for latex exploitation and possible adoption of low frequency tapping in Sri Lanka LFT/2003-4

The importance of low frequency tapping (LFT) systems in the context of tapper shortage is well understood. Therefore, the present study aimed to assess the severity of tapper shortage and the level of adoption of LFT (½S d/3 + ET) in both plantation and smallholder sectors of Sri Lanka whilst identifying the possible constraints, if any, for the adoption of LFT.

Plantation sector

A questionnaire was developed and pre-tested in two commercial estates. Then it was sent by post to 160 estates in 17 Plantation Companies that govern all rubber plantations in Sri Lanka. Tapper availability was evaluated in terms of average daily outturn of both permanent and substitute tappers and vacant tapping blocks. Adoption of the LFT and its potential effectiveness to solve the negative effects of tapper shortage was assessed.

The age distribution of tappers was also examined in order to assess the future trends in tapper availability. Also, availability of casual labour was examined to consider the possibilities of training them for tapping.

The productivity of latex production at the estate level varied between 530 to 1314 kg ha^{-1} on area basis and from 3 to 9.8 kg day^{-1} on tapper basis with mean values of 893 and 6.4 kg, respectively. Low frequency tapping with ethrel stimulation was practiced by a few estates (10%) representing less than 2% of total mature extent. However, the LFT was generally practiced without stimulation in a larger extent (*ca.*10%) during the first year of tapping (*i.e.* 48% estates) in the clearings of clones recommended for tapping at d/3 without stimulation (*i.e.*25% estates) (Table 27). On average, for the plantation sector, trees with intensified tapping occupied in the 13.5% of mature extent whilst the composition of the area under the d/2 tapping in virgin and renewed barks were 55% and 32%, respectively (Table 27).

The daily total requirement of tappers in an estate depends on the area under mature rubber, however on average, tapper requirement of an estate was 135 (Table 28).

Majority of tappers (*ca.* 60%) were in the age group of 31 to 50. Tappers falling into the age groups of 21-30 and 51-60 were more or less the same and only a few were in the age above 60 and below 20. Similar to the age distribution of tappers, number of casual labourers falling into the age group 31 to 50 was greatest and then in 21-30yr and 51-60yr age categories.

The composition of skill tappers was only 62% leaving 38% as unskilled. In some estates, percentage of unskilled tappers was as high as 89%. Gender ratio of tappers was bias towards female representing over 60%. However in the case of casual workers, females were only 53% showing about 10% difference from that of

tappers. In general, the majority of tappers were residing within the estate whilst the ratio of residents to non-residents was approximately 1:1 for casual workers.

Table 27. *Productivity levels and the adoption of tapping systems in the plantation sector of Sri Lanka*

Average yield (kg/ha/yr)	893.4
Average daily intake per tapper (kg)	6.4
% estates practicing 1/2S d/2 tapping	100.0
% estates practicing 1/2S d/3 +ET	10.0
% estates practicing 1/2S d/3 during the 1st year of tapping	47.8
% estates practicing 1/2S d/3 for d /3 clones	24.6
% area of mature rubber under 1/2S d/2 tapping;	87.6
in virgin bark	54.8
in renewed bark	31.8
% area of mature rubber under intensified tapping	13.5
% area of mature rubber under 1/2S d/3 + ET tapping	1.3
% area of mature rubber under 1/2S d/3 during the 1st year of tapping	5.4
% area of mature rubber under 1/2S d/3 for d /3 clones	5.6

Table 28. *Summary on the tapper requirement and availability per estate in plantation companies of Sri Lanka*

Company	Tapper requirement per day	Usage of tappers and vacant tapping blocks			Yield loss due to vacant tapping blocks (kg/ha/yr)
		Permanent tappers %	Substitute tappers %	Vacant blocks %	
A	154	77.2	10.9	11.9	112.7
B	228	93.1	5.9	1.0	97.1
C	62	69.6	5.1	25.3	223.5
D	106	74.5	13.9	11.9	101.1
E	99	48.0	21.4	30.6	278.1
F	225	21.5	76.8	1.7	12.6
G	153	90.8	3.2	6.0	55.7
H	89	70.3	7.9	14.5	149.5
I	103	92.8	3.8	3.7	31.7

Smallholder sector

Preliminary level information on rubber tapping in the smallholder sector was gathered through discussions with extension personnel. Three categories of labour use in tapping, *i.e.* tapping with family, hired and both types of labour, were identified. This was followed by a questionnaire based survey in three major rubber growing areas of the country (*i.e.* Kalutara, Kegalle and Rathnapura) with a stratified sampling

procedure on the above mentioned labour use categories. Tapping with both family and hired labour was practiced only on few sites limiting the sample size 12 smallholdings. Number of smallholdings surveyed for tapping with only family and hired labour was 73 and 74, respectively.

Average intake per tapper per day was slightly less than that in the plantation sector and the lowest value was recorded in the smallholdings tapped with family labour (Table 29). Hired workers showed more skilled taping than the family workers hence the quality of tapping was greater in the smallholdings tapped by hired tappers than in those tapped with family labour. Generally hired labour are skilled tappers and that must be the reason for high intakes. Obviously, use of hired labour was limited by the difficulty in finding labour for tapping.

Table 29. *Summary of the information gathered on tapping in the smallholder sector of Sri Lanka*

Type of labour use in tapping	Hired labour	Family labour	Both types
Number of holdings surveyed	73	74	12
Intake per tapper (kg)	5.6	4.81	6.73
Quality of tapping	69.33	62.86	61.91
Ability to find tapper			
Difficult	69.86	82.43	66.67
Not difficult	21.92	17.57	33.33
Medium	8.22	0	0
Tapping system			
Daily tapping (d/1)	64.26	67.73	58.33
Alternate day tapping (d/2)	25.27	29.38	16.67
Daily tapping with rainguards	6.94	0	0
Alternate tapping with rainguards	4.17	2.7	25
Skilled factor			
Skilled	87.88	77.05	
Unskilled	12.12	39.34	
Ability to find sundry worker			
Difficult	84.21	76.71	
No Difficult	33.33	23.29	
Fertilizer application			
Irregular	23.61	13.89	
No applied	76.39	86.11	

Daily tapping was the predominant tapping system in the smallholdings irrespective of the type of labour used (either hired or family labour). No single smallholding was tapped with a low frequency tapping (LFT) system. In general,

smallholders were unaware of the LFT and even the stimulants used in LFT. Majority of smallholders do not apply fertilizer to mature rubber. Even in the places where fertilizer was applied, it was irregular (V H L Rodrigo, N A A D Wickramaratna, R D Vidanapathirana, W Karunatilaka, P D Pathirana and G P Wijesinghe).

Rainguards 2004

In order to improve the easiness in fixing rainguard, a new system of fixing the polythene cover was developed based on the information gathered from the Rubber Research Institute of India. This system comprised of a strip of cloth together with the brushable type sealant. The system was tested in both Dartonfield estate and Kuruwita substation and found to be superior compared to the traditional way of fixing. Also, semi skirt type rainguards with both high and low density polythene were tested to facilitate situations where tappers have negative thoughts on rainguards. Low density polythene was found to be more suitable in this regards. Sticker type adhesive tapes developed by the Raw Rubber Process Development and Chemical Engineering Department were tested, however no suitable sticker type system was identified (V H L Rodrigo, R P Karunasena and W Karunatilaka).

Intercropping

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

Details of experimental layout were reported in the annual report 2002. Growth measurements of all crops except Durian were made at six moth intervals. Harvesting of cinnamon began in August 2004 with training given by the Cinnamon Research Station of the Department of Export Agriculture. However, harvesting has to be postponed to 2005 due to poor peeling quality resulted by dry weather. Rambutan flowered in May and fruits were affected by fungal disease. Tea was harvested throughout the year and high yields were recorded in the treatments with wider alleys. Growth of rubber with respect to the girth measured at 150 cm height was comparable among treatments (Table 30). Also, growth of rabutan was comparable among treatments. The estimated yield of cinnamon was recorded over 600 kg in each treatment (Table 31).

Table 30. *Summary on the 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)
T1- (3mx3m)×15m	32.7	13.26	31.75	11.46
T2 -(3mx3m)×18m	32.6	12.72	32.12	12.9
T3-(3.5mx3.5m)×15m	30.13	13.46	37.88	12.6
T4-(3.5mx3.5m)×18m	32.87	13.74	34.75	10.28

Table 31. *Summary of the growth performance of Rambutan and yield performance of tea and cinnamon under different planting arrangements of rubber. Yield of tea is given as the mean fresh weight per year and for cinnamon, yield was estimated based on the number of sticks in each treatment*

Treatments	Rambutan	Tea	Cinnamon
	Girth (cm)	Crop (kg/ha.)	Crop (kg/ ha)
T_1 (3m× 3m) -15m	20.22	10,829.31	893
T_2 (3m× 3m) -18m	17.46	10,284.43	811
T_3 (3.5m× 3.5m) -15m	19.39	10,483.57	630
T_4 (3.5m× 3.5m) -18m	18.7	11,786.96	805

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

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

Few plants were damaged by wild boars and the rest were maintained. Vanila plants were also incorporated to this experiment under 25%, 50% and 75% shade levels. Since the Infra Red Gas Analyzer was out of order, no eco-physiological measurements could be made (V H L Rodrigo, W Seneviratne and W Karunatilaka).

Quantification of carbon fixing capability of rubber

The study aimed to assess the capability of carbon fixation of rubber with respect to different climatic regimes, planting density and genotypes.

Ontogenic development of rubber;

In the wet zone where the majority of rubber is grown, 26 sites with similar growth conditions but in different ages, were selected from the genotype RRIC 100. Girth at 1.5 m height of 25 trees, total height and wood density of the tree were measured in each site without disturbing the trees. Then, three models were

developed to explain the ontogenic variation of girth at 1.5m height, total height and the wood density of the tree (Model 1, 2 and 3).

Girth (cm) = 26.035 Ln (YAP) +0.0863 ------Model 1
Total height = 8.0077 Ln (YAP) – 0.8571 ------Model 2
Wood density (kg/m3) = $0.019(YAP)^3$-$1.36(YAP)^2$+32.61(YAP)+507.85 ----Model 3
Where, YAP refers to years after planting.

Assessment on rubber timber

Rubber trees in four sites comprising three genotypes, *i.e.* 28 and 30 year old RRIC100 in two sites, 11 year old RRIC121 and 30 year old RRIM600, were selected for the detailed assessment of timber volume. In total, 64 uprooted trees were assessed. The main trunk of the tree and branches up to girth of 20cm were separated into sections and timber volume was measured using Smalian's formula [Volume = π ($d1^2$ + $d2^2$)/ 80000 * H, where, d1 and d2 were the diameters at two ends of the cylinder in centimeters whilst H was the height of it in meters]. Two simple models (Models 4 & 5) were developed and fitted lines based on two models to estimate timber volumes are shown in figures 6 and 7.

Total timber volume (m^3) = -0.02 + 0.394 (D^2 * TH) ----- Model 4
Total timber volume (m^3) = -0.13 + 9.87 D^2 ----- Model 5

Where, D refers to the tree diameter in meters at the height of 1.5m, whist TH for the total tree height in meters.

Assessment on biomass in rubber

In order to assess the biomass of the above ground components, twenty trees with age 4 to 28 years were uprooted and separated into different categories i.e. main trunk, branches up to 20cm girth, branches less than 20cm girth, petioles and leaves. Timber volume of the main trunk and branches up to the 20cm girth was measured and converted into biomass with the knowledge of wood density. Total fresh weight was taken in other sections and sub samples were taken for dry weight analyses. Then, the proportional allocation of total biomass to different sections was determined on percentage basis.

Then two models were fitted to total biomass and the biomass in the timber sections as a function of square diameter (Models 6 and 7) (Figure 8).

Biomass in timber (kg) = -109.02 + 7299.4 D^2 ------Model 6
Total biomass (kg) = -124.15 + 8312.7 D^2 ------Model 7

D refers to the tree diameter in meters at the height of 1.5 m.

Assessment on carbon in rubber

Organic carbon content of different plant component *i.e.* four from woody sections up to 20cm girth, one from branches below 20cm girth, twigs (girth between 5-20cm) and one from leaves and petioles was assessed using the Walkley and Black's Rapid Titration Method (Piper 1950).

Similarly, another two models were developed to estimate the amount of organic carbon in timber sections (Model 8) and in all above ground components (Model 9) (Fig. 9).

Organic carbon in timber (kg) = $-44.72 + 2994.2\ D^2$ ------Model 8
Total organic carbon (kg) = $-50.92 + 3409.8\ D^2$ ------Model 9
D refers to the tree diameter in meters at the height of 1.5 m.

Based on the models shown above, the estimated values of total timber volume, above ground biomass and organic carbon for timber and other non-timber sections at different time levels are given in Table 32. The cumulative values for biomass and carbon including the of annual leaf fall and latex harvested are given in Table 33.

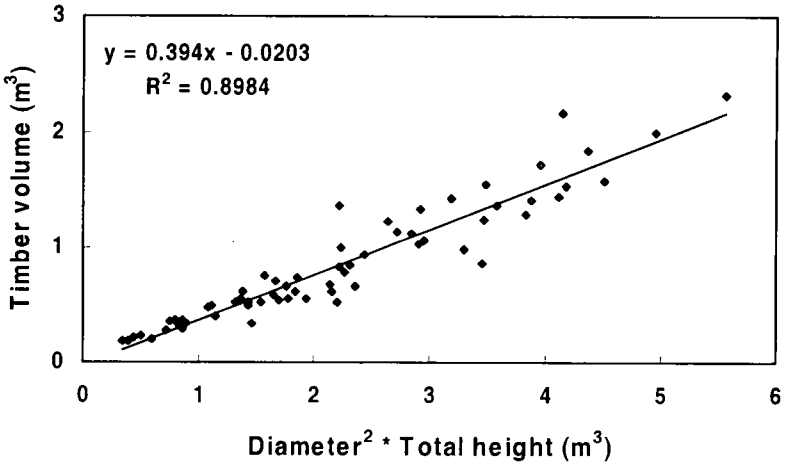


Fig. 6. Relationship between timber volume and the tree diameter (at 1.5 m height) and total height

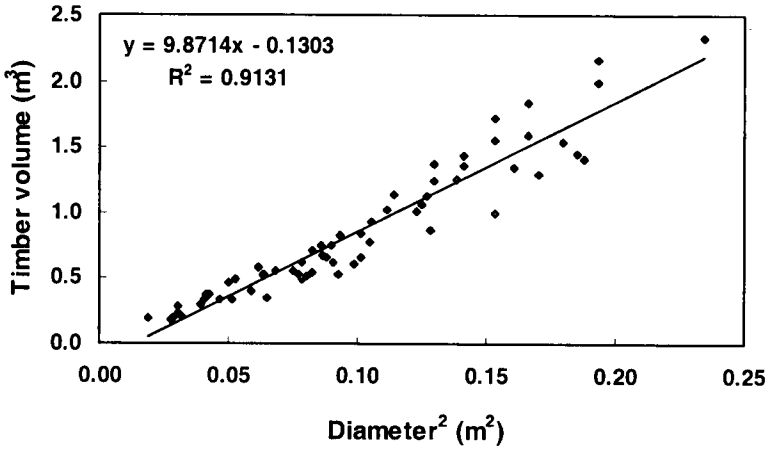


Fig. 7. Relationship between timber volume and the tree diameter (at 1.5 m height)

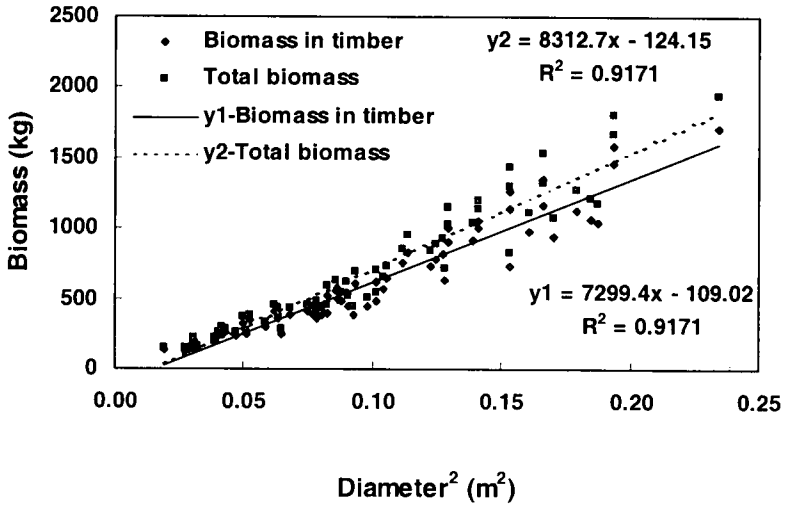


Fig. 8. Relationship of the biomass in timber and total biomass with the tree diameter (at 150 cm height). y1 and y2 show the fitted lines to the values

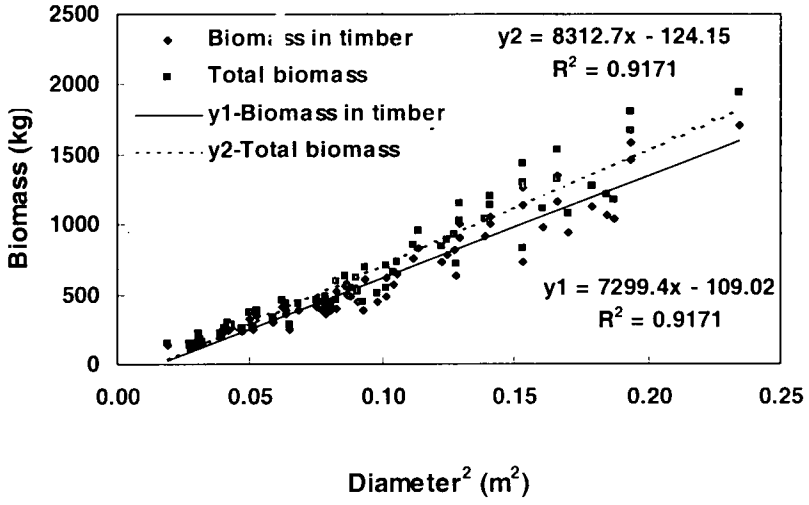


Fig. 9. Relationship of the organic carbon in timber and in total biomass (per tree) with the tree diameter (at 1.5 m height). y1 and y2 show the fitted lines to the values

Table 32. *Estimated values of total timber volume, biomass and carbon contents ('C') in above ground components of rubber*

Age (years)	Timber volume (m^3/ha)	Biomass in timber (MT/ha)	Total biomass (MT/ha)	'C' in timber (MT/ha)	'C' in total biomass (MT/ha)
7	60.50	40.55	46.18	16.63	18.96
10	102.21	69.42	79.05	28.48	32.46
15	144.38	100.21	114.12	41.11	46.85
20	163.25	115.74	131.81	47.48	54.11
25	165.63	119.89	136.54	49.18	56.06
30	155.37	114.79	130.72	47.09	53.67

Table 33. *Cumulative total aboveground biomass and carbon contents ('C') including annual leaf fall and latex yield of rubber*

Age (years)	Total biomass- Cumulative (MT/ha)	Total carbon- Cumulative (MT/ha)
7	48.46	20.66
10	88.27	38.47
15	138.44	61.55
20	172.81	78.15
25	193.29	89.05
30	200.31	94.44

(V H L Rodrigo, A Nugawela, E S Munasinghe and P K W Karunatilake - This project was funded by Climate Change Enabling Activity (Phase II) Project of the Ministry of Environment & Natural Resources)

Assessment on potential capability of fixing carbon in different genotypes of the rubber crop

The study was aimed to quantify the potential carbon fixation of the mature rubber crop through the photosynthesis and to establish the genotypic differences of rubber in fixing atmospheric carbon.

The experiment was conducted in Dartonfield Estate, Agalawatte. RRIC 100 and RRIC 121 genotypes which planted in 1991 (12 yeas after planting) were selected for the study. Leaf area index (LAI) of a rubber tree was calculated by measuring leaf area of fallen leaves collected to litter traps during the winter period of the experimental field. The proportion of LAI found at three strata of the canopy was studied by physical counting using point quadrates. The mean LAI of genotype RRIC 121 and RRIC 100 for the whole canopy was found as 5.88 and 3.47, respectively. Both genotypes have shown a similar pattern of leaf distribution within the canopy (Table 34).

The light extinction coefficient of the clone RRIC 121 and RRIC 100 was calculated as 0.3 and 0.58, respectively with the knowledge of light attenuation through the canopy.

Photosynthetic capacity at leaf level was assessed in the form of Light Response Curve (LRC) of fully matured detached leaves at three levels of the canopy. Photosynthetic parameters such as maximum rates of photosynthesis, photosynthetic efficiency and convexity of the LRC were estimated from LRCs and mean rate of photosynthesis of different strata was calculated for both sunny and dull days (Table 35).

Table 34. *LAI at different positions of the rubber canopy*

Clone	Top stratum	Middle stratum	Lowest stratum
RRIC 121	3.13	1.76	0.99
RRIC 100	1.84	1.08	0.54

Table 35. *Photosynthesis rates at different positions of the rubber canopy*

Clone	Light condition of the day	Mean photosynthesis rates ($\mu molm^{-2}s^{-1}$)		
		Top stratum	Middle stratum	Lowest stratum
RRIC 121	sunny	4.86	3.51	2.72
	Dull	4.10	2.71	1.88
RRIC 100	sunny	3.43	2.05	1.45
	Dull	2.91	1.49	1.01

The amount of carbon fixed on a sunny and a dull day was estimated as 8.65 and 7.0 gm^{-2}, respectively. On this basis, the annual rate of carbon fixed in the genotype RRIC 121 was 31.8 $MTha^{-1}$ whilst 12.21 $MTha^{-1}$ in RRIC 100 (E S Munasinghe, V H L Rodrigo and P K W Karunatilake - This project was funded by Climate Change Enabling Activity (Phase II) Junior Research Programme of the Ministry of Environment and Natural Resources).

Economic assessment of rubber plantations of Sri Lanka with special emphasis on carbon sequestering capability and timber production

This is an extension of the project on 'Quantification of carbon fixing capability of rubber', aiming to assess the economic benefits rubber plantations in terms of latex, timber and environment. Also, the study aimed to evaluate the economics of rubber plantations under different widely adopted rubber based intercropping systems.

In order to assess the biomass of the below ground components, seventeen trees with age 8 to 23 years were selected and root biomass up to 1cm diameter was measured. Total fresh weight was taken and sub samples were taken for dry weight and carbon analyses. Then, total biomass and total carbon content of roots were determined on dry weight basis.

Two models were fitted to total biomass and the organic carbon content in the root sections as a function of square diameter (Models 1 & 2) (Figures 10 &11).

Total root biomass (kg) = $11.94 + 561.65\ D^2$ ------Model 1
Total organic carbon (kg) = $4.83 + 227.02\ D^2$ ------Model 2
(in roots)
D refers to the tree diameter in meters at the height of 1.5 m.

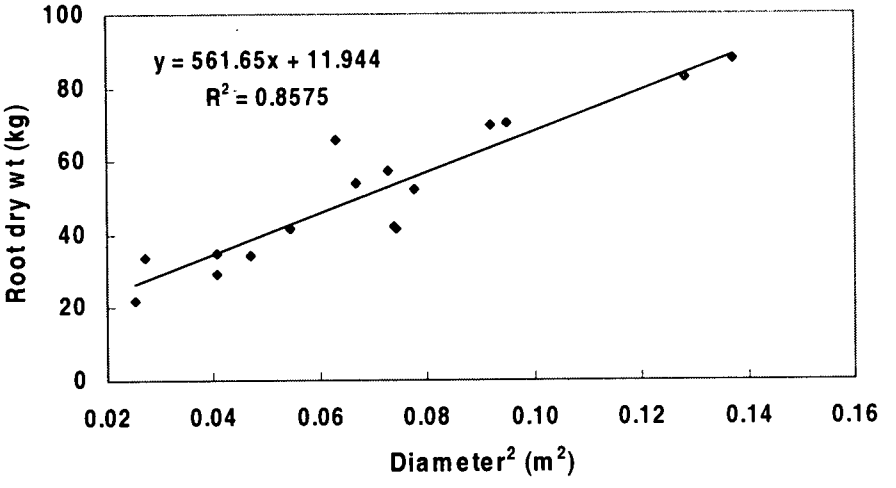


Fig. 10. Relationship of total root biomass with the tree diameter (at 1.5 m height)

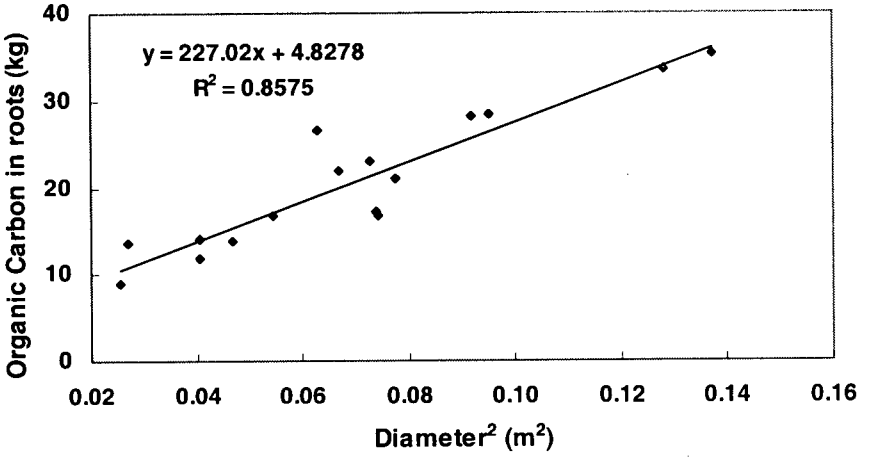


Fig.11. Relationship of the organic carbon in roots with the tree diameter (at 1.5 m height)

A field survey was commenced to investigate the socio economic conditions of rubber based intercropping systems. A financial evaluation at the smallholder farmer level on three widely used intercropping systems such as banana, tea and pineapple was the focus in this survey. Twenty farmers were interviewed by end of the year 2004 (V H L Rodrigo, E S Munasinghe and P K W Karunatilake in collaboration with the University of Sri Jayawardenapura. - This project was initially

funded by Climate Change Enabling Activity (Phase II) Project of the Ministry of Environment & Natural Resources and subsequently extended with the financial assistant given by CARP).

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

This rubber/rattan intercropping trial was established in October 1996 and comprised of three indigenous species of rattan (Annual Review 1996). The growth of rattan was good but measuring the growth in height of rattan plants was not possible due to the tallness, bending of the stems and inaccessibility due to the thorny fronds (L S S Pathiratna and M K P Perera).

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

The experimental details are given in Annual Review 1998. The growth in girth of rubber trees was highest in treatments having widest inter row spacing with single rows of rubber. The growth in all treatments with paired rows was comparable with the 8.4m inter row spacing treatment (Table 36).

Cinnamon bark yield was highest in wider inter row spacing treatments with rubber planted with paired rows. Those treatments with narrow inter row spacing gave low yields (Table 37).

Table 36. *Growth of rubber trees in girth (cm) under different inter row spacing treatments*

	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 (cm) *	49.9 d	52.8 bcd	52.2 bcd	54.0 abc	55.2 ab	56.3 a	52.0 bcd	50.8 cd	49.9 d	49.6 d	51.4 cd

(Figures with the same letter are not significantly different)

Table 37. *Bark yield of cinnamon (Kg/ha) under different inter row spacing treatments*

	Inter row spacing treatments (m)										
	7.2 S	**8.4 S**	**9.6 S**	**10.8 S**	**12.0 S**	**13.2 S**	**13.2 P**	**14.4 P**	**15.6 P**	**16.8 P**	**18.0 P**
Bark yield	335.0	244.5	319.3	336.3	414.8	488.8	382.2	477.7	552.2	629.6	534.6

(S- Single row of rubber; P- paired rows of rubber)

(L S S Pathiratna and M K P Perera)

PLANT PATHOLOGY AND MICROBIOLOGY

C K Jayasinghe

SUMMARY

The incidence of *Phytophthora* leaf fall (PLF) reached the epidemic proportions in all rubber growing districts, and it was the highest recorded for the last decade. This situation was predicted early and an interim circular was sent to all authorities for them to be vigilant of bark rot, the 2nd phase of PLF. Observations of an island-wide survey indicated that no clone recommended for large scale planting was susceptible to *Corynespora* leaf fall disease (CLF). However, clone recommendation was revised as few clones from Group II & III were found to be susceptible to CLF. *Mangiferae indica* was proved to be a new alternate host for the pathogen *Colletotrichum acutatum* in Sri Lanka. *C. acutatum* was reconfirmed to be the major cause of *Colletotrichum* leaf disease in rubber plantations using DNA technology. New protocols were developed to screen rubber clones against major leaf diseases and three surveys were conducted using this newly developed methodology. Benomyl and tebuconazole were found to be effective in controlling *Botryodiplodia theobromae*. A biocontrol formulation based on antagonistic fungus *Trichoderma harzianum* was proved to be effective in controlling white root disease.

DETAILED REVIEW

Dr C K Jayasinghe, Head of Plant Pathology and Microbiology Department was appointed as the Acting Deputy Director Research with effect from 08.01.2004. Principal Research Officer Dr (Miss) W P K Silva left overseas on special leave on 15th October. She is expected to resume duties on 3rd January 2005. Principal Research Officer, Dr K E Jayasuriya and Audio Visual Production Officer, Mr W Amaratunge were on duty throughout the year. Experimental Officers, Mr E B Fernando, Mrs T H P S Fernando and Mrs B I Tennakoon, Technical Officers Mr C Wijeratne, Mr S R D P C Peiris, Mrs N Jayawardene and Mr E A D N Nishantha, Clerk Typist, Mrs P Amarasekera continued to work in the Department. Mrs D Siriwardene, Experimental Officer was on maternity leave from 5th August to 7th December.

Research Students

Miss T A D P Thambugala, an undergraduate from the University of Kelaniya, completed her final year project entitled "Pathogenesis and control of *Colletotrichum* species, causative agents of *Colletotrichum* leaf disease of rubber" under the supervision of Dr C K Jayasinghe.

Seminars/Conferences/Meetings/Workshops attended

Officer	Subject	Organization
Dr C K Jayasinghe	Pesticide technical advisory committee	Dept. of Agriculture
Dr C K Jayasinghe	National committee on coconut mite	CRI
Dr C K Jayasinghe	Specialist committee on plant protection	CARP
Dr C K Jayasinghe Dr W P K Silva Dr K E Jayasuriya	Symposium on plantation crop research	TRI/CRI/RRI
Dr C K Jayasinghe	Attended the CFC – *Corynespora* project inception meeting held in Medan, Indonesia, 16th –20th December 2004.	IRRDB

Seminars/Training programs conducted

Dr C K Jayasinghe, Dr W P K Silva and Dr K E Jayasuriya served as resource personal in training Estate Managers, trainee Asst. Managers, Asst. Managers and Field Officers. Mr E B Fernando, Mrs T H P S Fernando, Mrs B I Tennakoon and Mrs D Siriwardene covered the practical aspects of above programmes while all the staff members extended their fullest cooperation in educating students from Universities, Technical Colleges and schools on Department activities. Dr K E Jayasuriya served as a resource personal in the workshop on "Status of Biological Methods of Crop Pest Control and Potential for Future Use" conducted by CARP.

Visits

The Department staff made 11 Advisory visits, 140 Experimental and 94 visits for other purposes.

GENERAL

The incidence of *Phytophthora* leaf fall (PLF) reached the epidemic proportions in all rubber growing districts. Main factors that contributed to this severe outbreak were the prolonged SW monsoon and low incidence of *Oidium* leaf fall during the refoliation period due to the dry weather that prevailed at the beginning of the year. This situation was predicted early and an interim circular was sent to all authorities requesting them to be vigilant of bark rot, the second phase of PLF.

Observations of an island-wide survey carried out on new RRISL clones revealed that RRISL 201, RRISL 215, RRISL 222, RRISL 223, RRISL 226, and RRISL 208 are susceptible to *Phytophthora* infection.

Island-wide survey on *Corynespora* disease situation was undertaken. No clone recommended for large scale planting was found to be infected with the disease. However, two heavily affected clones, namely RRISL 202 (a clone recommended for small scale planting), and RRISL 200 (Experimental clone) were removed from the recommendation and experimental trials respectively. Moderate infections have been

detected on clones recommended for small scale planting namely RRISL 201 and RRISL 217 and it was decided to make further observations on these clones before recommending for growers.

The project, Possibility of the popularization of *Oidium*-susceptible high yielding clones with the predicted climate change" was awarded to Mrs T H P S Fernando by the Ministry of Environmental and Natural Resources under Climate Change Enabling Activity (Phase II) and successfully completed under the supervision of Dr C K Jayasinghe. A safety guide entitled "Safety Hand Book: Precautions Against Chemical Hazards and Biological Threats" was published. It will provide step-by-step advise to protect the researcher and the environment from chemical and bio threats.

New protocols were introduced based on statistical designs to screen *Hevea* clones against common canopy diseases, *Oidium* leaf fall, *Phytophthora* leaf fall and *Corynespora* leaf fall. These protocols were developed based on the experience of the Plant Pathology and Microbiology Department and internationally accepted field screening procedures. This newly developed methodology will be used in all future studies on screening of rubber clones.

Rodent damage on oil palm plantations has become a serious threat during 2003 and 2004. Several workshops were organized with the collaboration of the Registrar of Pesticides to educate the growers on the managements of bandicoots.

Dr C K Jayasinghe was invited by the International Rubber Research and Development Board (IRRDB) to attend the CFC – *Corynespora* Project Inception Meeting held in Indonesia during 16^{th}-20^{th} December. This meeting was held to discuss the details of programmes suggested by the scientists of five South and South East Asian rubber growing countries including the writer on the efficient management of *Corynespora* leaf fall. Common Fund for Commodities tentatively agreed to provide around 13,000 US $ to be utilized in future research on CLF in Sri Lanka.

LABORATORY AND FIELD INVESTIGATIONS

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

Screening of fungicides against Corynespora cassiicola

Final observations on the spraying program against *Corynespora* leaf fall disease were made and summary of the results are presented in the Table 1. It was revealed that there was no significant improvement of the canopy density in most of the plots sprayed with fungicides (C K Jayasinghe and C Wijeratne).

Table 1. *Disease severity score of the clone RRIC 110 in treated and control plots of chemical spraying trials at different sites*

Site	Average disease severity index	
	Treated plots	**Control plots**
Salawa Estate	1.80 (M)	2.03 (S)
Lagos Estate	2.23 (S)	2.20 (S)
	2.06 (S)	2.26 (S)
	1.63 (M)	2.23 (S)
Kuruwita Estate	BID1 - 2.25	
	BID2 - 2.46 (S)	NA
	BID3 - 2.31	
	BD4 – 2.20	
	B2D1 - 2.30	
	B2D2 - 2.20 (S)	NA
	B2D3 - 2.40	
	B2D4 - 2.40	
Four densities	B3D1 - 2.66	
	B3D2 - 2.33 (S)	NA
	B3D3 - 2.10	
	B3D4 - 2.46	
	B4D1 - 2.4-	
	B4D2 - 2.12 (S)	NA
	B4D3 - 2.31	
	B4D4 - 2.24	

NA – Data not available; M – Mobile; S - Severe

Screening of fungicides against bark rot caused by* Phytophthora *spp.

In vitro screening of fungicides was completed. Field trials with selected chemicals are in progress (C K Jayasinghe and N Dharmadasa).

In vitro *screening of fungicides against* Rigidoporus microporus

Commercially available phenolic compounds such as Catecol, Salicylic acid and Quinol were screened against the growth of *R. microporus* under laboratory condition in view of finding new alternative substances that could be used as a cheap material (K E Jayasuriya, C K Jayasinghe and D Siriwardene).

Biology of Common Pathogens (BCP/90/1)

Authentification of* Colletotrichum *species causing* Colletotrichum *leaf disease of rubber by molecular markers

Polymorphic RAPD bands generated were used in identifying several *Colletotrichum* isolates collected from different clones of rubber grown in different agro-climatic regions. It was found that most of the isolates collected were *Colletotrichum acutatum* (W P K Silva, C K Jayasinghe, T H P S Fernando, A Jayakody and E H Karunanayake: collaborative project with the University of Colombo. Partially funded by CARP).

***Cross inoculation studies with* Cylindrocladium quinqueseptatum**

Results of the screening of rubber clones against *C. quinqueseptatum*, a new record on rubber showed that all the clones tested were susceptible to the pathogen under laboratory conditions. However, they showed varying intensities of susceptibility to *Cylindrocladium*. Statistical analysis revealed that IAN 717 is a resistant clone to *Cylindrocladium* leaf Spot disease (C K Jayasinghe, W P K Silva and N Nishantha).

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

Possibility of the use of "Cassicolin" in screening of clones against* Corynespora *leaf fall

New experiment was initiated to check the possibility of the use of cassicolin (a toxin extracted from *C. cassiicola*) in screening of clones against CLFD (W P K Silva, C K Jayasinghe, N Nishantha and T H P S Fernando).

Screening of clones against* Corynespora *using scopoletin

Leaf extracts of several clones were tested for the presence of scopoletin using thin layer chromatography. Experiment is in progress to screen all the recommended clones (W P K Silva, C K Jayasinghe and P Pieris).

Development of molecular markers to identify clones resistant to Corynespora leaf fall

AFLP technique was employed to develop a molecular marker in identifying resistant clones to CLF. Preamplification was completed and selective amplification reactions are in progress (W P K Silva, C K Jayasinghe, N Nishantha, A Jayakody and E H Karunanayake: Collaborative project with the University of Colombo. Partially funded by CARP).

Screening of clones against Phytophthora leaf fall

Observations of an island-wide survey carried out on new RRISL clones revealed that RRISL 203, RRISL 201, RRISL 215, RRISL 222, RRISL 223, RRISL

226 and RRISL 208 are susceptible to *Phytophthora* infections. However, moderate to severe infections were observed on tolerant clones also in locations where microclimate was extremely favourable for propagation and spread of the pathogen (C K Jayasinghe and E B Fernando).

Maintenance of nurseries established for screening purposes

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

Island-wide survey on* Corynespora *leaf fall disease incidence in Sri Lanka

The above survey was completed using newly developed protocols and observations were made throughout the island on recommended and potential clones in Group 1, Group 2 and Group 3 (Table 2, 3 and 4).

Ranking given based on the disease severity index, revealed that 8 clones among the 34 clones were susceptible to the disease at varying intensities. No clone recommended for large scale planting was found to be infected with the disease. Two heavily affected clones namely RRISL 202 (a clone recommended for small scale planting) and RRISL 200 (experimental clone) were removed from the recommendation and kept under observations. Moderate infections have been detected on RRISL 201 and RRISL 217 which are recommended for small scale planting and it was decided to make further observations on these clones before recommending for growers. The other Group 2 clone susceptible to the disease was RRISL 133 and it showed very light infection. The rest of the susceptible clones represented the Group 3, genetic materials recommended for estate/RRI collaborative trials (C K Jayasinghe, W P K Silva, T H P S Fernando, N Nishantha collaborative project with CARP).

Table 2. *Disease severity score of the clones recommended in Group (recommended to be planted upto 10% of the extent)*

Clone	Average disease severity index
RRIC 100	0
RRIC 102	0
RRIC 121	0
RRIC 130	0
PB 217	0
PB 28/59	0

0 – highly resistant

Table 3. *Disease severity score of the clones recommended in Group 2 (recommended to be planted upto 3% of the extent)*

Clone	Average disease severity index
RRIC 117	0
RRIC 133	0.67
RRISL 203	0
RRISL 205	0
RRISL 206	0
RRISL 211	0
RRISL 215	0
RRISL 217	1.76
PB235	0
PB 260	0
BPM 24	0

0, highly resistant; 0.01 – 1.00, light infections; 1.01 – 2.00, moderate infections

Table 4. *Disease severity score of the clones recommended in Group 3 (recommended to be planted as estate/RRI collaborative clone trials. Each clone to be planted upto 2 ha)*

Clone	Average disease severity index
RRISL 200	3.83
RRISL 201	1.57
RRISL 204	0
RRISL 208	2.86
RRISL 218	0.133
RRISL 220	0
RRISL 221	0
RRISL 222	0
RRISL 226	0
GPS 1	0
PB 255	0
PR 255	0.03
RRII 105	0
RRISL 2000	0
RRISL 2001	0
RRISL 219	0

0, highly resistant; 0.01 – 1.00, light infections; 1.01 – 2.00, moderate infections, 2.01 – 3.00, severe infections

Biological Control of *Hevea* Diseases (BC/89/1)

Biological control of white root disease

The evaluation of the T_{10} medium has been continued during this period, using the 3rd consecutive experiment established in the premises of RRI (K E Jayasuriya and B I Tennakoon).

Biological control of rubber nursery diseases

The biocontrol isolate T_{21} was initially identified as *Trichoderma aureo-viride* according to Rifai identification procedure, and was initially screened in field conditions using young plants. Attempts were made to produce new virulent biotypes from T_{21} using UV radiation (K E Jayasuriya and C Wijeratne).

Biological control of bark and stem diseases

Initial studies were commenced to isolate and identify microflora antagonistic against bark and stem infecting pathogens from bark and trunk area of three clones, *viz.* RRIC 100, 121 and 130. Bark sample were collected from the above clones from different areas and organism were isolated on PDA (K E Jayasuriya and D Siriwardene).

Defence mechanism of rubber (DM/89/1)

Defence mechanism of rubber

Total soluble phenolic compounds were determined in leaves of some selected, new clones as a one criteria of defense aspect to be compared. However, according to the results obtained from the investigated clones, a firm relationship could not be found with relation to the overall response of clones against leaf disease. Therefore other criteria were considered to be investigated (K E Jayasuriya and B I Tennakoon).

MISCELLANEOUS

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

Assessments were taken from the critical trial established at Gallewatta division. The decaying rate of cut logs was determined using a simple key developed by the Dept. of Plant Pathology and Microbiology. During the period, different decaying fungi were isolated from treated logs, purified and subjected to a laboratory trial to determine the wood decaying rate. Rubber wood blocks (1 cm^3) were sterilized and inoculated with the isolates for determination of the decaying rate of the inoculated organism (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 is in progress and an application for funding was forwarded to the CARP, which was considered favourably by the committee. Financial support to carryout the project for a period of 3 years commencing from January 2005 was granted. Note that details of the projects were given in the 2003 Annual Review (K E Jayasuriya, C K Jayasinghe, E B Fernando and P Peiris).

Mangifera indica*: an alternative host for *Colletotrichum acutatum

Mangifera indica (mango), a fruit tree planted in an around rubber plantations was proved to be an alternate host for *C. acutatum* (C K Jayasinghe and T H P S Fernando).

Possibility of the popularisation of Oidium susceptible high yielding clones with the predicted climate change

The above project was awarded to Mrs T H P S Fernando by the Ministry of Environment and Natural Resources under the Climate Change Enabling Activity (Phase II) and it was successfully completed under the supervision of Dr C K Jayasinghe. The study revealed that the elongation of the dry spells and the temporal variation during the refoliation period in main rubber growing areas directly affect the severity of secondary leaf fall (T H P S Fernando and C K Jayasinghe).

Antifungal activity of extracts from common cover crops of rubber plantations in Sri Lanka

Leaf extracts of *Muccuna* and *Pueraria* were tested against rubber pathogens using Poisoned Food Technique. It was found that there is an antifungal effect in both extracts (C K Jayasinghe and D Siriwardene).

Laboratory screening of fungicides against* Botryodiplodia *isolates

Benomyl and Folicur were found to be the best in controlling the mycelial growth out of five fungicides tested, *viz.* Macksel, Captan, Copper oxychloride, Benomyl and Folicur against 14 isolates (C K Jayasinghe and N Jayawardene).

***Morphological characters and Pycnidia production of 14 isolates of* Botryodiplodia theobromae**

Morphological characters of 14 isolates on Potato Dextrose Agar (PDA) were investigated. Isolate B3 produced significantly higher number of pycnidia compared to B16 on PDA (C K Jayasinghe and N Jayawardene).

SOILS AND PLANT NUTRITION

Lalani Samarappuli

SUMMARY

It is shown that weed control was better under the leguminous cover crop, *Mucuna bracteata,* compared to *Pueraria phaseoloides*, probably due to its very vigorous growth and the potential saving from selective weeding during the immature period of rubber is around Rs.25,000/ha. Placement of encapsulated fertilizer in the polybag appears to be agronomically as effective as the current fertilizer recommendation for young budding plants. Data revealed that the growth of the scion could be improved by resuming fertilizer application at the time of cutback, although the differences were not statistically significant. Delaying of bud grafting and cut back, as often being the case in large-scale commercial nurseries, significantly affect the scion growth and this negative effect cannot be recovered by applying fertilizer at cut back time. It also appears that sulfate of ammonia is more effective than urea as the source of N for young budding seedlings. Moreover, data revealed that diammonium phosphate is not effective as a basal P source in young budding nurseries compared to phosphate rock fertilizers.

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. The site-specific fertilizer recommendation programme for mature rubber provided fertilizer recommendations for 6500 hectares in the estate sector. Under the land selection programme for planting rubber 300 hectares were surveyed. The Department analyzed approximately 350 samples (1500 parameters) for outside organizations during the year.

DETAILED REVIEW

Staff

The Head of the Department, Dr (Mrs) Lalani Samarappuli and Dr R S Dharmakeerthi, Soils Chemist were on duty throughout the year. 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, V Edirimanne and A Thevarapperuma and Technical Officers, Messrs P R Puhambugoda, J A S Chandrasiri and T Gunatilleke and the English Stenographer Mrs L Rupasinghe were on duty throughout the year.

Research students

- Miss H A N Upeakshani, an undergraduate student from the University of Ruhuna, completed her final year project on "An investigation on nitrogen mineralization of *Hevea* leaf litter in rubber growing soils" under the supervision of Dr R S Dharmakeerthi.

Seminars/Conferences/Meetings/Work-shops addressed

Officer	Subject	Organization
Lalani Samarappuli	*Mucuna bracteata* as a cover crop for rubber (*Hevea brasiliensis*) in Sri Lanka	First symposium on Plantation Crop Research: TRI/RRI/CRI
Lalani Samarappuli	CDM and Kyoto Protocol – Where are we?	Institute of Engineers, Sri Lanka
Lalani Samarappuli	Possibilities of C trading in the plantation sector	Asia Carbon Net
Lalani Samarappuli	Impact of climate change on productivity of rubber, adaptation measures and role of rubber plantations as a mitigation option	Ministry of Environment and Natural Resources
Lalani Samarappuli	Recent advances in fertilizer use in rubber	RRISL
Lalani Samarappuli	Establishment of *Mucuna bracteata* in the field	Bogawantalawa Plantations Ltd.
Lalani Samarappuli	Physical Properties of Soil and It's Importance in Agriculture	Soil Science Society of Sri Lanka
S Dharmakeerthi	Fertilizer application to rubber	Bogawantalawa Plantations Ltd.

Seminars/Conferences/Meetings/Work-shops attended

Officer	Subject	Organization
Lalani Samarappuli	C Trading for plantation sector	Ministry of Plantation Industries
Lalani Samarappuli	Working Group on Organic Fertilizers	Sri Lanka Standards Institution
Lalani Samarappuli	Developing Strategies for Soil Fertility Improvement	Dept. of Agriculture
Lalani Samarappuli	Organic farming	Lanka Organic Agricultural Movement
Lalani Samarappuli	MIS	CARP

Officer	Subject	Organization
Lalani Samarappuli	Fertilizer distribution in small holdings	Ministry of Plantation Industries
Lalani Samarappuli S Dharmakeerthi	Scientific Committee Meeting	Rubber Research Institute
S Dharmakeerthi	First symposium on Plantation Crop Research	TRI/RRI/CRI
S Dharmakeerthi	Advances in K research in Sri Lanka	NFS
S Dharmakeerthi	Geo-Informatics 2004	PGIA

Training programmes

Client	No. of programmes
Plantation Executives	02
Estate Managers	06
Field Officers	04
Estate Workers	03
Rubber Development Officers	00
Smallholders	02
University Students	06
NDT Students	02

Advisory visits

Client	No. of visits
Plantations	14
Smallholdings	10

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 (Table 1) (Lalani Samarappuli, U Mitrasena and T Gunathilaka).

Table 1. *Effect of mulching on yield of rubber*

Species	Yield (g/t/t)
No fertilizer, no mulching	38.6^{A}
Fertilizer only, no mulching	44.2^{B}
Mulching without fertilizer	43.8^{B}
Mulching with fertilizer	47.5^{B}

(Means with same letter are not significantly different)

Ground cover management

New cover crop species

The experiment on *Mucuna bracteata* in comparison with *Pueraria*, was continued. Data indicated that dry weight of green matter of *Mucuna* under mature rubber was four times higher than *Pueraria* (Table 2) (Lalani Samarappuli, P Karunadasa, U Mitrasena and T Gunathillake).

Table 2. *Growth of* Mucuna *under mature rubber*

Species	Biomass production (kg/ha)
Pueraria phaseoloides	$2{,}440^{A}$
Mucuna bracteata	645^{B}

(Means with same letter are not significantly different)

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 growth of rubber plants are presented in Table 3 (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 3. *Effect of* Wedelia trilobeta *(Arunadevi) on growth of rubber plants*

Treatment	Girth (cm)
Pueraria phaseoloides + P	52.3^{A}
Wedelia trilobeta + P	48.9^{B}

(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 leaf P content of rubber plants is presented in Table 4. 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 4. *Effect of different sources of phosphate for* Mucuna and Flemingia *on leaf P content of rubber plants*

Treatment	Leaf P (%)	
	Mucuna	***Flemingia***
No P	0.150^{A}	0.153^{A}
ERP	0.169^{B}	0.171^{B}
IRP	0.172^{B}	0.175^{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 is presented in Table 5 (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 5. *Effect of different planting systems on girth of rubber plants*

Treatment	Girth (cm)
Crotolaria micans	53.0^{A}
Flemingia macrophylla	53.8^{A}
Flemingia + Crotolaria	54.1^{A}

(Means with same letter are not significantly different)

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 and data are being analysed (Lalani Samarappuli and T Gunatilleke).

Weeds and weed control

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

The other field experiment started to study the control of different weed species by *Mucuna bracteata* was also continued (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 six years after planting in Bibile and girth at five years after planting in Kahapathwela are given in Tables 6 (Lalani Samarappuli, P Karunadasa, U Mitrasena and T Dissanayake).

Table 6. *Effect of mulching on girth of rubber plants*

Treatment	Girth (cm) in Bibile	Girth (cm) in Kahapathwela
No mulch	42.9^{B}	48.7^{B}
With mulch	47.6^{A}	52.5^{A}

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 five and a half years after planting and tappability of rubber plants are given in Table 7 (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 7. *Effect of different mulching materials on girth of rubber plants*

Treatment	Girth (cm)	Tappability (%)
No mulch	47.1^{A}	42.7^{B}
Paddy husk	50.3^{B}	70.0^{A}
Coir dust	50.7^{BC}	58.5^{AB}
Green manure	52.3^{BC}	78.0^{A}
Paddy straw	52.9^{C}	81.5^{A}

(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 *Crotolaria micans* and *Flemingia macrophylla* as successful tree legumes under dry agro-climatic condition was also studied. Data on girth at six years after planting under two situations are given in Tables 8 and 9, respectively (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 8. *Effect of growing* Mucuna *on girth of rubber at six years after planting*

Species	Girth (cm)
Pueraria phaseoloides	41.0^{A}
Mucuna bracteata	44.3^{B}

(Means with same letter are not significantly different)

Table 9. *Effect of different planting systems on girth of rubber plants at six years after planting*

Treatment	Girth (cm)
Crotolaria micans	45.2^{A}
Flemingia macrophylla	47.0^{A}
Flemingia + Crotolaria	48.3^{A}

(Means with same letter are not significantly different)

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. This experiment was continued (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 10 and 11, respectively (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 10. *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	45.4^{A}	45.8^{A}	49.5^{B}	49.9^{BC}
M_1	51.7^{BC}	53.0^{BC}	52.3^{C}	52.7^{BC}

(Means with same letter are not significantly different)

Table 11. *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	42.3^{A}	42.6^{A}	44.1^{AB}	44.8^{B}
M_1	48.5^{B}	48.3^{B}	47.1^{B}	46.6^{B}

(Means with same letter are not significantly different)

Soil moisture requirement of rubber under different densities

The experiment (SMC-Ag/D/97/1), started at Dorset division, Clyde estate to study the soil moisture requirement of rubber under different densities was continued. 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] (Lalani Samarappuli, P Karunadasa and U Mitrasena in collaboration with the Plant Science Department).

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

Biomass accumulation (carbon sequestration) in rubber plantations

The study started to estimate the biomass accumulation (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 was continued. Different ages of rubber fields were demarcated for uprooting to estimate the biomass accumulation of rubber (Lalani Samarappuli, Wasana Wijesuriya, T Dissanayake, U Mitrasena and T Gunatillake).

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

The experiment initiated at the Dartonfield estate to investigate the possibilities of substituting chemical fertilizers with commercially available municipal solid waste compost to reduce the fertilizer application frequency in young budding nurseries was continued. Statistical analysis on plant growth data indicates that compost and fertilizer enriched compost used may not be agronomically as effective as the currently recommended liquid fertilizer (Table 12). However, the rates of fertilizer application may be reduced by half if compost is used at bag filling stage at rates used in this experiment (R S Dharmakeerthi, S N Silva and S Chandrasiri).

Slow-release fertilizers for young budding nurseries

The experiment initiated at the Dartonfield Estate in 2003, in collaboration with the polymer chemistry department, to develop a slow-release fertilizer (SRF) for young budding nurseries was continued. Placement of encapsulated fertilizer in the polybag appears to be agronomicaly as effective as the current fertilizer recommendation, as indicated by the statistical analysis of the plant data (Table 13) (R S Dharmakeerthi, N Liyanage, H N K K Chandralal, S N Silva and S Chandrasiri).

Table 12. *Effect of municipal solid waste compost on % buddable plants, % budding success and scion diameter (mm)*

Treatment	Buddable plants† (%)	Budding success† (%)	Scion diameter† (mm)
1. No compost, no fertilizer control	51 ^{D}	100 ^{A}	4.4 ^{A}
2. Current fertilizer recommendation	100 ^{A}	88 ^{AB}	4.9 ^{A}
3. 1:5 soil-compost mixture	90 ^{BC}	81 ^{B}	4.9 ^{A}
4. 1:5 soil-0.05% fertilizer enriched compost mixture	83 ^{C}	82 ^{AB}	4.5 ^{A}
5. 1:5 soil-0.1% fertilizer enriched compost mixture	87^{C}	58 ^{B}	4.6^{A}
6. 1:5 soil-compost mixture + ½ current fertilizer recommendation	97 ^{AB}	76 ^{B}	4.9 ^{A}

† values in a column with the same superscript are not significantly different

Table 13. *Effect of encapsulated slow-release fertilizer on % buddable plants, % budding success and scion diameter (mm)*

Treatment	Buddable plants† (%)	Budding success† (%)	Scion diameter† (mm)
1. No fertilizer control	75 ^{B}	100 ^{A}	4.7 ^{A}
2. Current fertilizer recommendation	100 ^{A}	95 ^{A}	5.2 ^{A}
3. Two blocks of encapsulated fertilizer	100 ^{A}	94 ^{A}	5.5 ^{A}
4. One block of encapsulated fertilizer	100 ^{A}	90 ^{A}	4.9 ^{A}

†values in a column with the same superscript are not significantly different

Effect of continuous fertilizer application on bud grafting and scion growth

Four experiments initiated in December 2003 at government rubber nurseries (*i.e.*, Egaloya, Welikadamulla, Meerigama and Karapinche), in collaboration with the Plant Science Department, 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 were abandoned as the prolonged drought and severe *Gleosporium* attack incurred heavy causalities in the experimental plots.

However, another experiment was started at the Welikadamulla government rubber nursery in February 2004 to study the same effects. The currently recommended liquid based fertilizer mixture was applied on 150 plants per treatment

under the normal nursery management conditions as follows;

Treatment No.	Description
1	Fertilizer application was stopped two weeks prior to bud grafting and resumed four weeks after cut back (current recommendation)
2	Fertilizer application was stopped two weeks prior to cut back and resumed four weeks after cut back
3	Fertilizer application was stopped two weeks prior to bud grafting and resumed at the time of cut back
4	As of treatment 1 but both bud grafting and cut back were delayed by two more weeks
5	As of treatment 2 but both bud grafting and cut back were delayed by two more weeks
6	As of treatment 3 but both bud grafting and cut back were delayed by two more weeks

Fertilizer application during the bud grafting and cut back periods did not significantly affect grafting success or the scion die back. It appears that the growth of the scion could be improved by resuming fertilizer application at the time of cutback, although the differences were not statistically significant (Table 14). Delaying of bud grafting and cut back (treatments 4, 5 and 6), as often being the case in large scale commercial nurseries, significantly affect the scion growth as compared to treatments 1, 2 and 3. And this negative effect cannot be recovered by applying fertilizer at cut back time (R S Dharmakeerthi, A M W K Seneviratne and S Chandrasiri).

Table 14. *Budding success, scion die back and scion growth as affected by the fertilizer application during the bud grafting and cut back period*

Treatment No	Budding success[†] (%)	Die back[†] (%)	Diameter[†] (mm)	Height[†] (cm)
1	94 ^{A}	1 ^{A}	6.6 ^{ABC}	41 ^{A}
2	97 ^{A}	3 ^{A}	6.7 ^{AB}	40 ^{A}
3	98 ^{A}	0 ^{A}	7.0 ^{A}	41 ^{A}
4	94 ^{A}	2 ^{A}	6.3 ^{BC}	35 ^{B}
5	99 ^{A}	2 ^{A}	6.2 ^{B}	34 ^{B}
6	85 ^{A}	0 ^{A}	6.0 ^{C}	36 ^{B}

[†]Values in a column with the same superscript are not significantly different

Effectiveness of urea as the N source in young budding fertilizer mixtures

An experiment was initiated at the Welikadamulla government rubber nursery to determine whether urea could be used as a N source in young budding fertilizer mixtures.

It appears that the girth of the urea applied seedlings were significantly low compared those of sulfate of ammonia applied seedlings (Table 15) in these soils (R S Dharmakeerthi, V Edirimanne and S Chandrasiri).

Table 15. *Comparison of seedling diameter (mm) as affected by the N source*

Treatment	Weeks after planting[†]	
	8	16
Sulfate of ammonia based	5.1 [A]	7.4 [A]
Urea based	4.8 [B]	6.7 [B]
No fertilizer control	4.6 [B]	6.1 [C]

[†]Values in a column with the same superscript are not significantly different

Effectiveness of diammonium phosphate as a basal P source in young budding nurseries

In large scale young budding nurseries, the application of phosphate rock fertilizers as the basal dressing is often not carried out due to practical reasons. Therefore the effectiveness of application of diammonium phosphate (DAP) in liquid form was evaluated in a experiment established in the Welikadamulla government rubber nursery in 2004 (Table 16). The growth of seedling could not be improved by DAP application at rates and frequencies used in this experiment. In fact, the seedling growth was retarded when DAP was applied two times (R S Dharmakeerthi, S Chandrasiri and V Edirimanne).

Table 16. *The seedling diameter (mm) as affected by DAP when used as a basal P source in young budding nurseries*

Treatment	Weeks after planting[†]	
	8	16
No P as a basal dressing	5.2 [A]	8.0 [A]
2g of DAP at planting	5.1 [AB]	7.6 [A]
2g of DAP at planting + 2g of DAP at 2 weeks after planting	4.4 [C]	6.8 [B]
4g of DAP at planting	4.8 [B]	7.4 [A]
4g of DAP at planting + 4g of DAP at 2 weeks after planting	4.2 [C]	6.6 [B]

[†]Values in a column with the same superscript are not significantly different

Fertilizer requirement of young budding plants raised using sub soil

Most of the large scale rubber nurseries lose their fertile top soil as soil filled bags are removed from the site every year. Therefore in the future these nurseries would have to bring fertile top soil from other places for bag filling or else use the less

fertile subsoil for this purpose. An experiment was started in the Welikadamulla government rubber nursery in 2004 to determine the fertilizer requirement of young budding plants when sub soil is used for bag filling. Growth of the seedlings is poor in subsoil even when the current liquid formulation is applied at 200% the recommended level (Table 17) (R S Dharmakeerthi, V Edirimanne and S Chandrasiri).

Table 17. *Diameter of the seedlings (mm) grown in sub soil as affected by the fertilizer level*

Treatment	Weeks after planting[†]	
	8	16
Top Soil + Current recommendation	5.2 ^{A}	8.0 ^{A}
Sub soil + No fertilizer	4.6 ^{B}	5.6 ^{C}
Sub soil + Current recommendation	5.2 ^{A}	7.6 ^{B}
Sub soil + 150% Current recommendation	5.1 ^{A}	7.6 ^{B}
Sub soil + 200% Current recommendation	5.0 ^{A}	7.6 ^{B}

[†]Values in a column with the same superscript are not significantly different

Fertilizers to immature rubber

Different fertilizer sources

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

The experiment, started at Pembroke division, Payagala estate in a 2001 replanting to study the feasibility of using Dolomite during the first year of planting was terminated. Data are being analysed. A new experiment was initiated on the same subject at Nottinghill estate, Kahapathwala to confirm the results. Effect of same treatments on girth of rubber plants at the end of 5 months after planting is presented in Table 18 (Lalani Samarappuli, P Karunadasa,T Gunatilleke and U Mitrasena).

Table 18. *Effect of different treatments on diameter of rubber plants*

Fertilizer treatments	Diameter (mm)
75g kieserite in 2 applications (Control)	23.4^{A}
25g kieserite + 75g dolomite	22.0^{A}
50g dolomite + 75g dolomite	22.9^{A}
75g dolomite only (planting hole)	22.8^{A}
75g dolomite (planting hole) + 25g kieserite	22.4^{A}
100g dolomite (planting hole) + 25g kieserite	21.7^{A}
50g dolomite (planting hole) + 75g dolomite	23.4^{A}
75g dolomite (planting hole) + 25g kieserite	20.0^{A}
100g dolomite only (planting hole)	22.1^{A}
150g dolomite only (planting hole)	22.2^{A}

(Means with same letter are not significantly different)

Foliar nutrients

The field experiment, started in 2000 replanting to study the effect of a foliar fertilizer; Humat 2000, on the performance of rubber plants was terminated. Data are being analyzed (Lalani Samarappuli, U Mitrasena and T Gunatilleke).

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. Residual effect of different fertilizer treatments was monitored (Lalani Samarappuli, P Karunadasa and U Mitrasena in collaboration with the Plant Science Department).

Nutrient requirement of rubber based cropping systems

No work was conducted due to unavailability of staff.

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 uninterruptedly during the initial period of tapping, at least in the virgin panels (Table 19). 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).

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 6500 hectares in the estate sector.

Table 19. *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	2.2	0.18	1.2	0.29
	A panel	2.4	0.22	1.0	0.33
Kegalle	$5^{th}/6^{th}$ year	2.1	0.17	0.9	0.27
	A panel	2.3	0.17	1.1	0.32
Avissawella	$5^{th}/6^{th}$ year	2.2	0.15	0.9	0.33
	A panel	2.6	0.16	0.9	0.28
Ratnapura	$5^{th}/6^{th}$ year	1.9	0.15	0.9	0.29
	A panel	2.3	0.19	0.8	0.31
Galle/Matara	$5^{th}/6^{th}$ year	2.3	0.22	0.9	0.28
	A panel	2.6	0.19	0.8	0.28

Nutrient requirement of new* Hevea *clones

Several experiments have been established using different clones and different fertilizer treatments to determine the fertilizer requirement of new vigorously growing, high yielding clones.

Trials conducted in group III soils

The trial at Lagos Division, Paiyagala Estate, which was established in 1992 and consist of five clones (RRIC 121, RRIC 110, RRISL 203, PB 260 and RRIM 712 of which RRIC 110 was later removed due to the *Corynespora* leaf fall disease) and four fertilizer levels (0, 0.5, 1 and 1.5 times the currently recommended fertilizer levels). Statistical analysis on the yield data after 12 years of planting, reveled that there were no significant differences among fertilizer levels but it was significantly

different among clones. The PB 260 clone gave the highest yield whereas RRIM 712 gave the lowest yield among the clones tested (Table 20).

Table 20. *Effect of clone and fertilizer level on latex yield during the year 2004*

Clone	Yield† (g/t/t)	Fertilizer level	Yield† (g/t/t)
PB 260	50.7 ^{A}	No fertilizer	41.4 ^{A}
RRISL 203	45.9 ^{AB}	0.5 Current Recommendation	43.6 ^{A}
RRIC 121	41.4 ^{B}	1.0 Current Recommendation	41.4 ^{A}
RRIM 712	31.0 ^{C}	1.5 Current Recommendation	42.5 ^{A}

†values with the same superscript in a column are not significantly different

Two more trials have been established in RRISL substation, Kuruwita and in Vogan Estate, Matugama on clearings established in 1997, to determine the fertilizer requirement of some new clones after they were brought into tapping. Fertilizer treatments were initiated in the year 2003. The girth increments of the clones tested were not significantly affected by the fertilizer level during the first year of fertilizer application (Table 21).

Table 21. *Effect of fertilizer level on girth increment (cm) of some new clones during the 7th year after planting*

Fertilizer Level	Vogan†		Kuruwita†		
	GPS 1	RRISL 217	RRISL 201	RRISL 202	RRISL 217
No fertilizer	3.4 ^{A}	4.5 ^{A}	2.5 ^{A}	2.2 ^{AB}	3.1 ^{A}
100% Current recommendation	3.8 ^{A}	4.7 ^{A}	2.3 ^{A}	1.9 ^{B}	3.8 ^{A}
200% Current recommendation	3.5 ^{A}	4.6 ^{A}	2.7 ^{A}	2.2 ^{A}	3.3 ^{A}

†values with the same superscript in a column are not significantly different

The trial established in 1998 at Eladuwa estate to study the interactions of P, K and Mg on growth of three new high yielding *Hevea* clones (RRISL 201, RRISL 202 and BPM 24) continued for the sixth year. Statistical analysis revealed that the girth of clone RRISL 201 is significantly increased by increasing K levels from 0.6 to 2.2 times the currently recommended levels. For the other two clones (RRISL 202 and BPM 24), the girths were significantly increased when both P and K levels were increased from 0.6 to 2.2 times the currently recommended levels. Moreover, the increase in girth due to P or K was greater at higher rates of the other nutrient indicating a significant positive interaction effect between P and K (Table 22).

Table 22. *Regression equations describing the girth (cm) of each clone as affected by the P and/or K levels*

Clone	Regression equation[†]
RRISL 201	56.4 + 1.47 K
RRISL 202	49.8 + 0.61 K×P
BPM 24	56.6 + 0.63 K×P

[†] K and P signifies the fertilizer levels at 0.6, 1.4 or 2.2 times the currently recommended level

Management of diseases through fertilizer application

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

The severity of the disease was measured in RRISL 201 and RRISL 202 clones in the fertilizer experimental plots in the Eladuwa estate and the data are being analyzed. Severity of this disease was also monitored in RRISL 201, 202 and 217 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 severity of the CLF disease in these plots had been masked due to Phytopthora attack in this year (R S Dharmakeerthi, C K Jayasinghe, S N Silva and E A D N Nishantha).

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 (L Samarappuli and P Perera).

Organic fertilizers

Planting stage

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 23 and 24, respectively (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 23. *Effect of different treatments on growth of rubber plants*

Treatment	Girth (cm)
Nil (control)	10.9^{A}
Paddy straw	12.5^{A}
Poultry litter	12.4^{A}
Cow dung	12.9^{A}
Green manure	11.0^{A}
EM treated compost type 1	12.9^{A}
EM treated compost type 2	12.8^{A}
Burned paddy husk	11.2^{A}

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

Treatment	Girth (cm)
Nil (control)	11.6^{A}
EM treated compost	14.1^{B}
Burned paddy husk	12.9^{B}
Coconut husk	13.0^{B}

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 + 1^{st} to 6^{th} year, (T3) Organic manure to planting hole + 2^{nd} year + 4^{th} year + 6^{th} year (Level 1), (T4) Organic manure to planting hole + 2^{nd} year + 4^{th} year + 6^{th} year (Level 2), (T5) Organic manure to planting hole + 3rd year + 6^{th} year (T6) Organic manure to 3rd year + 5^{th} year. Effect of treatments on girth at the end of three and a half years is given in Table 25 (Lalani Samarappuli, P Karunadasa, U Mitrasena and T Dissanayake).

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

Treatment	Girth (cm)
T1	26.9^{A}
T2	32.0^{B}
T3	32.2^{B}
T4	32.2^{B}
T5	30.8^{B}
T6	32.3^{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. Data on effects of treatments on different parameters are being analyzed (Lalani Samarappuli, P Karunadasa and U Mitrasena).

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). Data colleted during the immature period of rubber are being analyzed (Lalani Samarappuli, P Karunadasa and U Mitrasena).

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 26 (Lalani Samarappuli, U Mitrasena, and T Gunatilleke).

Table 26. *Residual effect of sludge on yield of rubber plants*

Treatment	Yield (ml/t/t)
Without sludge	62.6
With sludge	68.5

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 (Lalani Samarappuli, 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". Data on effects of different treatments are being analyzed (Lalani Samarappuli, P Karunadasa and T Dissanayake).

Rubber growing soils - Spatial variability of rubber growing soils and the growth of rubber

Spatial variability of growth of rubber across variable landscapes

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. Girth of rubber trees in 70m × 130m area (Kuruwita) or 20m × 190m area (Neboda) were measured. Elevation at 20 m intervals of each field were also measured. Average girth data in the steep field indicates that the plant growth is poor towards the top of the hill compared to the plant growth at the bottom of the hill (Figure 1). In the other field, the plant girths were similar, on the average, every where in the field. This suggests that in lands with steep slopes either the soil fertility management or the nutrient requirement of plants or both has been variable along the gradient. The experiment is in progress (R S Dharmakeerthi, S P Perera, S N Silva and S Chandrasiri).

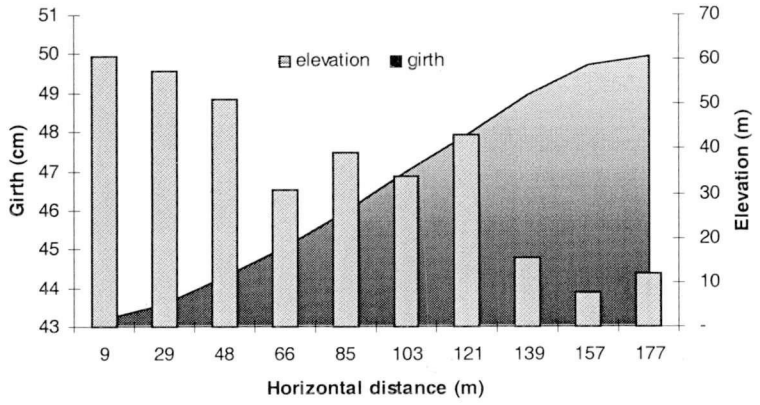


Fig. 1. The relationship between the change in elevation and the plant growth across the landscape at Neuchatel Estate, Neboda

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 300 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 27.

Table 27. *Details of the analysis done during the year*

Source	No. of analysis				
	Plant	**Soil**	**Fertilizer**	**Organic manure**	**Other***
Experimental	1000	100	-	50	-
Soil and Foliar survey	2000	-	-	-	-
Other Departments of RRI	100	40	-	15	100
Research Institutes	-	-	-	-	-
Rubber Development Department	-	-	115	-	-
Plantation Mgt. Companies	04	430	350	20	12
Other Private Companies	16	16	-	36	04
Total	3120	486	411	121	116

* 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

V H L Rodrigo and G V Lakmali Nilmini

SUMMARY

Experiments were continued to develop an economically feasible method to extract "Quebrachitol", a valuable biochemical from rubber serum, during the process of raw rubber manufacture.

Studies on biochemical changes associated with tapping panel dryness were continued for the purpose of identifying the mechanism for this physiological disorder. Further, attention was paid to identify the seasonal variations of non-rubber constituents in latex, particularly with recently developed rubber genotypes.

Biochemical changes in latex during the wintering period were identified. The impact of the rainfall on the pollution associated with the rubber factory effluent was investigated. Since measurement of dry rubber content in latex with the metrolac is found to be not consistent with the changes in ambient temperature, particularly in the latex harvested in high elevations investigations, a study was commenced to develop a ready reckoner chart for such circumstances.

The effectiveness of coconut fiber medium on biological wastewater treatment of rubber factory effluent was found to be more efficient than the that of other commonly used media with that specific surface area of the Bio – brush medium could be increased up to 200 m^2/m^3.

DETAILED REVIEW

Staff

Dr V H L Rodrigo was appointed as the Acting Head of the Department with effect from 23.09.2004. Assistant Biochemist, Mrs G V L Nilmini reported for duty after maternity leave on 20th of September. Experimental Officers, Mrs K V V S Kudaligama Wijesundera, Mr P D J Rodrigo and Mr D Ramawickrama, were on duty through out the year.

Seminars/Conferences/Meetings/Workshops attended

Officer	Subject	Organization
G V Lakmali Nilmini	Scientific Committee Meetings	Rubber Research Institute
KV V S Kudaligama	Effect of rainfall on the pollution problem associated with natural rubber processing factories	Ministry of Environmental and Natural Resources
K V V S Kudaligama	National Symposium on Air Resource Management in Sri Lanka	Air Resource Management Centre and Clean Air Sri Lanka

Training Programmes

Client	Subject	No. of programmes
Undergraduates - University of Sabaragamuwa	Wastewater Management	01
Students from Universities, Agriculture Schools and Schools	Rubber manufacturing and wastewater treatment	several

LABORATORY AND FIELD INVESTIGATIONS

Extraction of Quebrachitol from rubber serum

Finding a suitable method for the extraction of Quebrachitol from rubber serum was continued. It was able to purify this chemical partially and further development was limited by the non availability of required instruments within the department (G V Lakmali Nilmini, K V V S Kudaligama, P D J Rodrigo, D Ramawickrama).

Biochemical studies of Tapping Panel Dryness (TPD)

This project attempts to identity possible causes for the TPD which is considered to be a physiological disorder. Preliminary investigations were carried out to assess some biochemical changes (*e.g.* carbohydrates and proteins) in TPD affected trees (G V Lakmali Nilmini, K V V S Kudaligama, P D J Rodrigo, D Ramawickrama in collaboration with the Plant Science Department - This project is funded by the Council for Agricultural Research Policy).

Studies on non-rubber constituents present in latex

Seasonal variation of non-rubber constituents present in latex was investigated in 4 clones, *i.e.* RRIC 100, RRIC 121, RRIC 130 and RRIC 102. Latex samples were collected from two replicates and were analysed for contents of dry rubber, total solid, acetone extractable non rubber and ash (Fig. 1 - 4).

Seasonal variation of all parameters was prominent around March time (*i.e.* just after defoliation) with the lowest values recorded for the year. Nevertheless, seasonal variation of ash content was prominent with lowest values in the whole wintering period (February to April) and highest values in June. In general, the clone RRIC 121 maintained the highest dry rubber and total solid contents throughout the year whilst those were lowest in RRIC 102. Highest Acetone extractable non rubber content was recorded in RRIC 102 and that of other clones was comparable. Ash content in RRIC 121 showed the highest level of seasonal variation (G V Lakmali Nilmini, K V V S Kudaligama, P D J Rodrigo and D Ramawickrama).

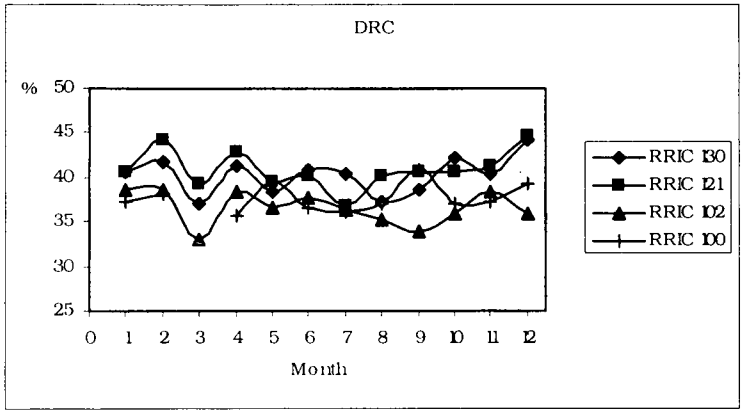


Fig. 1. Variation of dry rubber content during the year 2004

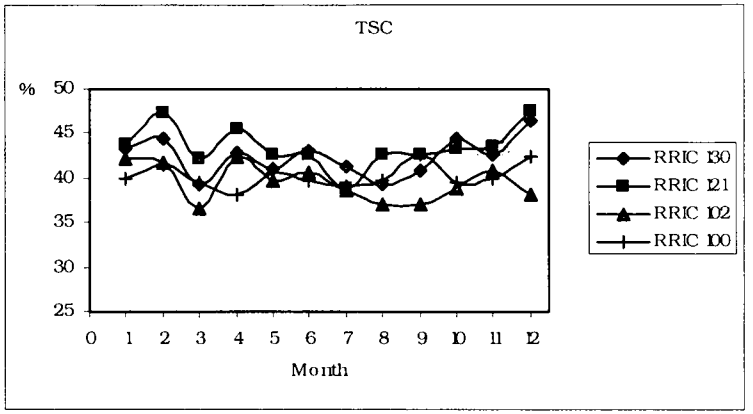


Fig.2. Variation of total solid content during year 2004

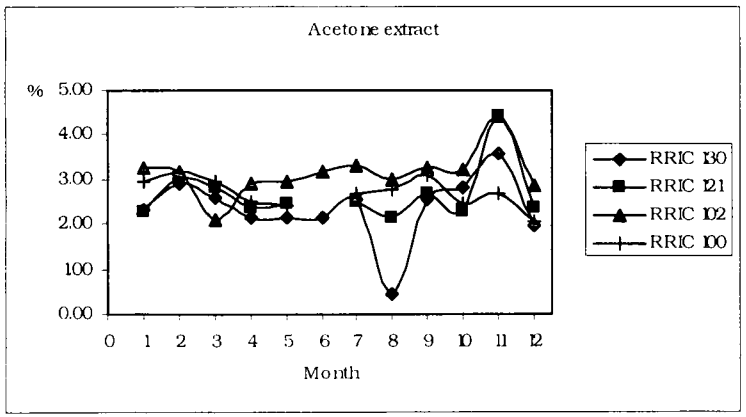


Fig. 3. Variation of acetone extractable non rubber content during

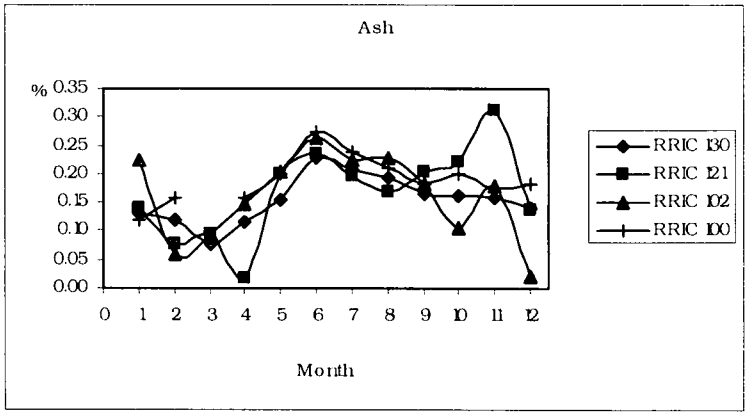


Fig. 4. Variation of ash content during year 2004

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

This research project was funded by the Junior Research programme of the Climatic Change Enabling Activity (Phase II) Project of Ministry of Environment and Natural Resources. This project was focused on the variation of stability of the latex during the year. Latex samples collected from RRIC 102 and RRIC 121 were analysed for amino acids, phenols and technical properties in *ca.* 2 weeks intervals from January to August. Similar analyses were done for the latex collected from the manually defoliated trees in August. Output of the project has been published as a working paper of the Climate Change Secretariat. Defoliation during the non wintering period results reduction in phenol content which may affect the Plasticity Retention Index of the raw rubber (G V Lakmali Nilmini and L M K Tillekeratne).

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

This study was carried out to assess the impact of rainfall on the water pollution problem associated with rubber processing factories. Delkith, Pallegoda, Dartonfield, Culloden and Frocester crepe rubber factories were selected for the study. In all five locations, the period of maximum dry spell showed increasing trends in most of the months. Flow patterns and waste dilution patterns of the waste receiving stream of the Culloden factory was selected for the detailed assessment. Water flow in the stream during rainy periods was considerably high when compared to dry periods. The chemical oxygen demand (COD) values of the samples collected during dry period were comparatively higher than those of rainy periods (Fig 1). During the dry period, water quality was not in an acceptable level even at the 1km down the stream.

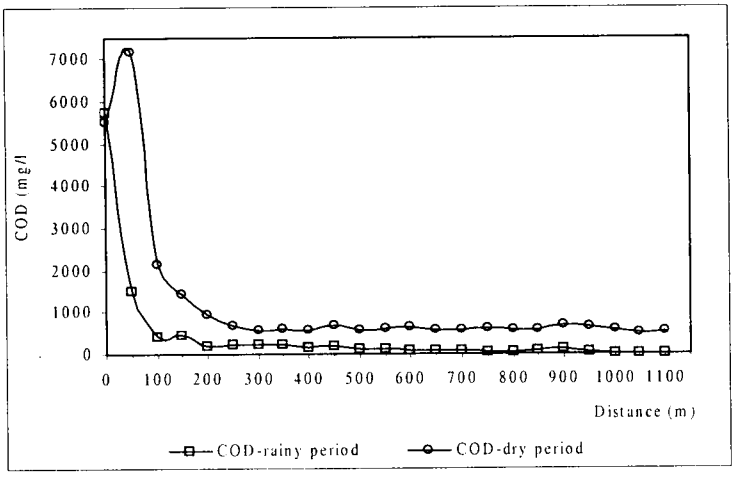


Fig. 5. The profile of the chemical oxygen demand (COD) in the stream during wet and dry periods

A Participatory Rural Appraisal carried out with 20 participants from the vicinity of Culloden factory confirmed the water pollution by factory effluent and further, it appeared that river sand becomes unsuitable for construction purpose. This project was 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 and Wasana Wijesuriya).

Effect of low temperature on metrolac reading

This research project aims to solve the temperature associated problem of measuring dry rubber content of latex with the metrolac in high elevations. Initial studies on metrolac readings at low temperatures showed the high level of deviation in predicted dry rubber content from the actual values. Data collection is continued to establish a ready reckoner chart on dry rubber content and temperature (G V Lakmali Nilmini, K V V S Kudaligama, P D J Rodrigo and D Ramawickrama).

Effectiveness of coconut fibre media in 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 for the purpose of improving the treatment efficiency of Covered Activated Ditch System. At laboratory scale, test reactors were set to investigate the effect of nitrogen content of effluent and processing chemicals on treatment efficiency. The COD removal efficiency of the two reactors was analysed statistically and standard logistic curves were fitted (Fig. 6 and 7). Nitrogen content of the effluent increases the efficiency of treatment while the processing chemicals lower the efficiency of reactors ($p<0.001$).

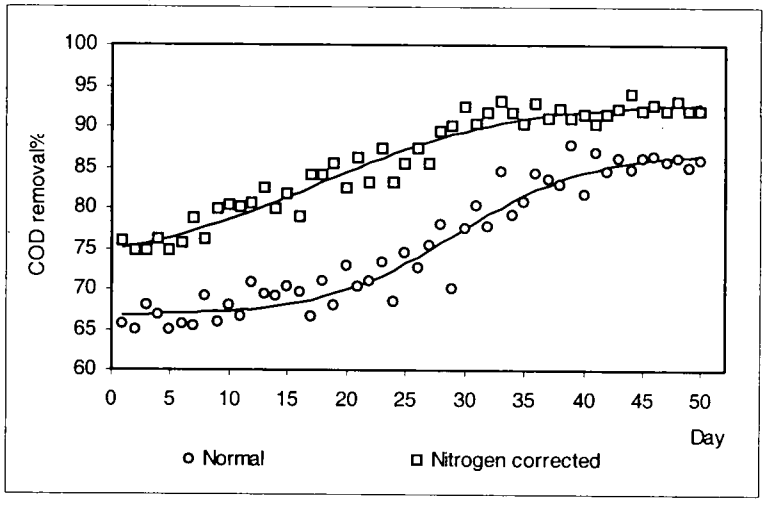


Fig. 6. COD removal % of the reactors run with normal effluent and nitrogen content corrected effluent

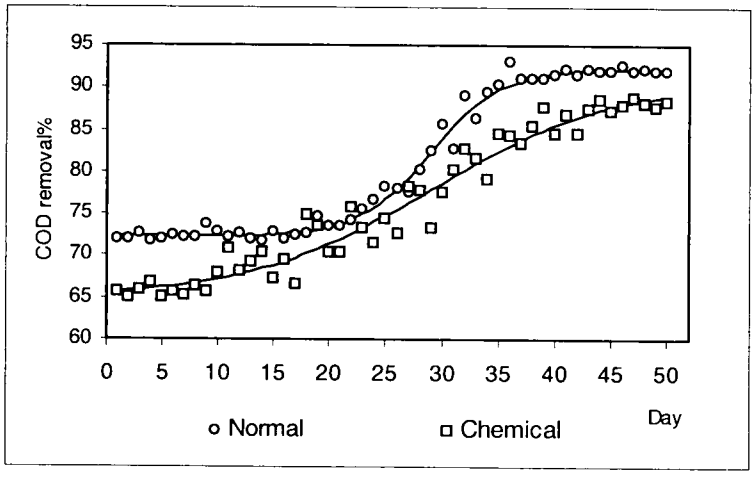


Fig. 7. COD removal % of the reactors run with chemical free effluent (Normal) and effluent with processing chemicals (Chemical) (K V V S Kudaligama, W M Thurul, P A J Yapa and C K Jayasinghe)

ADVISORY SERVICES

A Dissanayake

SUMMARY

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

Fixing rain guards was identified as a priority project. Number of new processing centers were constructed and a large number of substandard processing centers 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, organizing and motivating farmers to apply fertilizer in their mature lands.

Medium scale rubber growers associations were formed at regional level to facilitate the transfer of technology. A number of training programmes, workshops and seminars were conducted to improve the performance of this sector.

DETAILED REVIEW

Staff

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

Dr Anura Dissanayake, Head/ASD was re appointed as the Chairman of the Thurusaviya Fund of the Ministry of Plantation Industries. He was also appointed as a member of the board of Governors of the National Institute of Plantation Management (NIPM). He continued to serve as a member of the National working committee of the Forest Stewardship/certification project (FSC) in Sri Lanka.

Seminars/Conferences/Meetings/Work shops attended

Officer	Subject	Organization
A Dissanayake	Thurusaviya Fund Board Meeting	MPI
A Dissanayake	Meetings of institutional arrangements for fertilizer and plant distributions activities of the smallholder project	MPI
A Dissanayake	Meetings of the plantation and smallholder subcommittee under the Ministry of Policy Planning	Ministry of Policy Planning

Officer	Subject	Organization
A Dissanayake	Scientific Committee meetings	RRI
A Dissanayake	Rubber Sector Review Meetings	MPI
A Dissanayake	Meetings of Monthly progress review in different regions	ASD
A Dissanayake	Workshops on grading and marketing of RSS conducted for REOO and Thurusaviya society officials	Thurusaviya Fund

REOO and RAOO attended the followings

1. Advisory visits on specific requests of rubber growers
2. District and Regional Level coordinating meetings organized by other relevant officers of the ASD
3. 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.*
4. Meetings with the Public Sector Banks to organize loan schemes for the smallholder sector.

Staff training

1. An in-service training programme was conducted for the ASD staff in collaboration with the scientific staff of the RRI on the 8th January 2004
2. A special one day work shop for REOO was conducted by the RRI scientific staff, on rain guard sealant manufacturing and fixing on 8th March 2004

SERVICES

National level projects

Establishment of Medium Scale Rubber Growers Association

A national level survey was carried out to collect production and performance data of medium scale rubber growers who own between 4 ha. to 20 ha. of rubber lands.

A series of seminars and a research/extension dialogs were conducted at district level for that group of rubber growers and "Medium Scale Rubber Growers Associations" were formed in each region.

Training programmes were successfully conducted for selected representatives of each "Medium scale rubber growers associations" in collaboration with the scientific staff of the RRI as follows.

Table 1. *Training programmes conducted for representatives of the Medium Scale Rubber Growers*

Region	Training period	No of Medium Scale Rubber Growers participated
Gampaha	October 6th & 7th	30
Kegalle	November 9th & 10th	36
Colombo	November 16th & 17th	35

One day programme on "Timber Certification", was successfully conducted in collaboration with the "Export development board" for Medium Scale Rubber Growers in the Kalutara district. 70 Medium Scale Rubber Growers participated in the programme.

Establishment of "Mobile Tapper Training Schools" for the improvement of tapper productivity and as a solution for tapper shortage

A "Mobile tapper training school programme" was established with the financial assistant of the Thurusaviya Fund.

Trainees were identified through an interview and a selection process and two mobile schools were successfully completed.

Table 2. *Mobile tapper training schools conducted in 2004*

Range	Period of training	No. of trainees participated
Mawanella	09.08.2004 – 31.08.2004	40
Eheliyagoda	15.12.2004 – 31.12.2004	40

Nearly 70,000 Rupees were spent on each programme by the Thurusaviya Fund. The project is in progress.

Selection and maintenance of model rubber estates

Maintenance of Model Rubber Estates which comprised of properly maintained rubber plantations, cover crops, intercrops, rainguards standard production units *etc.*, as per RRI recommendations, were carried out successfully in each REOO range. These model estates are closely supervised by REOO and used for training and demonstration purposes.

Rehabilitation of substandard rubber holdings

Nearly 352.37 ha. of substandard rubber holdings were rehabilitated by REOO during this period.

Table 3. *Acreage of substandard holdings rehabilitated*

Region	Hectarage rehabilitated
Kegalle	34.2
Colombo/Gampaha	31.87
Galle	82.9
Kalutara	176.2
Ratnapura	27.2

Promotion of use of ERP mixtures

16 smallholdings selected jointly with the Lanka Phosphate Limited in the Kalutara region in the year 2003 for demonstration activities were maintained successfully. Project is in progress.

Fixing rainguards

Rain guard fixing was identified as a national level project and highest priority was given to it.

Nearly 100 village level training programmes and demonstrations were held in 31 REOO ranges and rain guards were fixed in 1095 acres during the period.

Table 4. *Fixing rainguards in regional level 2004*

Region	Hectarage
Kegalle	187.78
Colombo/Gampaha	31.16
Galle	15.37
Ratnapura	148.12
Kalutara	60.70
Total	443.14

A new yield recording form was introduced to all farmers who fixed rain guards in their holdings, to compare yield with rain guards.

Soil conservation aspects

Growing Mucuna *as a cover crop*

The National Level project stated in the year 2003 to introduce *Mucuna* as cover crop was successfully conducted during the year 2004.

Table 5. *Introduction of* Mucuna *in smallholdings- 2004*

Region	Hectarage
Kegalle	75.2
Ratnapura	48.4
Kalutara	50.67
Galle	4.15
Colombo/Gampaha	11.51

Promotion of other soil conservation aspects

Nearly 208.77 hectares of rubber lands, which were substandard in soil conservation aspects, were successfully rehabilitated during the year.

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 continued successfully.

Table 6. *White root infected holdings identified and treated by REOO*

Region	Extent of rubber lands treated for white root disease (ha)
Kegalle	195.32
Ratnapura	91.0
Kalutara	52.4
Galle	8.8
Colombo/Gampaha	45.8

Production of good quality RSS

Farmers were encouraged and trained to up-grade the quality of RSS in both private processing units and in group processing centers.

Following achievements were made during the period.

- Construction of 105 new processing centers
- Refurbishment of 115 existing substandard processing centers
- Repair of 86 pairs of rubber sheet rolling units
- Organizing of 02 large scale marketing programmes
- 372 field training programmes to upgrade quality of RSS

REOO selected 20 well maintained Thurusaviya Societies to distribute rubber rolling units under a subsidy scheme funded by the Thurusaviya Fund.

Pandeniya Thurusaviya Society was selected as the first Thurusaviya society in the county to install the first Lohashilphi rubber sheeter machine, imported from India by the Thurusaviya Fund.

Thurusaviya society works

All village level Thurusaviya Societies in each REOO range was reorganized and office bearers were re-appointed by REOO.

Table 7. *Number of village level Thurusaviya Societies re-organized during the year 2004*

Region	No. of societies re-organized
Ratnapura	49
Kegalle	54
Kalutara	50
Colombo/Gampaha	30
Galle/Matara	18

REOO successfully carried out there village level training programmes, input distribution programmes, publicity and extension programmes together with technology transfer activities in collaboration which is Thurusaviya Societies.

Introduction of bank loan facilities for smallholders

Discussions held with local banks to arrange bank loan facilities for smallholders, to facilitate construction of smokehouses, fixing rain guards and purchase of fertilizer for mature rubber *etc.* were successful and a pilot project was started in the Ratnapura region with the Sabaragamuwa Development Bank.

Table 8. *Bank Loan Facilities granted by the Sabaragamuwa Development Bank under the pilot project - 2004*

Purpose	Amount of loan granted Rs Cts.	No. of farmers benefited
Fixing rain guards	90000.00	12
Construction of smoke houses	27000.00	03
Purchase of Rubber rolls	45000.00	01

The loan scheme is in progress.

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 programmes for the plantation sector.

RUBBER TECHNOLOGY AND DEVELOPMENT

Dilhara Edirisinghe

SUMMARY

The project on NR/PVAc latex blends was continued throughout the year and the moduli and strength properties of the cast films produced according to the blending technique developed were very much greater than those of the NR compound. Two new research projects on rubber blends were initiated. Work on IPNs was continued and properties of IPNs prepared with ENR as well as with some synthetic lattices were evaluated. Five latex-based product developments and six dry rubber-based product developments were carried out successfully at the request of some industries. Centrifuged latex, which gives special properties to latex based products was prepared using a special oil. About fifteen industries obtained services in testing rubber compounds/products and preparation of compounded latex. Further, several entrepreneurs were given a short training on setting up latex-based cottage industries. Furthermore, the staff was actively involved in organizing stalls at exhibitions organized by several Ministries.

DETAILED REVIEW

Staff

Mrs D G Edirisinghe, Rubber Chemist was on duty throughout the year. Mrs M M Jayasuriya, Rubber Chemist continued her studies at the RRISL during the year as a part fulfillment of her postgraduate studies leading to a PhD degree at the Loughborough University, UK.

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. Mr S L G Ranjith, Experimental Officer and Mrs Priyanthi Perera, Research and Development Assistant were transferred to the Department from the Polymer Chemistry Department and the Raw Rubber and Chemical Analysis Department, respectively with effect from 23rd January, 2004. Miss D N Wickramarachchi, Research and Development Assistant resigned from the Institute on 16th January, 2004.

Mr A I Siriwardena, Technical Officer was on duty throughout the year.

Research students

- Mr Thushara Samaraweera and Miss Pradeepa Gunaratnam, MSc (Polymer Science and Technology) students of the University of Sri Jayawardenapura commenced work on their MSc research projects titled "Development of NR/NBR latex blends for manufacture of high quality gloves'' and "Influence of

reclaimed rubber on the properties of NR/SBR/reclaimed rubber blends", respectively.

- The staff of the department assisted Materials Engineering and NDT (Polymer Technology) students from the University of Moratuwa on preparation of rubber compounds and test pieces required.

- The staff of the department were involved in conducting ten practical classes for the students following the MSc degree course in Polymer Science and Technology at the University of Sri Jayawardenapura.

Seminars/Conferences/Meetings/Workshops

Officer	Subject	Organization
Mrs D G Edirisinghe	Inauguration of the "Biennial Conference on Science and Technology"	Ministry of Science and Technology
Mrs D G Edirisinghe	Lecture on "Flame Retardant Foam"	National Science Foundation
Mrs D G Edirisinghe and Mrs M M Jayasuriya	First Symposium on Plantation Crop Research	Tea Research Institute Rubber Research Institute and Coconut Research Institute
Mrs D G Edirisinghe and Mrs M M Jayasuriya	Scientific Committee Meetings - Mrs D G Edirisinghe presented the "Research Programme of the Rubber Technology & Development Department"	Rubber Research Institute of Sri Lanka

Training programmes

Client	Subject	No. of programmes
Officers attached to the plantation sector (organized by the NIPM)	(i) Composition of NR latex and effects of non-rubber substances (ii) Collection, preservation and transportation of latex and chemicals used in the rubber industry - Professional Programme in Rubber Manufacture and Factory Practice	1

Client	Subject	No. of programmes
Students of the Plastics 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	(i) General properties of NR latex and latex technology (ii) Manufacture of RSS, Crepe and TSR (iii) Manufacture of Foam rubber - Diploma Course in Rubber Technology	1
NDT (Polymer Technology) students of the Institute of Technology, University of Moratuwa.	Rubber Technology	1
A group of entrepreneurs (organized by the IDB, Katubedda, Moratuwa)	"Preparation of compounded NR latex suitable for rubberized - coir manufacture"	1

Visits

Mrs D G Edirisinghe, Mrs M K Mahanama, Mrs P C Wettasinghe and Mr A I Siriwardena visited Lanka Tyre Retreaders (Pvt.) Ltd., Moratuwa in order to look into their problems at the request of the Company.

Mrs M K Mahanama visited Suyamas, Foam Rubber Factory at Waulugala, Horana to provide advice and assistance on the quality of their mattresses on a request made by the Company.

Mr P L Perera visited Quality Latex Products (Pvt.) Ltd., Pahathgama to solve sample testing problems encountered with their Hounsfield, tensile testing machine.

LABORATORY INVESTIGATIONS

Latex technology

Latex blends

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

This project, initiated on a suggestion made by Lalan Gloves (Pvt.) Ltd., was continued throughout the year. Results of the work carried out on uncompounded NR/PVAc latex blends during the previous year indicated that incorporation of 13% of PVAc into NR latex improves moduli and strength properties without a serious loss in elongation at break. Therefore, cast films of the composition of 87/13 NR/ PVAc latex blends with varied distributions of curing agents in the two polymer phases was prepared according to two different methods. The films were vulcanised at 70°C, leached in water for few minutes and dried at room temperature. Tensile properties and tear strength of the films were determined. Results indicate that the moduli and strength properties of the 87/13 NR/PVAc blend compound prepared according to Method 2 and by adding a greater proportion of curing agents initially into the NR phase are higher than those of the other 87/13 NR/PVAc blend compounds and the NR compound (Tables 1 and 2 - Sample No. 2).

Table 1. *Tensile properties of compounded 87/13 NR /PVAc latex blends (before ageing)*

Sample No.	Method of compounding	100% Mod. (MPa)	300% Mod. (MPa)	500% Mod. (MPa)	Tensile strength (MPa)	Elongation at break %
1	Method 1 87% in NR 13% in PVAc*	0.43	0.60	1.09	8.61	678
2	Method 2 87% in NR 13% in PVAc*	0.47	0.78	1.70	16.48	608
3	Method 1 50% in NR 50% in PVAc*	0.36	0.51	1.08	12.27	806
4	Method 2 50% in NR 50% in PVAc*	0.39	0.63	1.18	12.92	808
5	NR (Control)	0.28	0.44	0.78	12.36	881

* Percentages of the curing agents added into the two latices before blending

Table 2. *Tensile properties of compounded 87/13 NR / PVAc latex blends (after ageing)*

Sample No.	Method of compounding	100% Mod. (MPa)	300% Mod. (MPa)	Tensile strength (MPa)	Elongation at break %
1	Method 1 87% in NR 13% in PVAc*	0.43	0.82	17.83	906
2	Method 2 87% in NR 13% in PVAc*	0.53	0.97	20.67	887
3	Method 1 50% in NR 50% in PVAc*	0.34	0.70	13.15	870
4	Method 2 50% in NR 50% in PVAc*	0.43	0.77	15.23	878
5	NR (Control)	0.24	0.50	13.97	870

* Percentages of the curing agents added into the two latices before blending

The tear strength of Sample No. 2 is also greater than those compounded according to the other methods and to that of the NR sample (Control) (Fig. 1).

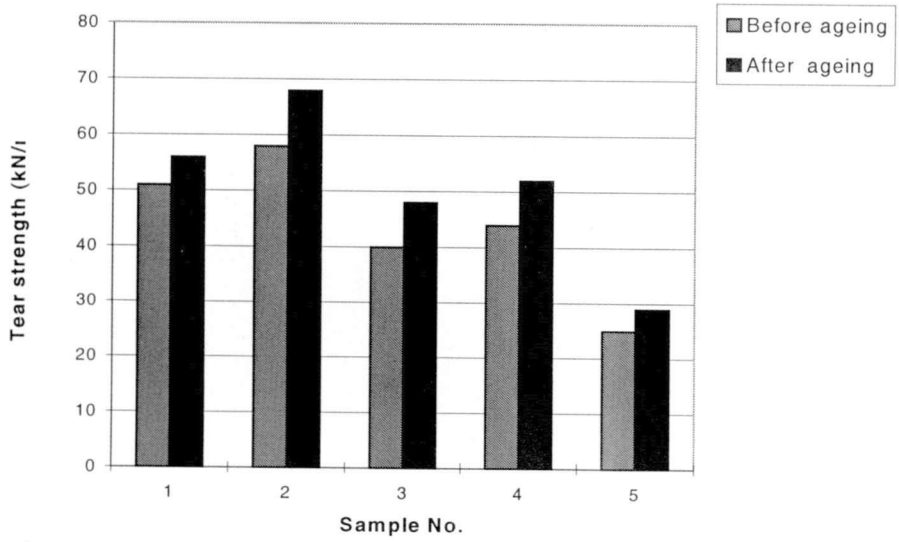


Fig. 1. Tear strength of compounded 87/13 NR/PVAc latex blends

A set of the above cast films were aged at 70°C for 168 hours and the above mentioned properties were evaluated. A further set of NR /PVAc blends was prepared by varying the blend ratio, method of blending and the initial location of curing agents in the two polymer phases. Properties of these cast films, before and after ageing are being evaluated (D G Edirisinghe, D N Wickramarachchi, P C Wettasinghe and Priyanthi Perera).

Natural rubber (NR) nitrile rubber (NBR) blends for dipped products

A project was initiated to produce high quality examination, industrial/household gloves using blends of NR and NBR latices in collaboration with Prime Polymer (Pvt.) Ltd., Seethawaka, Avissawella. Different property combinations are expected by blending the NR and NBR latices and it is expected that NR/NBR latex blends having physical properties superior to NBR compounds and a tolerable degree of swelling in non - polar oils and fuels could be developed. A literature survey was carried out. As initial experimental work, cast films were prepared by varying the NR/NBR blend ratio, blending conditions and the technique of blending (D G Edirisinghe, S Siriwardena, Thushara Samaraweera - MSc student, University of Sri Jayawardenapura and Priyanthi Perera)

NR latex/carbon black masterbatches for tyre paints

A set of paints was prepared with 60 % NR latex using different oils, in order to get a glossy appearance and a good surface finish to tyre treads as required by AMW (Pvt.) Ltd. The paint developed with one of these oils imparted a good gloss and a surface finish to the applied surface. Also some modifications to the method of incorporation of the special oil were carried out and the paint produced showed improved properties over the previously developed paint. Furthermore, the special ingredient was incorporated to latex at the stage of centrifuging. Interestingly, this ingredient acts as an excellent stabilizer and hence could be used to replace the conventional stabilizers used during centrifuged latex manufacture with added advantages. Products with a glossy surface appearance and thick walled articles can be manufactured out of the centrifuged latex prepared with this special ingredient (D G Edirisinghe, M K Mahanama, P L Perera and S L G Ranjith).

Development of a calf support out of foam rubber for a special kind of shoes

Few trials were conducted to develop a foam rubber compound suitable to replace the original plastic calf support used in a special kind of shoes. The texture of the calf support developed was closer to that of the original plastic support. Further developments using different types of polymers are in progress (L M K Tillekeratne, M M Jayasuriya, D G Edirisinghe, S I Yapa and Priyanthi Perera).

Development of latex compounds for rubberized - coir applications

Room temperature curing system

Work was initiated to develop a room temperature curing system suitable for rubberized-coir manufacture on a request made by an industrialist (M M Jayasuriya, S I Yapa and Priyanthi Perera)

Roof - top applications

Development of a latex compound suitable to produce rubberized - coir sheets for above applications was initiated on a request made by an industrialist. It was possible to improve the bonding between the coir fibres with the use of the developed latex compound. Further improvements are being investigated (M M Jayasuriya, S L G Ranjith and P C Wettasinghe).

Development of a bio-degradable rubberized-coir compound

A bio-degradable rubberized-coir compound suitable to grow grass was developed and handed over to the small scale industrialist who made the request (D G Edirisinghe and M K Mahanama).

Development of products out of the waste obtained from rubberized-coir manufacturing processes

Low cost sheets were produced out of coagulated latex crumbs using the hydraulic press at the request of Ceyesta, Nawinna, Maharagama (W M G Senevirathne and M K Mahanama).

Dry rubber technology

Development of value added products out of dipped products waste/rejects

Trials were carried out to manufacture rubber products out of dipped products waste/rejects. Products such as shoe soles with colourful, attractive surface designs and good physical properties were manufactured using a novel technique. An application was forwarded to register this new development under industrial designs, at the patent office. Application for a patent is also underway (D G Edirisinghe and M K Mahanama).

Development of an adhesive for surgical bandages/plasters

Work on this project initiated on the request of Tas Medical Suppliers and Co. (Pvt.) Ltd. was continued. A crepe rubber based compound was prepared by varying the mastication time of the rubber and the level of tackifier. Subsequently, the compound was converted to the paste form. The adhesive made out of the compound showed good adhesion. Conversion of the developed dry rubber compound into the paste form using different non-toxic solvents was carried out. Evaluation of the most suitable solvent in order to get the best properties is in progress (D G Edirisinghe, S Siriwardena, D N Wickramarachchi and Priyanthi Perera).

Dry rubber blends

NR/ SBR/ reclaimed rubber blends for tyre retreads

A project was initiated to improve the properties, especially abrasion resistance, tensile properties and tear strength of NR/SBR/reclaimed rubber blends used in tyre retread compounds. The ultimate aim of carrying out this research is to produce tyre retread compounds containing reclaimed rubber for a reduction in the cost of production, without a significant reduction in the required properties. A series of NR/ SBR/ reclaimed rubber blend compounds was prepared by replacing part of the rubber and carbon black with reclaimed rubber according to a single - stage mixing technique. Evaluation of the above mentioned properties of these blends is in progress (W M G Seneviratne, D G Edirisinghe, Pradeepa Gunaratnam – MSc student, University of Sri Jayawardenapura, P C Wettasinghe and M K Mahanama).

Development of hydraulic brake parts out of NR/NBR blends

A request was made by a small scale industrialist to improve the rubber compound formulation which is being used at present to produce hydraulic brake parts. A formulation out of a blend of 20 / 80 NR / NBR was developed and the brake parts produced according to the formulation showed improved properties over those produced previously. Development of the formulation for further improvements of those properties is in progress (D G Edirisinghe, M K Mahanama and S L G Ranjith).

Development of rubber blend compounds for engineering applications

A request was made by Lanka Rotariseals (Pvt.) Ltd. to develop rubber blend compounds suitable to produce accumulator diaphragms and shaft seals. Few blends of NR/EPDM of varying composition were developed and the properties of one these compounds were found to be in accordance with the properties required for accumulator diaphragms produced by transfer moulding. The formulation was forwarded to the company. Work on the development of a rubber blend compound possessing very high hardness, suitable to produce shaft seals is in progress (D G Edirisinghe, Priyanthi Perera and S L G Ranjith).

Development of an EPDM compound for water resistant applications

An EPDM rubber compound with improved properties was developed on a request made by J.S. Enterprises and Co. Panadura (D G Edirisinghe, S L G Ranjith and G D Dinesh Krishantha, Temporary Research Assistant).

Development of a rubber component for an oil processing machine

A rubber compound suitable to produce the rubber seal used in the coconut oil processing machine belonging to the NERD Centre was developed at the request of the inventor of the machine (D G Edirisinghe and M K Mahanama).

Interpenetrating Polymer Networks (IPNs)

A draft of the PhD thesis written on the above research work was submitted to the supervisor, Prof. D J Hourston of the IPTME, Loughborough University, UK. Determination of properties of IPNs prepared using ENR was carried out using FTIR/SEM analysis as an extension to the work completed so far, on Prof. Hourston's advice. Furthermore, methods which could be used to enhance chemical interactions between the individual constituents were investigated (M M Jayasuriya and D J Hourston).

Industrial extension

The following services to the companies were provided at their request.

Company	**Service**
Ceytra Ltd.	Testing of dry rubber compounds
Global Rubber (Pvt.) Ltd.	Testing of dry rubber compounds
Associated Motorways (Pvt.) Ltd.	Testing of dry rubber compounds
Associated Universal (Pvt.) Ltd.	Testing of dry rubber compounds
Prime Polymers	Testing of gloves
Quality Latex Products (Pvt.) Ltd.	Testing of latex based strips
Textrip Ltd.	Testing of latex based strips and tubes
Industrial Clothings Ltd.	Testing of gloves
Mapa-Lalan (Pvt.) Ltd.	Testing of gloves
Shums & Co. Ltd.	Testing of sole crepe
Kegalle Plantations Ltd. (Pallegama Estate)	Testing of sole crepe
Kegalle Plantations Ltd. (Atale Estate)	Testing of sole crepe
CIC Ltd.	Testing of latex based adhesives
Ceylon Rubber Industries	Testing of balloons and prevulcanized latex
Mona Plastics (Pvt.) Ltd.	Preparation of compounded latex

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

- Mrs M K Mahanama and Mrs P C Wettasinghe assisted the RRISL stall by conducting demonstrations at the "Science Exhibition" organized by D S Senanayake Madya Maha Vidyalaya held between 17th to 19th August.

- Mrs M K Mahanama and Mr P L Perera assisted the RRISL stall by conducting demonstrations at the "Job Fair" held at Ruwanwella Madya Maha Vidyalaya on the 19th September. This job fair was organized by the Ministry of Labour Affairs and Foreign Employment jointly with the Department of Labour.

- Mrs M K Mahanama, Mr S L G Ranjith, Mr P L Perera and Mrs Priyanthi Perera assisted the RRISL stall by conducting demonstrations at the Mahapola Exhibition held in Bopitiya, Kurunegala during mid September.

- Mrs M K Mahanama and Mrs P C Wettasinghe assisted the RRISL stall by conducting demonstrations at the "Job Fair" held at Badulla Madya Maha Vidyalaya on the 12th of December.

- Mrs M K Mahanama assisted the RRISL stall by conducting demonstrations held at the exhibition organized by the Department of Chemistry, University of Kelaniya.

POLYMER CHEMISTRY

Nilmini Liyanage

SUMMARY

An adhesive was developed using a blend of modified grade of natural rubber with Neoprene. Performance of it was found to be superior to that of commercial grade of adhesives.

A sealant prepared for application in pruned stems in the tea bushes using positex/bitumen mixture was successful. This will soon be put into commercial application to replace commercially available toxic fungicides.

Modification of latex/carbon black master batches prepared using the novel-dispersing agent was carried out.

Trials were conducted to introduce latex based herbal fungicide mixture for the Bark Rot disease in rubber.

Several laboratory scale trials were conducted to improve the storage stability of the pre vulcanized natural rubber concentrate.

Detailed study was carried out to find the applicability of Low viscosity latex in the preparation of latex/carbon black master batches.

Detailed analysis was carried out on several rubber products, which are used in contact with water and need in food storage applications, and comprehensive reports on toxicity were submitted to the industry.

A feasibility study was carried out to study the efficiency of grafting MMA on to the Natural rubber latex molecules under varying conditions.

DETAILED REVIEW

Ms Champa Wellappilli, Assistant Rubber Chemist continued her postgraduate studies at the University of Cardiff. Ms. Nilmini Liyanage left for Osaka, Japan for a training programme on "Polymer Technology" from 5th May to 31st July 2004.

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

Research students

- Mr Palitha and Ms Awanthi from the University of Colombo and Mr Suresh from the University of Ruhuna successfully completed their research projects as a

fulfillment of BSc Special Degree in Chemistry under the supervision of Ms Nilmini Liyanage and Mr H N K K Chandralal.

- Polymer Technology MSc students of the year 2004 batch from Sri Jayawardenapura University followed their practical work from 18th July to 22nd August in the Department.

Seminar/Conference/Meetings

Officer	Subject
Ms Nilmini Liyanage	Persistent Organic Pollutants
Ms Nilmini Liyanage	Knowledge Management for Innovation

LABORATORY INVESTIGATIONS

Rubber based adhesives

A request was made by an industrialist to prepare a general purpose adhesive system using a modified grade of natural rubber to compete with the locally available neoprene based adhesives. Several trials were initiated using Methyl Methacrylate Grafted Rubber (MG) and neoprene rubber. Promising results were obtained for different substrates in comparison with the locally available material. Large-scale trials were carried out using a general-purpose adhesive system developed in collaboration with EDNA group. Comparatively better performance was observed in this trial compared with the currently available adhesive system in the market.

Remarkable improvements were observed for wood to wood and ceramics to wood and plastics to paper surfaces by the application of the newly developed adhesive. Commercial trials will be conducted in due course (Nilmini Liyanage and Chitra Kuruppu).

Positex/Bitumen mixture for water proofing applications

The project was continued in collaboration with the TRI. Sealant prepared for application in the pruned tea stems using positex and bitumen was found to be ideal to be used in tea plantation in upcountry. However, the sealant appeared to show certain defects when applied in plantations in the low country region. Therefore, it was further modified to suit those low country conditions and as such, Nursery trials have been carried out at the tea nurseries at Ratnapura was found to be successful for low country applications.

The possibility of incorporation of herbal fungicides into the sealant was investigated to replace commercially available toxic fungicides, which are currently

being used. Parameters such as callus formation and growth of seedlings were more prominent and safe with the modified sealant compare to toxic fungicides incorporated material. Project was successful and TRI will make arrangements to implement this finding in the tea plantations. The technique will be patented in due course (Nilmini Liyanage, Chitra Kuruppu and Abaya Balasooriya - TRI).

Latex/Carbon Black Master batches

The project was continued using a novel-dispersing agent. A new pathway was introduced to prepare the carbon black dispersions instead of ball milling for 18 hrs. Physical properties of the carbon black master batch compounds were compared against mill mixed compounds. Some properties such as tensile strength, tear strength, tear and abrasion were found to be very much improved in the carbon black master batch compounds. Further, modification is being carried out for the process of manufacture of the carbon black master batches by the incorporation of additives such as tackifiers, peptisers *etc.* Addition of a tackifier in to the stabilized latex before incorporation of dispersed carbon black with low structure HAF black was carried out successfully. Efficiency of incorporation could be improved when the pH is increased to a certain point and the temperature of the coagulation is increased. It was observed from the preliminary studies that, at pH 11 and at the temperature of 50^0C the efficiency of incorporation becomes almost 100%. The coagulation of carbon black dispersed latex was carried out at 50^0C with 2% addition of 2% HCOOH. The coagulum with the serum kept at this temperature was matured overnight to complete the adsorption of carbon black to NRlatex. Large-scale master batches were handed over to Loadstar Company to evaluate physical properties in order to conduct trails to manufacture solid tyres (Nilmini Liyanage, H N K K Chandralal, Indra Denawaka and S S Warnapura).

Herbal based fungicide mixture for bark root disease

The project was initiated in collaboration with the Plant Pathology Department, RRISL to produce herbal-based fungicide mixture for Bark Rot disease. The mixture is being evaluated for its effectiveness towards the said disease at Pathology Department (Nilmini Liyanage, Chitra Kuruppu and C K Jayasinghe).

Improvement of the storage stability of the Pre Vulcanized Natural Rubber Latex Concentrate

Physical properties of prevulcanised lattices with different combinations of accelerator systems are being evaluated, as a preliminary study (Nilmini Liyanage, H N K K Chandralal, Priyanthi Perera and Ananda Samarakoon).

Low Viscosity Rubber

Ageing properties and the gel content of the low viscosity rubber were studied. Different antioxidants were used to prevent possible cross-links formation due to the presence of free radicals in the molecules. It was found that the antioxidant plays a significant role in controlling the cross-links formation during storage of latex as well as rubber after depolymerisation.

Low viscosity latex can be used in the preparation of carbon black master batches and in modification of NR lattices (Nilmini Liyanage, Indra Denewaka and Ananda Samarakoon).

Toxicity of rubber compounds

Various kinds of rubber products used in food and water contact applications were tested to identify the presence of toxic chemicals using FTIR Spectrophotometer. Comprehensive reports were submitted as requested by the industrialists. A literature survey was carried out on the chemicals permitted in the food and pharmaceutical industry for the benefit of the rubber based industries (Nilmini Liyanage and H N K K Chandralal).

Use of Enzyme treated latex for the preparation of MG rubber

A kinetic study was conducted on grafting reactions of Methyl Methacrylate molecules onto NR chain using latex treated with the enzyme papain. The effect of dilution and maturation of treated latex on grafting has also been studied. Treatment of latex prior to grafting of Methyl Methacrylate showed shorter induction period, high grafting efficiency (by selective extraction techniques) and better film forming properties of the resultant grafted rubber. The main advantage of this method is that the resultant product can be coagulated and filtered easily. These are the most difficult steps in the preparation of MG rubber.

Experiments will be continued to study the grafting efficiency under inert atmosphere under Nitrogen (Nilmini Liyanage, Susantha Siriwardena and Chitra Kuruppu).

Evaluation of physical properties of different grades of raw rubber

A project was initiated to evaluate physical properties of different types of rubber compounds using various grades of raw rubbers under conventional, semi and efficient vulcanizing systems in the presence of fillers and without fillers (Nilmini Liyanage, Susantha Siriwardena, Ananda Samarakoon and Manel Mahanama).

Preparation of oil – resin emulsions

A new emulsification technique for oil and resin has been carried out. Experiments conducted using processed oil emulsions reveal that 1-10 % resin can be incorporated easily into RSS during processing. This technique shows promising

results and would be useful in preparing rubber – resin master batches that would be useful in the manufacture of adhesives (Nilmini Liyanage, H N K K Chandralal and Indra Denawaka).

Production of prevulcanised latex

Project was initiated to study the factors that would effect the storage stability of the prevulcanized latex with the aim to prepare compounded latex with higher stability. Storage stability is influenced by the presence of excess chemicals used in vulcanization. Two alternative methods were proposed to deactivate/decant the excess chemicals. Latex films have been prepared using one of these two techniques. Film properties are yet to be investigated (Nilmini Liyanage, H N K K Chandralal, Ananda Samarakoon and Indra Denawaka).

RAW RUBBER AND CHEMICAL ANALYSIS

S Weeraman

SUMMARY

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 field latex and concentrated latex.
d. Analysis of chemicals and water used in processing raw rubber in the rubber products manufacturing industry, for purity.
e. Analysis of skim rubber adulteration in scrap grades of crepe rubber.
f. Recommendation of chemicals for the industry and analyzing them for percentage 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

Experimental Officer, Ms H S Weeraman was in Charge of overall activities of the department throughout the year.

Experimental Officers L Wanigatunga, H V K Gamage, C Lokuge, L P Vitharana, M Wijesekera, B Gunasiri, N Karunatilaka, W Vithanage, and Clerk/Typist, Mrs I Wijesinghe were on duty throughout the year.

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

Research and Development Assistant Mrs P Perera was temporarily transferred to Rubber Technology Department with effect from 23rd January 2004.

Research students

- Messrs Tilaka Samarakoon student from the University of Sri Jayawardenapura, completed her latex analysis projects work leading to her MSc degree.

- Mrs Ganga Illenchelvah, a post graduate student from University of Jayawardenapura, carried out the project on "Property variation of centrifuged latex against soap strength and maturation" under the supervision of Dr Shantha Walpolage.

- Mr P A S Janaka, a student from University of Ruhuna carried out the project on MMA Grafting on DPNR and centrifuged latex for the partial fulfillment of his degree work.

- Miss Jayatharshana Jesudason, a post-graduate student from the University of Jayewardenepura carried out the project on "Depolymerisation of NR latex master batches" under the supervision of Dr Kalyani Liyanage.

Work Shops attended

- H S Weerman, L Wanigatunga, V Gamage, C Lokuge, L P Vitharana, and M Wijesekara served as resource personnel at the series of one day workshop on "Correct Estimation of DRC" for Field Officers, Factory Officers and Laboratory personnel of the Plantation Industries.

- H S Weeraman, L Wanigatunga, H V K Gamage, C Lokuge, M Wijesekera, L P Vitharana, N Karunatilaka and W Vithanage served as resource personnel at two day workshop on latex testing for the laboratory personnel of Cosco Polymers Lanka (Pvt) Ltd.

Training programme

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

A group of NDT students	- University of Moratuwa
Sahan Ariyaratne	- Samson Reclaim Rubber
Premalal Malbulage	- Load Star Pvt Ltd.
A group of Field Officers	- Bogawantawala Plantations Pvt Ltd.
- do -	- Udabage Estate
- do -	- Mahaoya Group
- do -	- Udapolla Unit
- do -	- Sapumalkanda Estate
L Jayawardena	- Le-Ferne Laboratories, Getahetta
A Nishantha	- Le-Ferne Laboratories, Getahetta
H D Weeratunga	- University of Colombo
S N J P Silva	- Institute of Chemistry
A M KM A Abeyratna	- Cosco Polymer Lanka (Pvt) Ltd.

R M K U Ratnayaka	- Cosco Polymer Lanka (Pvt) Ltd.
W R Dhrmaratne	- Cosco Polymer Lanka (Pvt) Ltd.
H N M Amarasooriya	- Cosco Polymer Lanka (Pvt) Ltd.
S Seneviratne	- Cosco Polymer Lanka (Pvt) Ltd.
N S Chinthaka	- Glenross Rubber Factory, Neboda

Visits

- D G Edirisinghe, M K Mahanama, L Wanigatunga, P L Perera and S Weeraman made visited to Ceylon Rubber Industries, Arukwatta on their request for advisory work.

- H V K Gamage took part at the programme of educating the use of Metrolac organized by the Pitiyakanda Esate, Bogawantalawa Plantation under the assistance of Dr Nugawela.

- Champa Lokuge took part in the programme of educating the use of Metrolac organized by the Mahaoya Group, Bogawantalawa Plantation under the assistance of Dr Nugawela.

LABORATORY INVESTIGATIONS

Services

Manufacturing of CV rubber

A project on manufacture of CV crepe rubber was initiated in collaboration with RRPD & CE department. Analysis of raw rubber properties of CV rubber has been tested as a comparative study. This has not been continued due to lack of funds (S Siriwardena and H V K Gamage).

Fixing of rainguard

Assistance and technical advice were given for preparing and fixing of rain guards in all rubber growing districts initiated by Advisory Services Department (A Dissanayake, N Karunatilaka and W Vithanaga).

Quality assessment of latex by monitoring the Volatile Fatty Acid (VFA) and Mechanical Stability Time (MST) parameters

Literature was collected and locations were identified for the field experiments to be conducted. Preliminary investigations were perform in order to study the steps for which much attention has to be paid for quality assurance of latex. Latex samples were tested from Kegalle district (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	238
Sandhagiri Rubber Mills, Dompe	284
Total	**522**

Miscellaneous samples tested during the year were given below:

Raw rubber samples	533
Latex samples	2,217
Chemical samples	23
Bleaching agent samples	76
Glove samples	118
Total	2,967

RAW RUBBER PROCESS DEVELOPMENT AND CHEMICAL ENGINEERING

S Siriwardane

SUMMARY

The staff of the department provided their services to 12 crepe rubber factories to solve certain problems encountered during the manufacture of rubber on processing and quality related aspects. The department successfully conducted a series of one-day workshops for rubber factory officers and field staff of the plantation companies to clarify the unclear aspects of latex weighing in the industry. Three paint and glove industries were visited to provide advise connected with wastewater treatment. Number of estates were visited connected with wastewater problems and one commercial treatment plant was installed in a latex centrifuged processing plant.

The department carried out few experimental trials on pilot scale at five crepe rubber factories to asses the possibility of manufacturing Lankaprene rubber at their premises and to recommend any modifications required to achieve the expected results. It was found that some raw rubber properties such as Initial Wallace Plasticity (P_o), and percentage Nitrogen content are easily achievable without any modification in the existing manufacturing procedures while 95% of samples achieved standards required for percentage dirt and ash contents. However the percentages achievements of standards for PRI and V_R were found to be low and are 86 and 30 respectively. This shows that special attention should be given during the manufacturing process to achieve these standards. Few recommendations were made on preparations of Lankaprene based on the results of this series of experiments conducted in those five factories.

Results of a research conducted on the effect of Cu^{2+} ion revealed that processing water containing 5ppm of Cu^{2+} ion concentration or above adversely affect the quality of crepe rubber. The results of the studies carried out on leachable proteins (LP) in NR latex revealed that addition of DAHP, time of maturation, use of water soluble polymers and protein denaturing enzymes, Cholrination and leaching under different conditions have a significant effect on the LP content of both centrifuged latex and latex products. It was found that LP content gradually reduced with time of maturation even without any additions to reach levels below 50 μg/g within 7 days in the case of centrifuged lattices.

DETAILED REVIEW

Staff

Deputy Director-Research (Technology) overlooked the departmental activities until 25th August, 2004. Since then, the Director overlooked the

department activities as DDR (T) left abroad on personal leave. Dr Susantha Siriwardena, Principal Research Officer, Mr P P Jayasinghe, Development Officer, Mr C D Senanayake and Mr T A S Siriwardane, Experimental Officers, Mrs Chandrika Nalini, Mrs U M S Priyanka and Mr A K D Warnajith Prasad, Technical Officers, Mrs L Rukmanie, Store Keeper and Mrs Anusha Paranawithana, Typist/Clerk were on duty throughout the year.

Dr Susantha Siriwardena was promoted to the post of Principal Research Officer with effect from 08th May, 2004. Mr Upul Rathnayake, Assistant Rubber Chemist continued his postgraduate studies at the University of Loughborough, UK. Mr P H Sarath Kumara, Assistant Rubber Chemist who obtained a Master of science degree in polymer technology from the University of Sri Jayawardanepura in 2004 left for Japan for a training program at the Institute of IEARI on radiation vulcanization of latex project funded by the Japanese government on 18th October, 2004.

Mrs V C Rohanadeepa, Technical Officer resumed duties after maternity leave.

Mr G D D Krishantha, Temporary Research Assistant was recruited for the NSF funded research project (RG/2004/C/03) with effect from 8th November 2004.

Research students

Mr Suresh de Silva	-	University of Colombo
Ms Gayani Perera	-	University of Colombo
Ms S M G H Samarakoon	-	University of Sri Jayewardenapura
Ms B N K Fernando	-	University of Sri Jayewardenapura
Mr M K A J Maldeniya	-	University of Sri Jayawardenepura
Mr T S Shawfat	-	Sri Lanka Institute of Information Technology, Nawala
Ms W M R Tissera	-	Sri Lanka Institute of Information Technology, Nawala

Seminars/Workshops/Meetings

Officer	Subject	Organization
Dr W M G Seneviratne	TRI-RRI-CRI Joint Symposium held in July 2004 – Main organizer RRISL	RRI/TRI/CRI
Dr W M G Seneviratne	Participated in 3 weeks training workshop on Agricultural Research Management held in Hydrabad, India between 2 and 21 February 2004 at the National Academy of Agricultural Research Management (NAARM).	NAARM
Dr W M G Seneviratne	PRI Management Committee meetings and PRI Educational Committee meetings (once a month)	PRI
Dr W M G Seneviratne	Ceyesta Board meetings (Once a month)	Ceyesta

Officer	Subject	Organization
Dr Susantha Siriwardena	01st steering committee meeting of consultative meetings of directors of research and development institutes (as a representative of the Director, RRISL).	Ministry of Science and Technology
	Lecture on flame retardant foam	NSF
Mr P H Sarath Kumara	3 sittings of the Validation Committee Meetings for the validation of draft National Standards for Course Accreditation for the occupation of 'Rubber Processing Machine Operator'.	Tertiary and Vocational Education Commission
Dr Susantha Siriwardena and Mr P H Sarath Kumara	Delivered lectures on raw rubber processing and technology for the Professional Examination in Rubber Manufacture course	NIPM
	Served at the panel for the viva of the examination of induction course for planters training programme	NIPM
	First symposium on Plantation Crop Research	TRI/RRI/CRI
Mr A K D Warnajith Prasad	Held two demonstrations for rubber farmers on the manufacture of high quality sheet rubber at Monaragala.	ASD-RRISL
Messrs Susantha Siriwardena, P H Sarath Kumara, Sarath Siriwardena, A K D Warnajith Prasad and V C Rohanadeepa	Conducted an on site training program on effluent treatment plant maintenance for officers of Kotagala Plantations Limited (KPL)	KPL
Messrs P H Sarath Kumara, Sarath Siriwardena, A K D Warnajith Prasad and U M S Priyanka	Conducted several workshops on quality maintenance and weighing of latex for Field Officers of the 4 groups of Bongwantalawa Plantations Limited (BPL).	BPL
Officers at RRPD Dept & RRCE	One day workshop for Junior Executives, Factory and Field Officers on correct estimation of DRC	RRPD Dept & RRCE - RRI

Research awards

Funding agency	Project title	Budget (Rs.)	Awardees
NSF	Development of irradiated natural rubber (NR)/ Ethylene-Propylene-diene ter polymer (EPDM) based composite materials for outdoor applications	Rs.1,458,100	Susantha Siriwardena, Dilhara Edirisinghe Priyanthi Perera

Advisory visits

Client	Nature of the work	No. of visits
Crepe Rubber factories	Quality improvement and trouble shooting in crepe rubber processing	08
	Improving drying efficiency	03
	Preparation of Lankaprene rubber	05
	Effluent treatment of rubber processing factories	08
Raw Rubber Processing Factories	DRC estimation	07
Centrifuged Manufacturing Factories	Feasibility studies in centrifuged latex manufacture	01

Industrial visits

Client	Nature of the work	No. of visits
Paint and glove industries	Waste water treatment	03

Experimental visits

Client	Nature of the experiment	No. of visits
Crepe Rubber Factories	Trials on preparation of CV rubber	02
Lalan Rubber Factories	Feasibility studies in centrifuged latex manufacture	01
Dartonfield Factory	Mechanisation of crepe rubber processing	04

Sample testing

Description	Number
No. of waste water samples tested	79
No. of processing water samples tested	08
No of certificates issued for waste water	58
No of certificates issued for processing water	07
No of certificates of epidemic prevention issued for sole crepe	58

LABORATORY AND FIELD INVESTIGATIONS

Effect of metal ions on quality of crepe

Experiments were continued to investigate the effect of Cu^{2+} ions on the quality of crepe rubber. Samples were prepared using average processing water with varying amounts of Cu^{2+} ions ranging from 5 ppm and above. Samples were tested for raw rubber properties and the results showed that the colour, the Mooney viscosity, Po and PRI of crepe rubber were adversely affected and samples were deteriorated. These results led to investigate the effect of processing water with further low Cu^{2+} ions concentration (below 5 ppm). Trials are to be carried out incorporating lesser dosages of Cu^{2+} ions into processing water to find out the critical level of Cu^{2+} ions which affects the properties of crepe rubber (P H Sarath Kumara, T A Sarath Siriwardena and A K D Waranajith Prasad).

Mechanization of rubber factory operations

A project has been initiated to explore the possibility of mechanization of rubber factory operations. As the first step of this project five mechanical agitating systems for fractionation of latex will be designed to investigate its technical and economic viability. Of the five designs one has already been fabricated and ready for commencement of trials. A device has also been designed and fabricated to feed coagulum onto the macerator directly. An attempt was made to mechanize this process using the same device (Susantha Siriwardane, T A S Siriwardane, P L Perera and Gihan Perera).

Computer software package for rubber factories

A computer software package is being developed to make the factory operation easy and less cumbersome. The package has already been developed to auto compute the amount of water and chemicals etc required for daily operation. Paper work will be reduced with the introduction of this package. It will also make the decision making process very fast as the management will have access to all information in all rubber factories from a central place and therefore to monitor the activities daily (Susantha Siriwardane).

Preparation of CV crepe rubber

The project was restarted with the assistance from the Polymer Chemistry department and Raw Rubber and Chemical Analysis Department. Preliminary studies were conducted at Culloden estate by preparing few samples. Several trials were carried out to prepare CV 60 crepe rubber with Plasticity Retention Index (PRI) above 80. The results showed that CV 60 crepe rubber could be made at the expense of PRI. Further trails are required to be carried out to study the possibility of improving PRI in CV 60. This project was temporarily discontinued due to the unfavourable weather conditions (Susantha Siriwardane, Nilmini Liyanage, Wasantha Gamage and T A S Siriwardane).

Preparation of Lankaprene

Samples were prepared at five different factories by varying the dilution levels of field latex at fractionation and coagulation, and number of milling passes. Processing operations such as cleanliness, operating practices and mill conditions were also examined at each factory. Effects of those on the following raw rubber properties were investigated.

1. Dirt
2. Initial Plasticity (P0)
3. Plasticity Retention Index (PRI)
4. Ash content
5. Nitrogen content (N)
6. Colour

Number of different samples produced at each factory is shown in Table 1.

Table 1. *No. of different samples prepared at each factory*

Factory identification code	No. of samples
Factory A	09
Factory B	12
Factory C	06
Factory D	09
Factory E	06
Total	42

Percentage of samples, which have achieved the required standards for all raw rubber properties at each factory and the total average of them are shown in Table 2. It shows that 100% of the samples achieved P_0 and % Nitrogen standards of Lankaprene and more than 90% of the samples achieved standards for dirt and ash irrespective of the variations in manufacturing procedures. However, the percentages of achievement of standards for PRI and V_R are 83 and 26 respectively.

This indicates that special attention should be paid to achieve the V_R and then the PRI standards, when producing Lankaprene rubber.

Table 2. *Percentage achievement of raw rubber properties*

Estate		Dirt	Po	PRI	Ash	VR	N
Sunneycroft	Factory A	100	100	77.77	100	66.66	100
Atale	Factory B	91.67	100	91.67	100	16.66	100
Sorana	Factory C	83.33	100	66.66	100	16.66	100
Millewa	Factory D	100	100	100	100	0	100
Payagala	Factory E	83.33	100	66.66	83.33	33.33	100
Overall	**Total average**	**92.86**	**100**	**83.33**	**97.62**	**26.19**	**100**

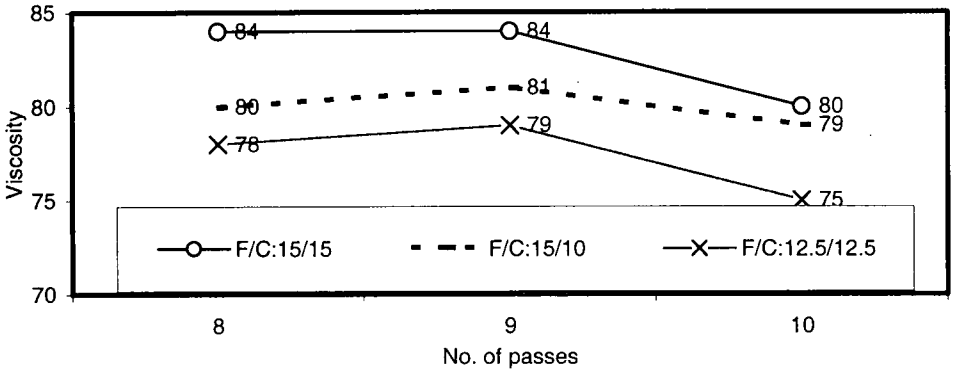
Effect of processing conditions on Raw Mooney viscosity (V_R)

Effect of dilution at fractionation and coagulation and number of milling passes on V_R are shown in Fig. 1 for all five factories.

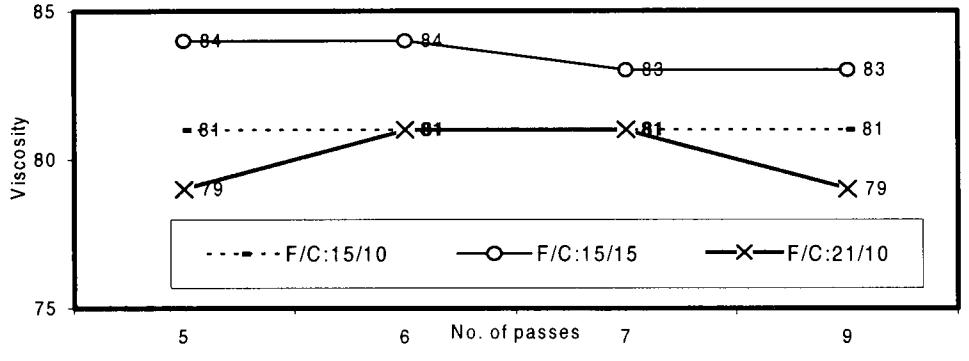
From the above results following observations could be made.

1. It is difficult to standardise and recommend an exact number of milling passes for all factories, as conditions of mills are not the same. Viscosity tends to decrease as the number of passes decreases, as expected.
2. If condition of the mills are satisfactory even with minimum number of passes low viscosities could be achieved as in the case of factory E. This reflects the importance of the quality of machinery in the manufacture of Lankaprene.
3. DRC at fractionation (15% or 21%) has no significant effect on the Mooney viscosity. However, it should be emphasized that fractionation at lower DRC will give low fraction percentage.
4. The level of dilution of field latex has an effect on the viscosity. Samples coagulated at lower DRC show a lower viscosity. As such, coagulation at 10% DRC would be suitable provided that PRI is not affected markedly.
5. As viscosity of rubber is continuously increasing with time during storage or transportation due to its inherent storage hardening features, it is important to specify the date of manufacture and the date of testing carried out when viscosity of a particular batch of rubber is reported.

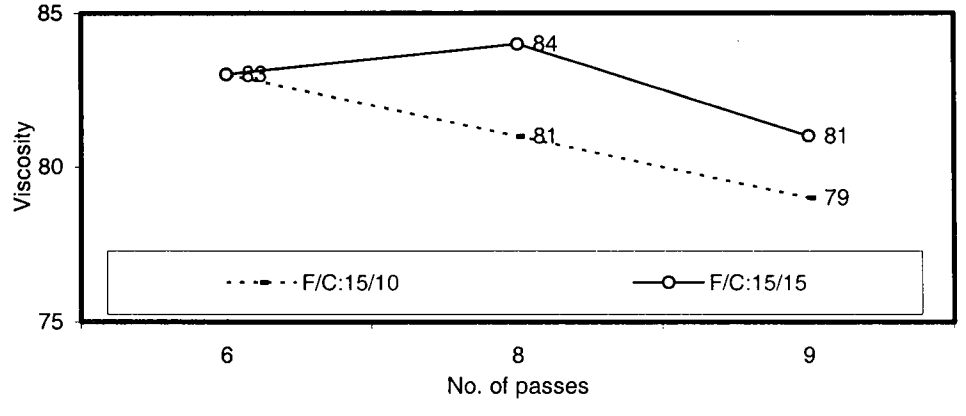
Factory A



Factory B



Factory C



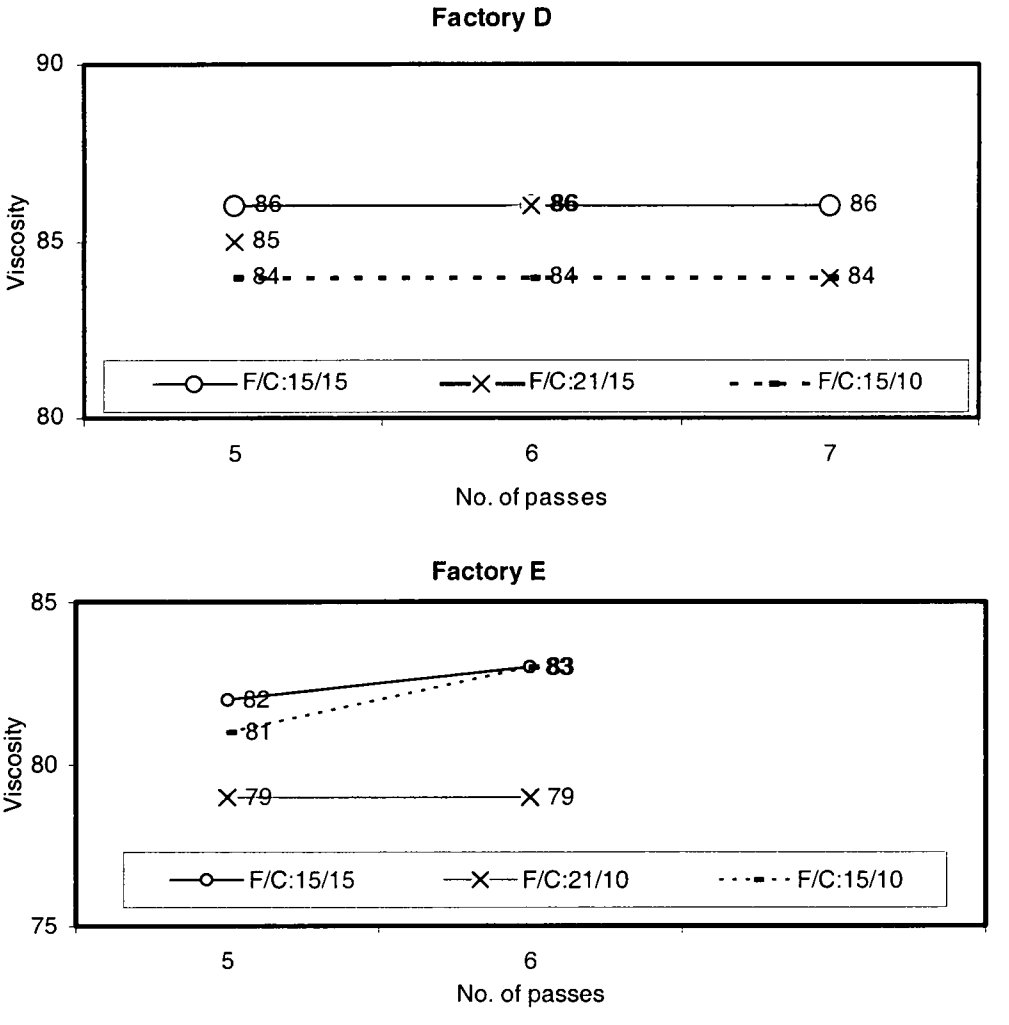
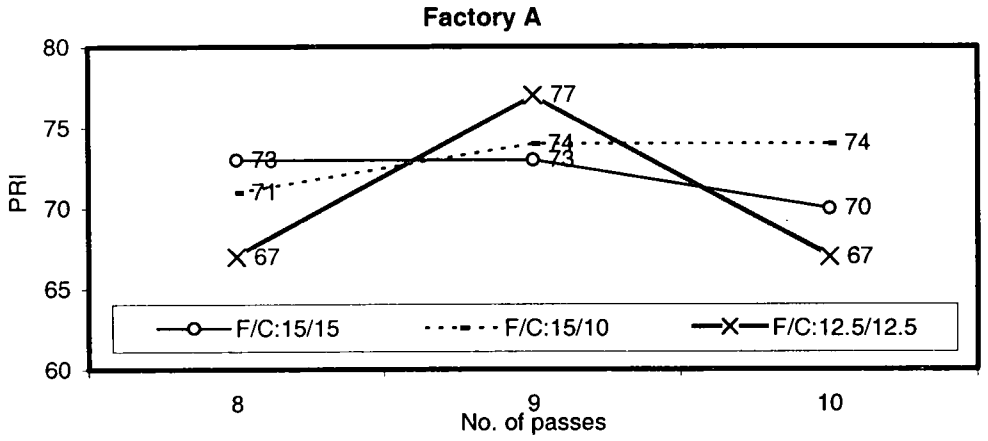
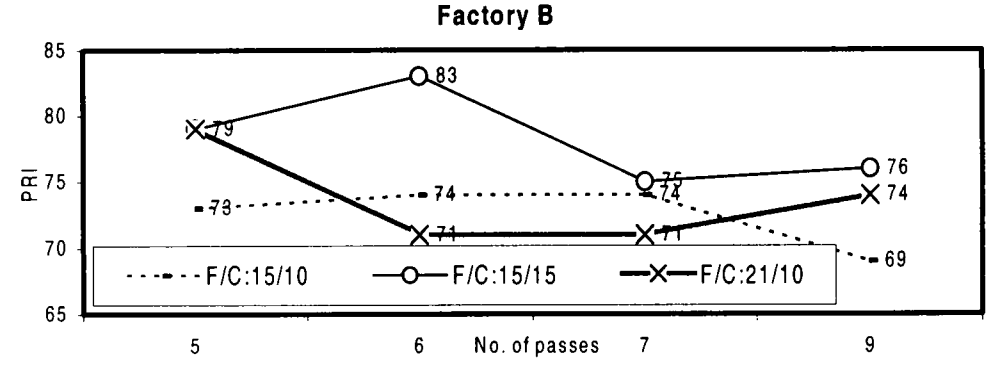


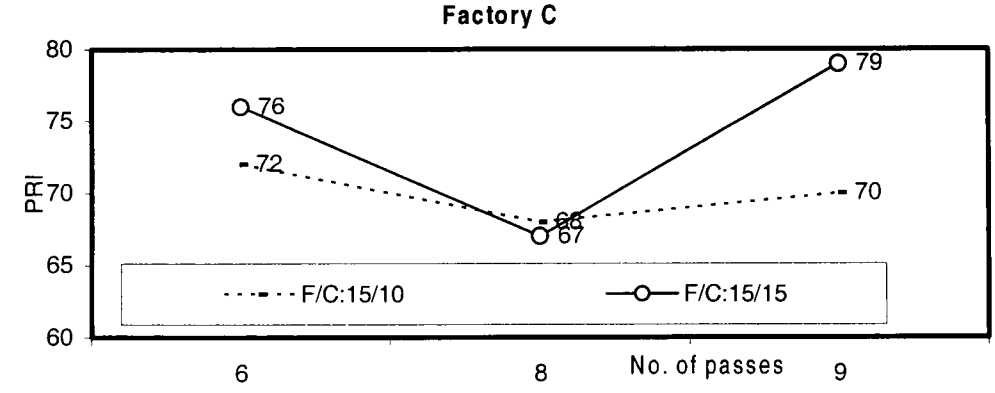
Fig. 1. Effect of some processing conditions on the viscosity

Effect of processing conditions on Plasticity Retention Index (PRI)

The results show that PRI gradually decreases with increasing number of mill passes (Fig 2). However, the maximum variation is only 5 units when the number of mill passes increased from 5 – 9 at Factory B. When dilution of latex at coagulation is reduced from 15% to 10%, PRI decreased by a maximum of 4 units. As such, considering the achievement of standard value for PRI, it is advisable to coagulate latex at 15% DRC. It should also be noted that the dilution of latex from 15 – 10% has not been led to a significant reduction in either viscosity or dirt levels.


Factory A
80
75
70
65
60
PRI
77
74
74
73
73
71
70
67
67
F/C:15/15
F/C:15/10
F/C:12.5/12.5
8
9
10
No. of passes


Factory B
85
80
75
70
65
PRI
83
79
76
75
74
74
74
73
71
71
69
F/C:15/10
F/C:15/15
F/C:21/10
5
6
No. of passes
7
9


Factory C
80
75
70
65
60
PRI
79
76
72
70
67
F/C:15/10
F/C:15/15
6
8
No. of passes
9

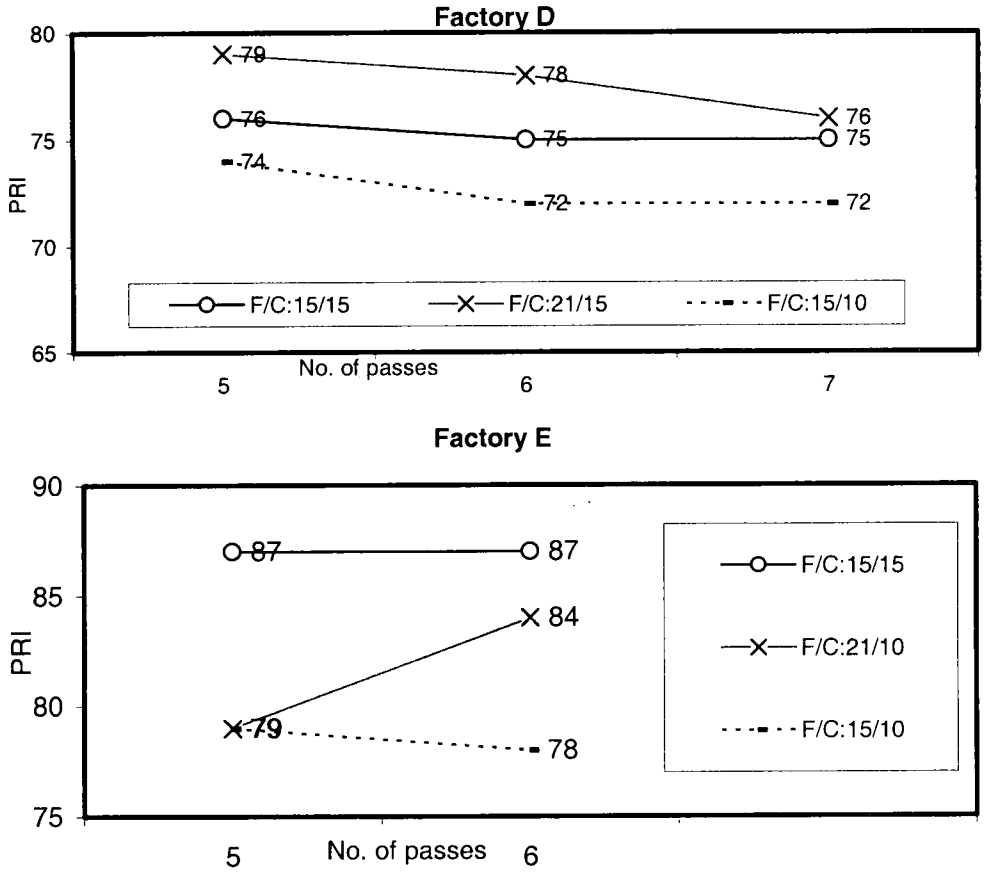
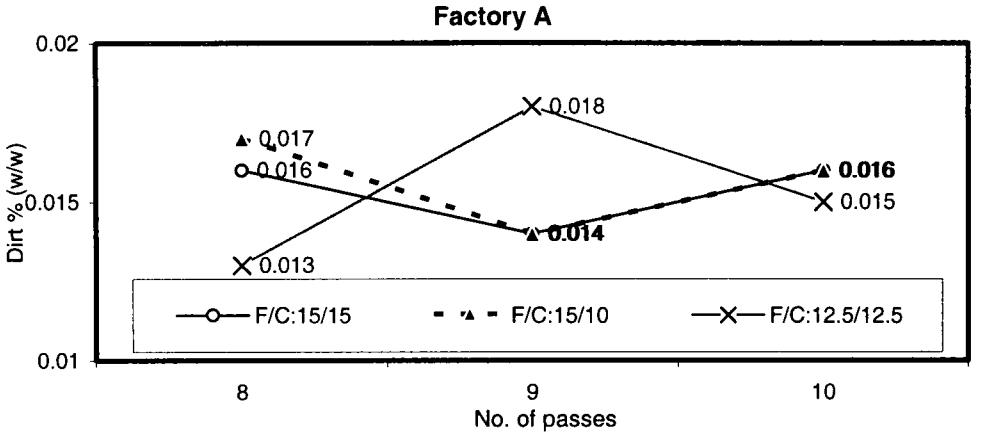
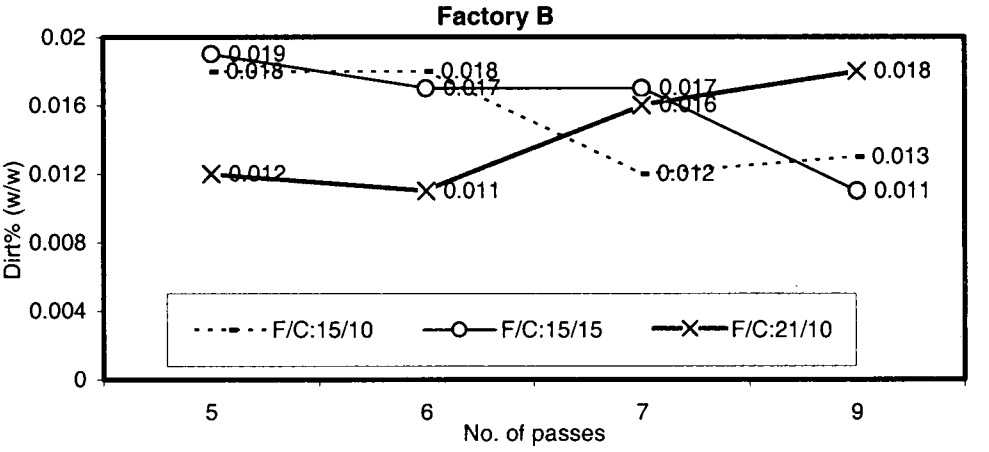


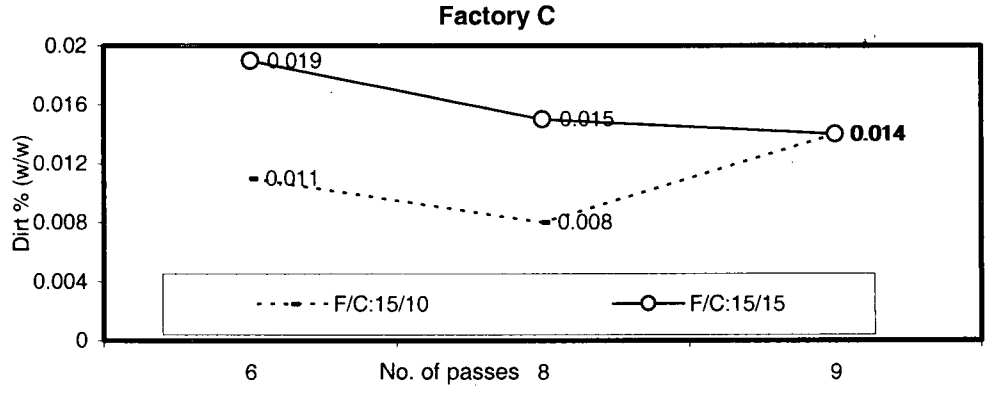
Fig. 2. Effect of some processing conditions on PRI

Effect of processing conditions on dirt content

Few samples produced at factory C and factory E show higher dirt contents than the maximum standard value (Fig 3). The reason for these values were attributed to dispersed fraction formation in factory C while factory E had dirt contamination of from the roof. Use of strainers with mesh size 50 is sufficient to reach the standard dirt levels at bulking and coagulation stages. The results show that number of milling passes do not have any relation with the dirt content of the samples.


Factory A
0.02
0.015
0.01
Dirt % (w/w)
0.017
0.016
0.013
0.018
0.014
0.016
0.015
F/C:15/15
F/C:15/10
F/C:12.5/12.5
8
9
10
No. of passes


Factory B
0.02
0.016
0.012
0.008
0.004
0
Dirt% (w/w)
0.019
0.018
0.018
0.017
0.017
0.016
0.012
0.011
0.012
0.013
0.018
0.011
F/C:15/10
F/C:15/15
F/C:21/10
5
6
7
9
No. of passes


Factory C
0.02
0.016
0.012
0.008
0.004
0
Dirt % (w/w)
0.019
0.015
0.014
0.011
0.008
F/C:15/10
F/C:15/15
6
No. of passes
8
9

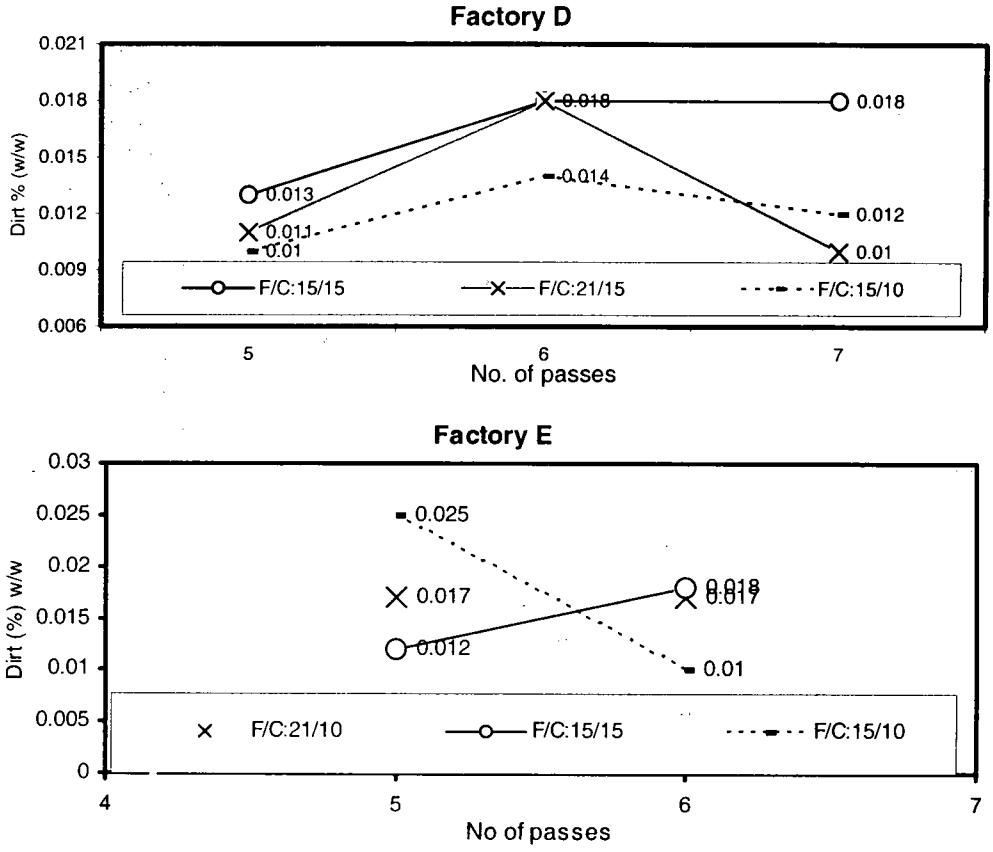


Fig.3. Effect of some processing conditions on the dirt

In summary, following recommendations could be made based on the above trial experiments in preparation of Lankaprene.

1. Mesh size for final straining of latex should be 50 mesh
2. DRC at fractionation 15%
3. DRC at coagulation 15%
4. Type of mills to be used (i). Horizontally grooved mill, (ii) an intermediate mill either horizontally grooved mill or diamond mill
5. No of mill Passes 6-8
6. Mills should be well maintained and free from defects (W M G Seneviratne, Susantha Siriwaradane and Sarath Siriwardane)

Striper sealant for rainguards

A new sealant for fixing rain guard was developed at the request of the plantation companies as the present sealant has certain shortcomings when in use. Laboratory trials were successful. Few industrial scale batches of sealant will be prepared in the next quarter and will be tried out in rubber plantation. A small batch of new striper sealant was prepared and several rain guards were fixed at Dartonfield. Results are yet to be evaluated (P H Sarath Kumara and Nimal Karunatilake).

Reduction of leachable proteins in NR latex and latex products

Number of experimental trial have been started during this year in view of developing an adoptable methodology to achieve low levels of leachable proteins of the latex products, particularly latex gloves manufactured in the country. One of such attempts was to investigate into the effects of latex stabilizing chemicals used in the preparation of latex (Ammonia, DAHP and Ammonium laurate) as well as other aspects such as dependence of maturation of latex, clonal variations *etc.* on leachable protein levels in latex and on gloves made out of them.

Effect of maturation of latex and dependence of DAHP addition on EP content

It was found that LP content was gradually reduced with time of maturation to reach below 50 µg/g within 7 days in each clone prepared as per normal procedure with the addition of ammonia and DAHP and soap (Fig. 4). From the four clones tested, RRIC 102 and RRIC 100 showed relatively high extractable protein levels.

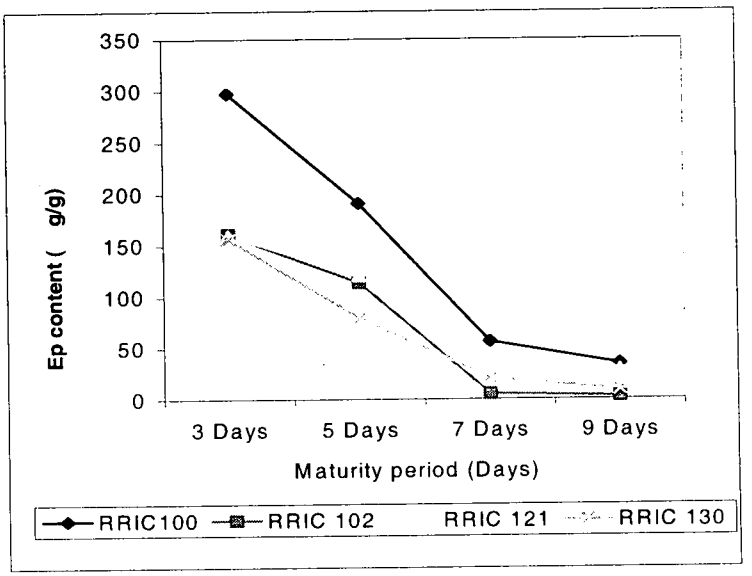


Fig. 4. Effect of maturing period on EP content in different clones

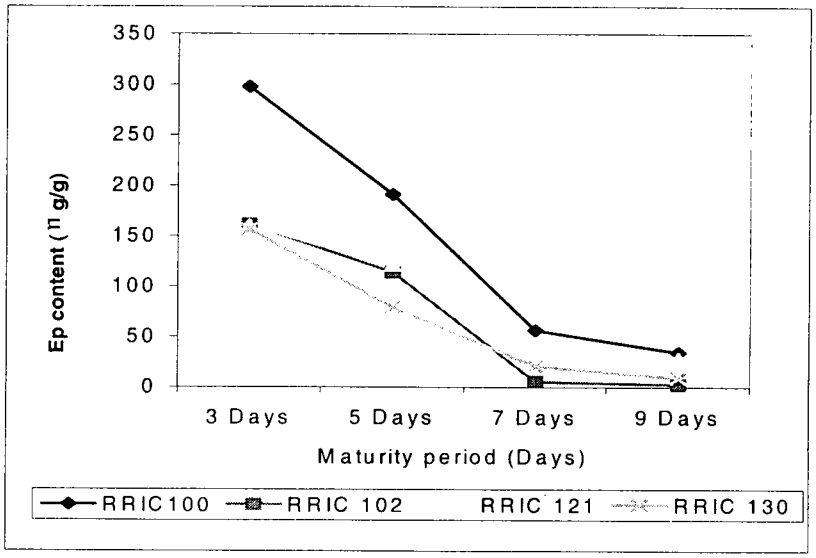


Fig. 5. Variation of EP content in the absence of DAHP

Figure 5 shows the extractable protein content in centrifuged latex manufactured without addition of DAHP. Eventhough, initial reduction of EP is found to be low in latex with the addition of DAHP, on keeping for usual 12-16 hours for separation of sludge, even the in latex without the addition of DAHP reported very low levels of EP. Hence addition of DAHP will not have a significant effect on the reduction of EP in latex.

Effect of ammonium laurate on extractable protein content

Figure 6 shows the effect of ammonium laurate on EP content in centrifuged latex. It shows that centrifuged latex added with ammonium laurate contain higher levels of extractable proteins compared with the lattices without the ammonium laurate.

Extractable protein content, in soap added samples, varied in the range of (138-320µg/g). While the level of extractable proteins varied within the range 8-28µg/g in samples not preserved with soap.

Effect of NH_3 concentration on extractable protein content

Effect of concentration of NH_3 on extractable protein content was represented by the Figure 7. As it can be seen from the graph, high ammoniated latex contain with higher amount of extractable proteins ranging from 297-478 µg/g,

compared with law ammoniated centrifuged latex containing relatively low level of extractable proteins in the range of 152-197µg/g.

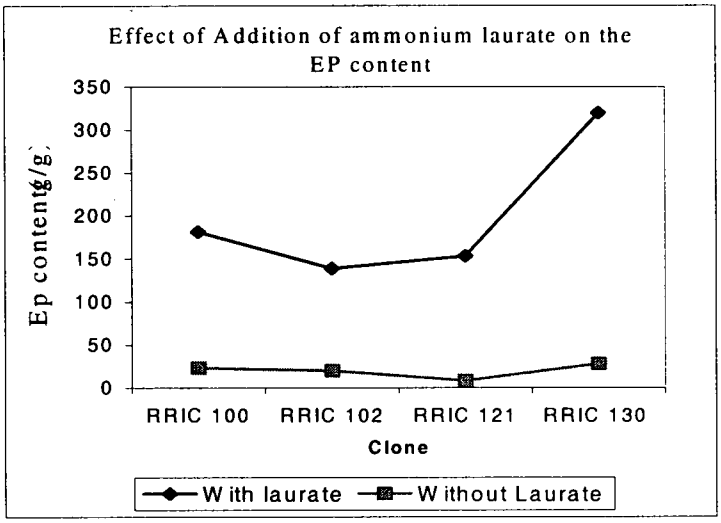


Fig. 6. Effect of addition of ammonium laurate on extractable protein content (After maturing centrifuged latex for 3 days)

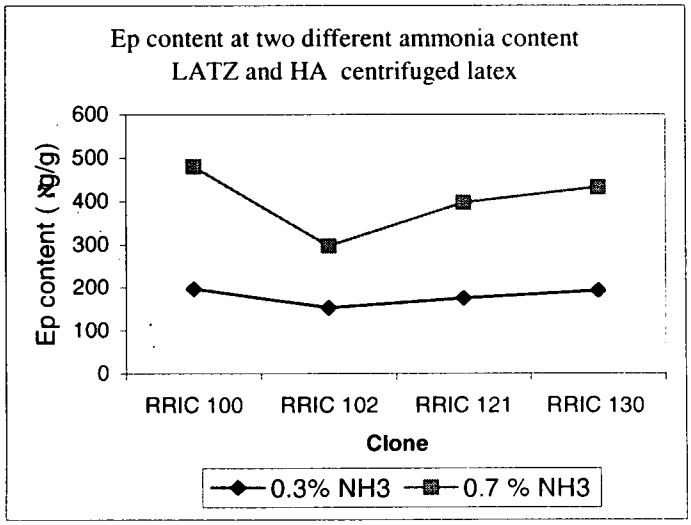


Fig. 7. Effect of ammonium concentration on extractable protein content

Reduction of leachable proteins in NR latex and latex products

EP of gloves drawn at different stages of the processing line were analysed in order to be able to understand the levels of leachablity of proteins at each stage of the process line. This data will be useful for removal of EP from gloves. This experiment was conducted at the Lalan glove factory Biyagama. The results are shown in the Table 3 as below.

Table 3. *Effect of different techniques on leachability on protein*

Treatment	EP content (µg/g)
Both pre cure and post cure leached powdered gloves (with talc)	185.46
Gloves without pre cure leaching and clorination but with post cure leaching	374.66
Gloves with pre cure leaching ,without post cure leaching and chlorination	302.03
Without leaching(both post and pre cure) and chlorination	515.03
With pre cure leaching + Post cure leaching CL and + after 1st chlorination	24.47
With pre cure leaching + Post cure leaching and after 1st & 2nd chlorination	22.93
After complete chlorination	4.01

Results suggest that both precure and post cure leaching would help the reduction of EP levels but larger level of reduction/removal of EP is achieved by chlorination (W M G Seneviratne, U M S Priyanka, A K D Warnajith Prasad and Gayani Perera).

Development of irradiated natural rubber (NR) ethylene Propylene-Diene terpolymer (EPDM) based composites material for out door applications

A grant was awarded for the above project submitted jointly by the Dept. of RRPD & CE and the Rubber Technology department. A research assistant has been recruited and the literature review was completed. Arrangements are being made to commence the experiments in collaboration with Sri Lanka Atomic Energy Authority (Susantha Siriwardena, Dilhara Edirisinghe, Priyanthi Perera and G D D Krishantha).

Rubber factory wastewater treatment

A new treatment plant has been installed at Udapola centrifuge latex factory belonging to Kegalle Plantations. The plant was commissioned in August 2004 and designed to refine 80,000 liters of effluent per day generating from centrifuged latex processing and skim rubber manufacture. The treatment mechanism is fully biological in nature and consists of both anaerobic and aerobic digestion processes (W M G Seneviratne and S Siriwardane).

ADAPTIVE RESEARCH

V H L Rodrigo and S M M Iqbal

SUMMARY

The feasibility of expanding the rubber cultivation to the eastern province was examined. The area under the intermediate zone was initially targeted for the establishment of rubber in the region. Growth performance of rubber in two small smallholdings established in Padiyathalawa was comparable with that of recorded for the traditional area. Trials on mixed clone systems in the smallholder sector were established. New programs on Rubber/Anthurium culture and Rubber/poultry systems were commenced. Preliminary arrangements to establish the sub-station of the RRISL in Polgahawela were made with the collaboration of all other departments in the institute.

DETAILED REVIEW

Staff

Dr V H L Rodrigo coordinated the activities of this unit from October 2004. Dr S M M Iqbal (Agronomist), Mr W A D D S Wettasinghe (Research Assistant) and Mr E A T Senadeera (Experimental Officer) were on duty throughout the year. Research Assistants, Mr A M A Perera and Mr R B Gunaratne retired from the services of RRISL on 18th May and 2nd June respectively.

Seminars/Conferences/Meetings/Workshops attended

Officer	Subject	Organization
Dr S M M Iqbal	Made a presentation on Intercropping rubber with tea - Current recommendation	Scientific Committee Meeting, Rubber Research Institute of Sri Lanka
	Attended closing ceremony of SRICANSOL project Phase III and initiating the phase IV.	Soil Science Society of Sri Lanka.
	Attended symposium on plantation crop research	TRI/RRI/CRI, at BMICH Colombo, Sri Lanka
	Attended International Conference, 75th Anniversary of the Coconut Research Institute Sri Lanka	Hotel Trans Asia, Colombo, Sri Lanka

Officer	Subject	Organization
Dr S M M Iqbal	Attended price giving ceremony of essay competition for serving as a Judger of this competition.	Sri Lanka Inventors Commission
	Conducted the work shop on plantation management of rubber to the smallholders of Padiyathalawa region at Monaragala	RRISL/RDD
Mr W A D D S Wettasinghe and Mr E A T S Senadeera	Delivered a lecture on Rubber/Tea intercropping for the Rubber small-holders	ARU/RDD/ASD at Yatiyanthota REO region, Kegalle
Mr W A D D S Wettasinghe	Practical training program on rubber plantation	School of Agriculture, Karapinche, Ratnapura
	Attended symposium on plantation crop research	TRI/RRI/CRI, at BMICH Colombo, Sri Lanka
Mr E A T Senadeera	Attended tapper training program	ASD/REO at Mawanella
	Attended the meeting of medium scale rubber growers association.	ASD/REO at Warakapola

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 (S M M Iqbal and W A D D S Wettasinghe).

Advisory visits

28 experimental visits and 5 advisory visits were made by unit staff.

FIELD INVESTIGATIONS

Adaptive Research Programme

***Bee keeping in rubber plantations* (AR1)**

Bee colonies established in the estates of Dartonfield and Sub-station Kuruwita were in progress. One harvest at Dartonfield and three harvests at Kuruwita were collected (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 (AR2)

The feasibility of establishing a project on rubber cultivation in the eastern province was examined. Rubber cultivation was started in the intermediate zone. Initially six farmers were selected and rubber was planted in November 2003 (Table 1). Growth of the rubber plants were monitored with the plant diameter measurements taken at 10cm height in September 2004 in two small holding in Padiyathalawa (Table 2). Growth performance of rubber in these holdings was comparable with that of recorded for the traditional area. However, rubber cultivation started with three farmers at Varapitiya, Maha Oya region one site at Padiyatalawa was terminated due to the poor response from the smallholders. A work shop on agronomic practices on rubber was conducted to the smallholders of Padiyathalawa region in collaboration with RDD. Another 27 acres of rubber was planted in the smallholder sector. In year 2005, it is extended plant rubber to 35 acres in this region. Cultural practices such as deep planting with poly-bagged plants and mulching was encouraged in these holdings.

Table 1. *Site details of the adaptive research eastern province programme*

Padiayatalawa Division	Mahaoya Division
1. Mr T B Attanayaka Marawa, Dorakumbura Padiayatalawa	1. Mr H B Gunawardana Mudugala, Warapitiya
2. Mr Gunesekara Marawa, Dorakumbura Padiayatalawa	2. Mr H B Premasiri Mudugala Warapitiya
3. Mr I K Udyaratna Komana, Dorakumbura Padiyatalawa	3. Mr Mahindakumara Mudugala Warapitiya

Table 2. *Growth of rubber Eastern Province*

Name address of the small holder	Mean plant diameter (cm)
Mr T B Attanayaka Marawa, Dorakumbura Padiayatalawa	5.50
Mr Gunesekara Marawa, Dorakumbura Padiayatalawa	5.06

(V H L Rodrigo, S M M Iqbal, R S Dharmakeerthi, K B A Karunasekera and A Nugawela).

Expansion of rubber cultivation in Wayamba region (North Western Province) (AR3)

The idea of setting up RRISL substation to develop the rubber cultivation in Wayamba was originated by the Hon. Minister of Plantation Industries in Polgahawela. The RRISL has given the top priority for this project and commenced work in December 2004. In order to meet the objective of establishing the nucleus estate, rubber will be planted in 5 acres with the onset of SW monsoon in 2005. This is an adaptive research trial on low and high density planting systems of rubber together with rubber/cinnamon and rubber/banana intercropping (V H L Rodrigo, S M M Iqbal, R S Dharmakeerthi, K B A Karunasekera and C K Jayasinghe).

Mixed clonal system for smallholder sectors (AR4)

This experiment aims to develop low risk system for rubber smallholders against the disease out break and to evaluate promising clones under mixed stand. Trials were initiated in the dry and wet areas in Monaragala and Kegalle regions, respectively. Two estates, one from each region were also selected for this experiment in order to assess the management impact under different situations. Details follows:

Estate sector
Estate 1 : Kumarawatta Estate-Monaragala
Date of commencement: North/East 2004
Estate 2 : Sapumalkanda Estate-Deraniyagala
Date of commencement: South/West 2004
Plot size of each treatment: 01 ha
Total extent/Estate : 08 ha

Treatments (clones):

T1: RRISL 205, RRISL 203, RRIC 121, RRIC 100 and RRIC 102 (as a mixed clone system)
T2: RRISL 205, RRISL 203, RRIC 121 and RRIC 100 (- do -)
T3: RRISL 205, RRISL 203 and RRIC 121 (- do -)
T4: RRISL 205 (as a mono clone)
T5: RRISL 203 (- do -)
T6: RRIC 121 (- do -)
T7: RRIC 100 (- do -)
T8 : RRIC 102 (- do -)

Smallhoder sector
Region 1 : Monaragala
Date of commencement: North/East 2004
Plot size of each treatment: 1/2 ac
Region 2 : Kegalle
Date of commencement: South/West 2004
Plot size of each treatment: 1/2 ac
Total extent/ Region : 4.5ac

Treatments (clones):
T1:RRISL 205, RRISL 203, RRIC 121, RRIC 100 and RRIC 102 (as a mixed clone system)
T2:RRISL 205, RRISL 203, RRIC 121 and RRIC 100 (- do -)
T3:RRISL 205, RRISL 203 and RRIC 121 (- do -)

No of Replicates: 3
(S M M Iqbal, V H L Rodrigo and K B A Karunasekara)

Anthurium culture under mature rubber (AR5)

In general, Anthurium plant grown, under 70 -75% of shade. The shade given by the natural rubber is ca. 70% and can be utilized to establish an Anthurium culture system. Since artificial shading is costly, Anthurium under mature rubber possibly allows a low cost system which would be beneficial to most of rubber smallholders. In order to study the feasibility of this system, the Anthurium under mature rubber at two locations, namely RRISL Dartonfield, Agalawatta and RRISL substation Kuruwita. Each site would comprise 150 plants from both Gauthamala and Tropical red varieties. Site preparation was completed and light intensity under mature rubber on the above site was measured by using a Ceptometer (W A D D S Wettasinghe, S M M Iqbal and V H L Rodrigo).

Rubber with poultry system (AR6)

A study was initiated to develop a sustainable system for free range poultry production under rubber. Initial discussion was made with Vettnary Research Institute (VRI) in this regard. Site selection was completed. First batch of chicks will be introduced in April 2005 (S M M Iqbal and V H L Rodrigo).

Assessments of different tapping systems practiced in smallholder sectors (AR7)

A study was started to assess the performance of recommended clones under different tapping systems practiced in small holder conditions. Five sites from each Kalutara and Ratnapura regions were selected for this purpose (S M M Iqbal and V H L Rodrigo).

Interplanting of rubber lands with tea (TR)

Productivity in Rubber/Tea systems (Kuruwita/TR 1)

Details of the experiment appeared in the Annual review 1990. Tea yield in each treatment plot was monitored throughout the year. In addition, test tapping was carried out to assess the rubber yield. Growth of rubber was monitored with the girth measurements taken at 150 cm height.

The growth of the rubber was greater in the intercrop treatment 8'×40' spacing than that in sole crop and Rubber 8'×27' intercrop system. However, these differences were not statistically significantly different (Table 3).

Table 3. *Growth of rubber in tea rubber systems (Kuruwitta estate)*

System	Mean girth (Rubber) cm
1. Rubber only (12'×18')	75.94 ^{A}
2. Rubber (8'×27')Un- rehabitation +Tea	72.50 ^{A}
3. Rubber (8'×27') Rehabitation +Tea	74.74 ^{A}
4. Rubber (8'×40') Un-rehabitation +Tea	82.98 ^{A}
5. Rubber (8'×40') Rehabitation +Tea	81.37 ^{A}

Girth sharing the same letter for each systems are not significantly different ($P<0.05$) (S M M Iqbal, A M A Perera and S Wettasinghe).

Productivity in Rubber/Tea systems (Agalawatta /TR 2)

Treatment details of the experiment were appeared in the Annual review 1990. Yields of rubber and tea were monitored by test tapping and plucking, respectively. Among the intercrop treatments, the girth of the rubber was significantly greatest in the rubber 8'× 44'system the lowest value recorded was in sole crop treatment (Table 4).

Table 4. *Growth of rubber (Agalawatta)*

System	Mean girth (Rubber) cm
1. Rubber only (100%) + Tea	72.503^{C}
2. Rubber 8' × 27' (100%) + Tea	75.453^{CB}
3. Rubber 8'×32' (85%) + Tea	74.855^{CB}
4. Rubber 8'×36' (75%) + Tea	74.580^{CB}
5. Rubber 8'×40 (70%) + Tea	77.903^{B}
6. Rubber 8'×44' (65%) + Tea	83.265^{A}

Girths not sharing the same letter for each system are significantly different ($P<0.05$) (S M M Iqbal and A M A Perera).

Productivity in rubber/tea system (Vogan estate/TR3)

Details of the experiment were appeared in the Annual review 1998.Tea yield were assessed with test pluckings. Girth of the rubber plants was measured at five feet height from the bud union. No significant differences between intercrop treatment plots with respect to the rubber growth was found (Table 5).

The following pre and post pruning assessments of tea in the treatment plots were conducted.

1. Five tea plants in each inter-row were selected.
2. Width, height and basal girth of tea plants.
3. No of pruning cuts.
4. Shoot count.

Table5. *Growth of rubber in tea rubber system (Vogan estate)*

System	Mean girth (Rubber) cm
1.F1S1 (½ fertilizer to 12'×18'Rubber)	55.41^{A}
2.F1S2 (½ fertilizer to 8'×8'×46' Rubber)	53.82^{A}
3.F1S3 (½ fertilizer to 8'×8'×60'Rubber)	55.71^{A}
4.F2S1 (1fertilizer to 12'×18'Rubber)	52.34^{A}
5.F2S2 (1fertilizer to 8'×8'×46' Rubber)	52.70^{A}
6.F2S3 (1 fertilizer to 8'×8'×60' Rubber)	55.24^{A}
7.F3S1 (1½ fertilizer to 12'×18'Rubber)	55.67^{A}
8.F3S2 (1½ fertilizer to 8'×8'×46' Rubber)	52.89^{A}
9.F3S3 (1½ fertilizer to 8'×8'×60'Rubber)	52.72^{A}

Girth sharing the same letter for each treatments are not significantly different ($P<0.05$) (S M M Iqbal and R B Gunaratna).

Smallholder sector (STR1)

Three smallholdings were selected to introduce the rubber/tea system of the spacing of 9' × 9 '×60' (Table 6) at Kegalle region (S M M Iqbal and E A T Senadeera).

AGRICULTURAL ECONOMICS

J C Edirisinghe

SUMMARY

A study on Marketing in the smallholder rubber sector: existing status and possible improvements was carried out during the year. The findings of the research on 'changing rates of interest, prices and the cost to the climate with special reference to rubber cultivation' were presented at the Ministry of Environment. 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 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.

Research students

- Ms H M D Tharanga Herath and Ms K A I Damayanthi Department of Agri-Business Management of Wayamba Campus started their research under the supervision of Assistant Agricultural Economist.

Seminars/Conferences/Meetings/Workshops attended

Officer	Activity	Organization
Jagath Edirisinghe	Scientific committee meetings	Rubber Research Institute
Jagath Edirisinghe	Presented a paper on Marketing in the smallholder rubber sector: existing status and possible improvements at the Symposium on plantation crops research	Tea Research Institute Rubber Research Institute and Coconut Research institute
Jagath Edirisinghe	Presented the findings of the project "Strategies for enhancing the productivity in small holder units of non-traditional rubber growing areas" in the Clients' conference of Centre for Poverty Analysis	Centre for Poverty Analysis (CEPA)

Officer	Activity	Organization
Jagath Edirisinghe	Workshop on scientific writing for young scientists in the field of forestry	National Science Foundation
Jagath Edirisinghe	Presented the findings of "Changing rates of interest, prices and the cost to the climate with special reference to rubber cultivation	Ministry of Environment

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. However, the increase in prices was marginal during the year. Prices of all grades of RSS were above that of the previous year (2003). However, the gap between the prices received in 2003 and 2004 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, there will be a slow down in prices during 2005. Prices of all RSS grades increased by 37-47% from 2003 to 2004. This was less than what was observed for the period 2002-2003, which was around 48-50%.

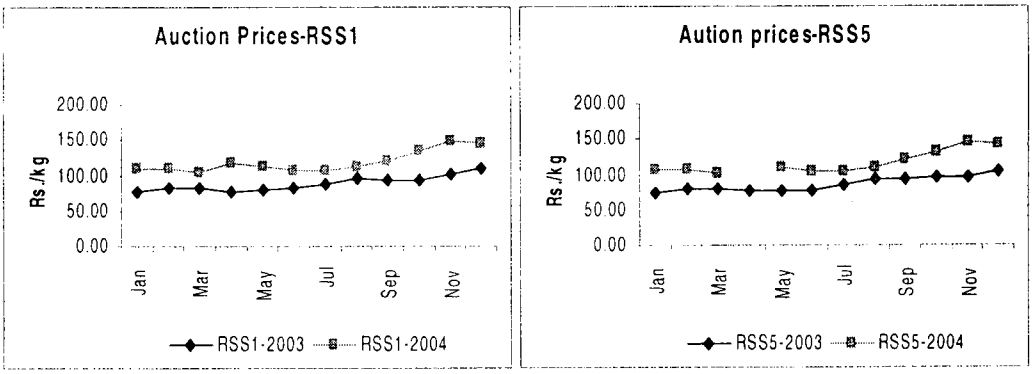


Fig. 1. Monthly averages of nominal RSS prices in year 2003 and 2004

Prices of Latex Crepe

The LC prices behaved similar to that of the RSS prices during the year 2004.

Though the prices were high than that of 2003, the trend in increase was marginal. Thus, the prices in 2005 will not increase as much as it did in the earlier years.

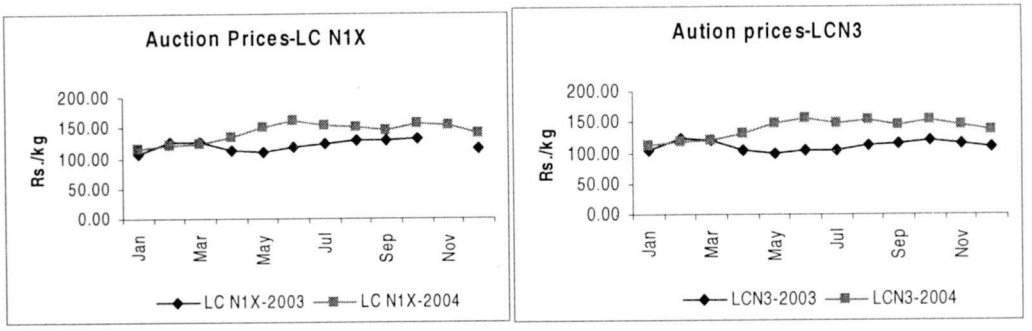


Fig. 2. Auction prices of Latex Crepe (LC) grades in the year 2003 and 2004

Quantities traded during 2003

The total quantities traded through the Colombo Auction are given in the figure below. 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 as in previous years. It is about 8% of the total traded through the auction.

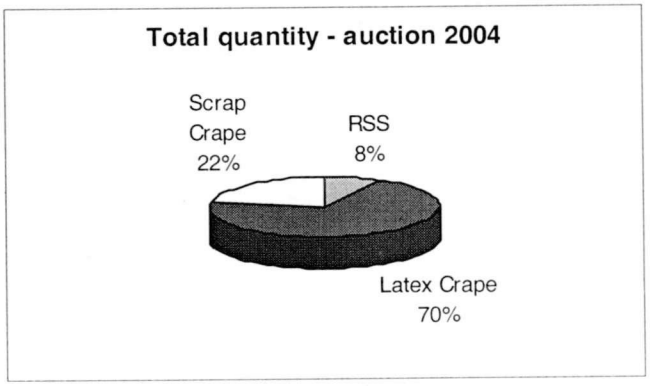


Fig. 3. Total quantities traded through Colombo Action in 2003

RESEARCH

Changing rates of interest, prices and cost to the climate with special reference to rubber cultivation

This research was funded by the Ministry of Environment and the results were presented and the report was submitted in the period under review.

Marketing in the smallholder rubber sector: existing status and possible improvements

Smallholders contribute significantly to the natural rubber production in Sri Lanka. However, it was seen in the recent past that the smallholder extents declining and they were moving out of the industry. The main reason associated with this was the low prices received by the smallholders. Though a recent hike in prices was observed, the income status of the small farmer is still very low. Therefore, it is necessary to understand why the high prices quoted at the auctions are not received by the producers and the reasons why smallholders are not keen on producing high quality rubber sheets. The inquiries into marketing of smallholder production hitherto have been very minimal and have been limited to study of marketing channels. Therefore, this research attempted to study the existing status of the smallholder rubber marketing through quantitative and participatory approaches, taking into consideration the marketing channels of smallholder production, marketing efficiency in terms of technical (production) and pricing efficiency.

The market channel of smallholder rubber

Data generated from the socio-economic survey and PRA were used to develop the smallholder market channel laid out in Fig. 4.

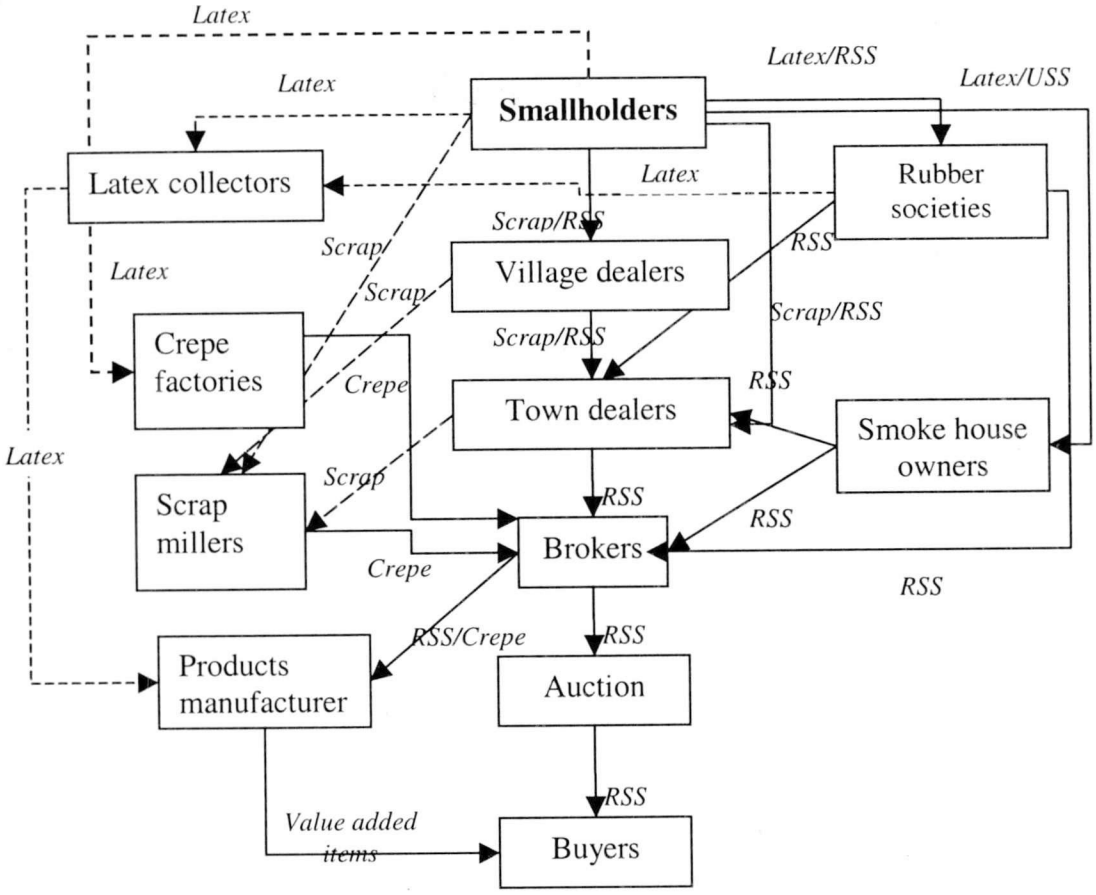
The marketing efficiency

Marketing efficiency is measured in terms of two aspects *viz*; technical efficiency and pricing efficiency. Factors that affect technical and pricing efficiencies were studied under the project.

Factors affecting technical (production) efficiency at smallholder level

Size of the holding

The size of the holding has an effect on the efficiency of production and marketing since the economies of scale comes into operation. In addition, when the holding size is higher, the production become higher. This leads to increased bargaining power of the smallhloder. The average size of the smallholder sector in the studied districts is given in Fig. 5.



RSS – Ribbed smoked sheets
USS – Unsmoked sheets

Fig. 4. Market channel for smallholder rubber

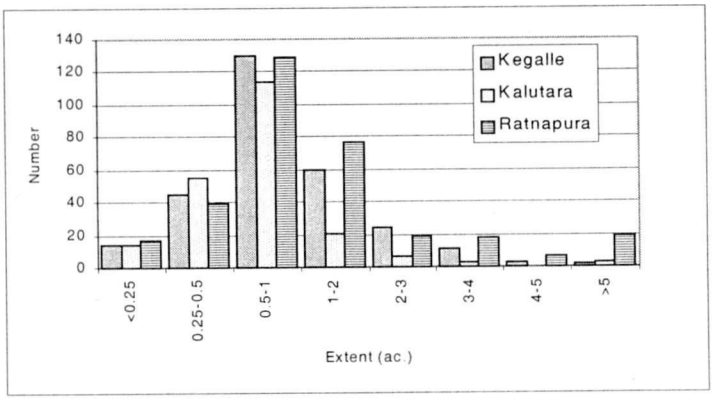


Fig. 5. Distribution of land extents of smallholdings

It is evident from Fig. 5, that majority of farmers have 0.5 – 1 acre holdings and thus are not in a position to have a higher bargaining power or obtain benefits of economies of scale.

Nature of rubber lands

Table 1 presents data on the percentage of rubber lands under immature, mature or in the abandoned status.

Table 1. *Present status of rubber lands*

Status	Percentage of lands in each district		
	Kegalle	Kalutara	Ratnapura
Immature	22%	24%	30%
Mature	73%	68%	63%
Abandoned	5%	5%	5%

The percentage of rubber lands under immature stage is too high in each district, indicating low adoption of recommended technologies. It is also a notable factor that a considerable portion of rubber extent is abandoned due to poor management or low prices received. The age distribution of immature rubber holdings in the three districts studied is given below in Fig.6.

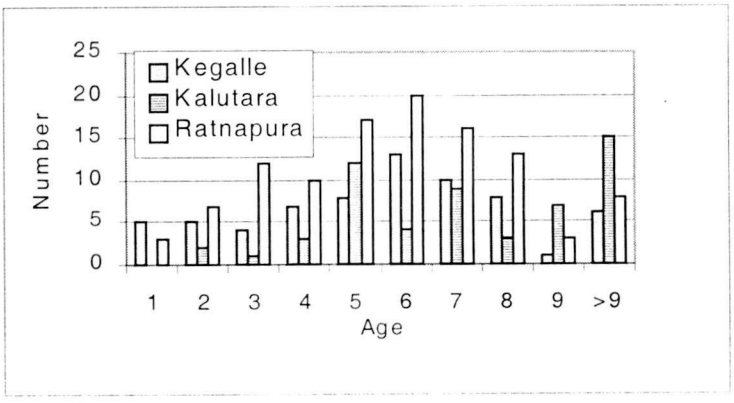


Fig. 6. Age distribution of immature rubber holdings

The normal length of the immature period of rubber is 6 years. However, above data indicates that there are lands that are above 8 years as well. The percentage of lands aged 8 years or above is 28%. This has a serious impact on technical efficiency. This is mainly due to poor adoption rates of recommended technologies during the immature phase of rubber.

Use of improved clonal material

Use of improved clonal material in the smallholdings improve the productivity and thus the technical efficiency. According to Table 4, though there is a higher percentage of improved clones in the immature holdings, the percentage of improved clones in the mature holdings which contribute to the productivity, is very low. It is below 50% in all three districts.

Table 2. *Percentage of improved clones in smallholdings*

Stage	% of improved clones in the selected districts		
	Kegalle	Kalutara	Ratnapura
Immature holdings	82	71	91
Mature holdings	22	45	47

Use of fertilizer

Another important input in rubber production is the use of fertilizer. It is evident form Fig. 4, that the use of fertilizer in the mature rubber is very low. Possibly the awareness on the importance of fertilizer application is poor with smallholders. A low income level is also another reason for the low adoption rates. This may hamper the productivity of the rubber land.

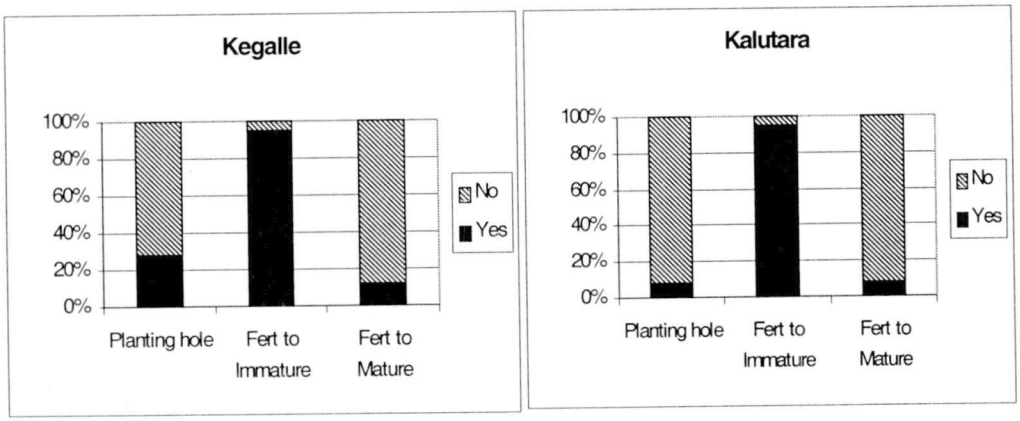


Fig.7. Use of fertilizer in Kegalle and Kalutara districts

Factors affecting pricing efficiency at smallholder level

The market margins

It was found that the middlemen involved in smallholder rubber markets retain at least Rs.10 per kg of rubber (Table 3). The major reason for this type of price discrepancy is associated with the grading system involved. Sheet rubber is graded visually. This is highly subjective and hence, the middlemen take the advantage of it by buying the rubber sheets in bulk regardless of their grade. The

middleman sorts this according to higher and lower grades and improves their profits. This has two impacts. First being the smallholder's income is foregone and the middleman grab smallholders' income. Second, the demand by the buyers is not correctly passed onto the producers and hence producers shun away from producing quality rubber.

Table 3. *Market margins involved in Ribbed Smoked Sheets (RSS)*

Village	Farm gate price (September, 2003) Rs/kg	Auction price (RSS1) (September, 2003) Rs/kg	Margin (Rs/kg)
Welihelatanne	97	107.21	10.21
Batugampola	94-96	107.21	13.21-11.21
Pohorabawa	95-98	107.21	12.21-9.21

It was evident from this study that to improve the marketing efficiency, the technical efficiency or the input-output relationship of the producer and the pricing efficiency of the total market system has to be improved. Technical efficiency is affected due to fragmentation of land (holding size), less use of improved clones (planting material), long immature period (due to low adoption of recommended technologies) *etc.* These can be overcome by way of improved information/education of the farmers through proper extension and provision of quality inputs, especially planting material (as it has a bearing on the productivity) so that the contribution from the smallholder sector to the national production can be improved significantly.

Table 4. *Expectations of Thurusaviya societies and the satisfaction*

(a) Village: Welihelatenna

Expectations	Farmers' perception on achievement of objective (%)
Leadership	30
Fair number of members	0
Intimacy between members	0
Honesty of officials	35
Finding a good market for rubber	0
Fertilizer & chemicals through the society	0
Collection of membership fees	0
Insurance scheme for the society	0
Meetings to be held at 3 months intervals	0
Providing technical know-how to farmers	0
Keeping up with the discipline of the society	5
Active roles of officials	5

(b) Village: Pohorabawa

Expectations	Farmers' perception on achievement of objective (%)
Free from politics	100
Honest devotion of members	40
Devotion of officials	75
Interactions with relevant government officials	75
Educating the farmers on how marketing arrangements could be made through the society	0
Marketing through the society	10
Providing needy inputs through the society	5
Providing credit facilities through the society	0
The society should have sufficient funds	15
Introducing a farmer insurance scheme	0
Introducing a farmer pension scheme	0
A fair number of members	20

- Note: these results were obtained in 2002

Also, the holding size is increasingly reducing with division of land among children. Therefore, policy measures in this regard are of immense importance to reduce/minimize the fragmentation.

The pricing efficiency is heavily affected by the subjective grading system prevalent in the rubber sector. The market margins kept by the middlemen can be reduced by increasing competition among buyers and also by intervention through forming farmer groups. However, in establishing farmer groups such as *Thurusaviya* societies, a more bottom up approach is necessary where farmers' expectations are met. In addition, improving the latex market through promotion of latex collecting centers or by involving private sector in latex collection is important, as at the moment the volume of rubber sold as latex is low (J Edirisinghe, W Wijesuriya, D M A P Dissanayake, M Wijeratne, K Herath and V Abeywardane).

Production behaviour and technical efficiency of small holder rubber farmers in Kalutara district

This study was commenced in 2004 and will be estimating a frontier production function and thereby estimate the technical efficiency. The estimated technical efficiency will be related to social and technical factors and identify the important factors that affect the technical efficiency. The study was commenced in 2004 and expected to be completed in 2005 (H M D Tharanga Herath - Wayamba Campus and Jagath Edirisinghe).

Development of leading indicators for natural rubber prices at Colombo Auction

A model to study supply of natural rubber in Sri Lanka will be developed using secondary data. The cyclical behavior of rubber prices which is one of the major concerns in the rubber industry and is difficult to be predicted. Thus, this study tries to develop suitable leading indicators to predict the turning points in the price cycles. The study was commenced in 2004 and expected to be completed in 2005 (K A I Damayanthi - Wayamba Campus and Jagath Edirisinghe).

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

Biometry section provided necessary research support to the other research departments in various aspects; *viz.* experimental design, analysis and interpretation of results. Statistical assistance is also provided to trainees and University students attached to the research departments. Databases on meteorological data collected in the meteorological station at Dartonfield and information on research personnel and experimental projects were maintained for the year under review.

To provide the best of its service to the clients, the staff of the Biometry section is in a routine process of upgrading their knowledge through a research focus to develop appropriate statistical methodologies for the rubber sector. In this regard, studies were carried out on statistical quality control, assessment of risk and uncertainty associated with tapping, indicator development and application of statistical methods for participatory studies. Studies on role of institutions on environmental change and poverty related issues in the rubber sector are among the new research focuses of the Biometry section conducted in collaboration with overseas institutions and various research departments of the institute.

DETAILED REVIEW

Staff

Dr (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 Nandana Gunaratne from the Faculty of Agriculture, University of Ruhuna submitted a report on "Application of statistical quality control in the rubber industry" for the partial fulfillment of the BSc degree in Agriculture under the supervision of the Biometrician.

Seminars/Conferences/Meetings/Workshops attended

Officer	Activity	Organization
Wasana Wijesuriya	Presented a paper on "Interactions between the environment, society and technology: The smallholder rubber sector" in the XXII International Biometrics Conference held in Cairns, Australia.	International Biometric Society
Wasana Wijesuriya	Scientific committee meetings	Rubber Research Institute
Wasana Wijesuriya	Addressed a public seminar on "Development of performance indicators for the smallholder sector"	Organized by the Postgraduate Institute of Agriculture, University of Peradeniya.
Wasana Wijesuriya and Keminda Herath	Presented a paper on "Smallholder rubber sector in Sri Lanka: A case study of three major rubber growing districts" for the Dissemination Review meeting of the INTEREST.	Rothamsted Research, UK
Wasana Wijesuriya and Keminda Herath	Symposium on plantation crops research	Jointly organized by Tea, Rubber & Coconut Research Institutes in Colombo.
Wasana Wijesuriya and Keminda Herath	First National Symposium on Geo-informatics	Geo-Informatics society of Sri Lanka and Postgraduate Institute of Agriculture
Wasana Wijesuriya and Keminda Herath	Presented the findings of the project "Strategies for enhancing the productivity in small holder units of non-traditional rubber growing areas" in the Clients' conference of Centre for Poverty Analysis	Centre for Poverty Analysis (CEPA)
Keminda Herath	Certificate course on GIS & Geo-informatics	Geo-Informatics society of Sri Lanka and Postgraduate Institute of Agriculture.
Keminda Herath	Research Seminar – 2004	Council for Agricultural Research Policy
Keminda Herath	Presented the findings of "Impact of climate change on yield of rubber"	Ministry of Environment

Services

Statistical analysis and interpretation

Research support in designing of experiments, statistical analyses and interpretation of experimental results was provided to other Research Departments and students attached to those departments (W Wijesuriya and K Herath).

Database management

(a) Meteorological

Daily data recording in the Dartonfield meteorological station was properly done and 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 on request (K Herath, C Munasinghe and V Abeywardene).

b) Management information

The personnel and project summary databases were updated for the year 2004. 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).

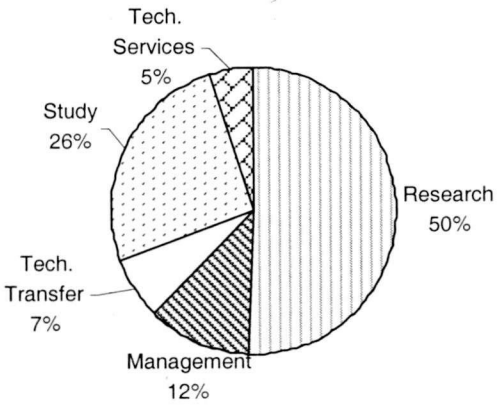


Fig. 1. How scientists spent time on various activities during the year 2004

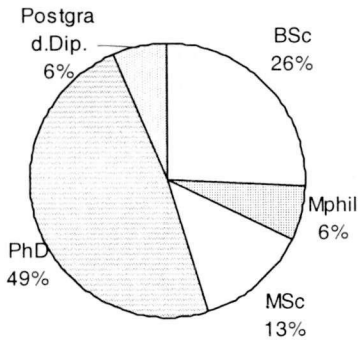


Fig. 2. Qualifications of scientists as at 2004

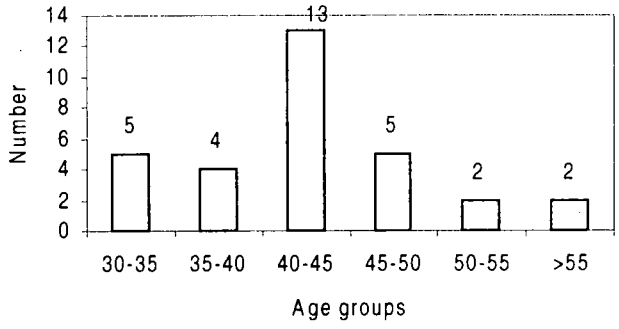


Fig 3. Age distribution of scientists at RRI

RESEARCH

The following studies were completed in year 2004.

Strategies for enhancing the productivity of smallholder rubber units in non-traditional rubber growing areas as an initiative to address poverty

This was a collaborative study with Advisory Services Department and Agricultural Economics unit and was funded by the Centre for Poverty Analysis (CEPA).

The highlights of the study are;

General

- Majority of the rubber lands (above 95%) are above 1 ac. Therefore, if rubber plantations are managed properly, the farmers are able to receive a considerable income.
- The average yield in the Moneragala district ranged from 2 to 6.2 kg/ac/day.

Immature holdings

- Intercropping is popular in REO ranges; Badalkumbura, Medagama, Moneragala and Maligatenna. Hence, providing necessary technical support is of paramount importance in areas where intercropping is popular and it is also important to carry out extension programmes in other areas to create awareness of farmers on the appropriateness of this technology.
- At present, majority of the immature holdings are of the age 5-7 years. Hence, it is important to pay more attention on awareness programmes on tapping panel marking, correct tapping practices and possible ways of bringing the fields into tapping as early as possible.

- Recently, most of the immature fields are comprised of RRIC 100. Therefore, steps need to be taken to popularize other clones like; RRIC 102 and RRIC 121.
- The adoption of use of poly-bagged plants is high in Moneragala district (72%). It should be further emphasized on the ability of this type of planting material to withstand drought conditions.
- When the fields are rated as; 'good', 'moderate' and 'bad' conditions according to the information on subsidy payments; 75% of the holdings are of state, 'good', which is a good indication of proper management by farmers.
- Drought and white root disease are found to be the main causes for vacancies in the field. Therefore, creating awareness is important on methods to overcome drought stress and controlling white root disease.
- Condition of cover crop in fields is not satisfactory and therefore this is another area to be looked into in awareness programmes.

Mature holdings

- Majority of the mature holdings are in the age group, 6-16 years; i.e. tapped in Panel A. Therefore, it is important to increase awareness of farmers on correct tapping methods since there is enough time to correct any incorrect practices.
- Farmers should be made aware of the benefits of fertilizing mature fields.
- Adoption of correct tapping frequency (alternate day tapping) is about 90%. However, the condition of the tapping panel is found to be in a 'good' condition only in 20% of the holdings. Hence, awareness programmes are needed which address on correct angle, depth and height of tapping.
- Tapping Panel Dryness is found to be serious in Atale and Wellawaya REO regions. Several fields in other regions are also affected by Brown bast except Bibila, Maligatenna and Medagama REO regions.

Processing and Marketing

- The main type of rubber produced by smallholders is RSS.
- Only about 5% is sold as latex while 13% is sold as un-smoked sheets.
- The weight of a sheet is in the acceptable range in about 65% of the fields.
- Nearly 80% of the farmers deal with town dealers for marketing of RSS. A considerable portion of farmers has direct links with Companies.
- RSS1 is produced in a very few places. RSS1 or 2 is produced by the majority of the smallholders in the Moneragala REO range. RSS produced in Atale, Maligatenna and Medagama are sold as 'bulk' while RSS produced in Badalkumbura, Bibila, Wellawaya and Kotagama are sold as RSS2 or 3.

Smoke Houses

- Nearly 75% of the smoke houses are not in agreement with the RRI recommendations

- All the smoke houses surveyed in the Badalkumbura REO range were built and being maintained according to the RRI recommendations.
- The general condition in most of the smoke houses is low.
- Processing machineries are of 'good' condition in about 50% of the smoke houses surveyed.

It is necessary to assist the smoke house owners to maintain and modify their smoke houses and also to maintain rollers. These areas need to be focused in awareness programmes (*Principal investigators*: Wasana Wijesuriya and D M A P Dissanayake, *Team members*: 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 was conducted in collaboration with the Department of Soils and Plant Nutrition. The final report was submitted to the Ministry of Environment (L Samarappuli and W Wijesuriya).

b) Junior research programme: Impact of climate change on yield of rubber.
The objective of this study was to relate rubber yield with meteorological parameters. The study was completed during the year under review and the final report was submitted to the Ministry of Environment.
It was found that the impact of climatic factors is different in different yield strata of the year. Climatic factors have a comparatively higher impact on latex yield during the wintering period. In general, the climate alone can describe about 25% of the variability in daily latex yield while the management and genetic factors determine the rest (K Herath and W Wijesuriya).

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 3rd year of the project.

Stakeholder discussion meetings were done in the villages to describe the issues related to sustainability of the eco-system and to update the networks on based on various issues. The questionnaire survey done during the 2nd year of the project

was analyzed. The findings were disseminated to the local and international community through;

a) Project home page: *http://www.rothamsted.bbsrc.ac.uk/aen/interest/index.htm*
b) Dissemination review of INTEREST at Rothamsted Research, UK
c) Special session on "Interactions between the Environment, Society and Technology" at the International Biometric Conference in Cairns, Australia
d) The first symposium on plantation crops in Colombo.

(Wasana Wijesuriya, Mahinda Wijeratne (University of Ruhuna), D M A P Dissanayake L M K Tillekeratne, Keminda Herath, Jagath Edirisinghe and Vidura Abeywardene).

Role of institutions on global environmental change

The joint proposal submitted by Energy and Resources Institute (teri) of India, Environment and Public Health Organization (ENPHO) of Nepal and RRISL, on "Role of institutions on global environmental change" to Asia Pacific Network (APN) was selected for funding and the agreement was signed in August. The information gathered from the studies conducted on climate change will be used to recommend suitable remedial measures to combat adverse effects of climate change. The aim of this project will be to educate people on the adverse impacts of climate change and to suggest adaptation measures to minimize the impact on rubber plantations (Wasana Wijesuriya, Lalani Samarappuli, Anura Dissanayake, Keminda Herath and Jagath Edirisinghe)

Uncertainty of tapping due to the incidence of rainfall in different seasons of the year

Most of the rubber plantations in Sri Lanka are confined to the wet zone, where the annual rainfall of exceeds 2500 mm. Therefore, rainfall critically affects tapping leading to an uncertainty of economic returns from rubber. Therefore, the objectives of this study are to assess the uncertainty of tapping due to rain interference and study the effectiveness of fixing rainguards as a measure to combat rain interference during different rainy seasons of the year.

Rainfall records were collected from the recording type rain gauge installed at Dartonfield agro-meteorological station and tapping records were from the Dartonfield estate covering the period 2002-2004. The target is to develop probabilities associated with tapping under different scenarios; *viz.* seasonal and diurnal variation in rainfall and the effect of rainguards. Distribution fitting and log-linear models will be employed in the analysis (Keminda Herath and Wasana Wijesuriya).

LIBRARY AND PUBLICATIONS

S U Amarasinghe

SUMMARY

The Library and Publications Section was engaged in the following activities during the year.

a. Maintaining, processing and publishing of Institute's regular publications.
b. Collecting and disseminating of information on NR and related areas.
c. Participation in AGRINET (Agricultural Information Network) activities.

DETAILED REVIEW

Staff

Mr S U Amarasinghe, Librarian and Publications Officer, Mrs Thilaka Danthanarayana (Colombo Office) and Mrs Ramani Amaratunga, Library Assistants and Assistant Publications Officers and Mr P M Prema Jayantha, Clerk/Typist were on duty throughout the year.

Seminars and Workshops

Librarian and Publications Officer attended the following:

- The AGM of the Sri Lanka Library Association at BMICH on 25th June.
- Three AGRINET Librarians meeting at CARP on 13th February, 10th June and 2nd September.
- The seminar for SLSTINET members on 23rd November at NSF.

Resource development activities

The book strength increased up to 5168 with the arrival of 47 new books. The Library subscribed to a limited number of journals due to financial constraints. To overcome this problem, content pages of scientific journals required by the scientists were obtained through Internet.

Orders were placed to the purchase of nearly seventy five books for updating the Library collection.

Publications

The following publications were done during the year.

- Annual Review – 2002
- Annual Report – 2003
- Handbook of Rubber Vol.2: Processing Technology
- රබර් පුළ වත් වෙළුම **23** (2003)
- RRISL Journal Vol.**85** (2003)

SDI Service

Routine work on SDI *i.e.* circulation of content pages of current journals among the institute's scientific staff were done regularly.

Nearly twenty literature searches on *Hevea*/rubber were done using CD-ROM databases available at CARP Library.

Equipments

The following equipments were purchased during the year.

- Computer with colour Monitor
- Laser Printer: HP Laserjet 1300
- Red carpet

DATONFIELD GROUP

J Perera

SUMMARY

The total extent of institute group of estates known as Dartonfield Group comprising Dartonfield and Gallewatte divisions in Agalawatta and Nivitigalakele division in Matugama, bears planted hectarage of 226.14 of which 184.71ha. were tapped during the year under review. Kg/per/ha.

A crop of 159,445 kg. was harvested representing a yield per hectare (YPH) of 863. Due to higher intensity of rain fall and it's skew distribution experienced during the year, the estimated crop and YPH were decreased by 18,679 kg. and 101 kg., respectively. The cost of production (COP) and net sale average (NSA) for the year under review were Rs.74.50 and Rs.130.95, respectively, and secured a profit of Rs.56.45 per kg. of rubber. The group was able to secure a total profit of Rs.9,000,670.25, for the year 2004.

The average intake per tapper (IPT) of the group for the year 2004 was 8.7 kg- an increase of 0.3 kg. when compared with of year 2003.

Weather condition experienced during the year showed an unfavourable distribution of rain fall which was not conducive for both tapping and harvesting of crop in the three divisions.

The tapping system (½ S,d3, ET2.5%. Ba 1.6. 4/Y) introduced in last year, to over come scarcity of tappers was continued with satisfactory results in Gallewatta division where 75% of the group's crop was generated.

DETAILED REVIEW

Staff

Subject to following changes, the Department's staff remained the same. Mr Jehan Perera the Estate Superintendent, Mr K K P Gunawardene, Senior Clerk, Mrs S I K Pathirage, Junior Clerk, Mr D S K Ranaweera, Rubber Factory Officer, Mr W D D Senanayake, Assistant Factory Officer, Messrs S K S de Silva, T Somaratne, N L D Reggie, H M Jayantha Premalal Field Officers, were on duty through out the year.

Mrs C Dissanayake and Mr A K D A Wickramasinghe left the Department to take up duties in Accounts Department of the Institute.

The Estate Committee decided to revert Mr H M Jayantha Premalal, the Assistant Field Officer of Nivitigalakele division to his substantive post of Field Officer, at the meeting held on 23 November 2004.

Mrs S Hettiarachchi the Crèche Attendant resigned from service w.e.f. 23.10.2004.

The cadre of the Estate Department stands at 16, made up as follows:

Senior staff	- 01
Assistant staff	- 13
Minor staff	- 02
Total	- 16

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	36.92	135.28	12.51	184.71
Immature areas	2.10	20.61	18.72	41.43
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	13.90	19.03
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**	**180.35**	**73.24**	**327.88**

Building complex of Gallewatte division was given to National Institute of Plantation Management and 04.00 hectares of mature rubber was handed over in 2004.As a result total extent of Dartonfield Group which was 331.88 in 2003 reduced is 327.88 in 2004.

Crop

Total crop of 159445 kg was harvested from an extent of 184.71 ha. during the year 2004.The crop harvested for the year was 89% of Season's estimated crop.

Tappers productivity

The IPT of the three division in the group for last o5 years, is given in Table 3.

Table 2. *The YPH in the Dartonfield group from 1999 to 2004*

Division	Year					
	1999	2000	2001	2002	2003	2004
Dartonfield	649	730	764	1218	1177	850
Gallewatta	713	828	890	815	1010	872
Nivitigalakele	858	885	657	754	613	689
Group average	728	820	838	879	1002	863
Group estimate	926	1093	901	943	989	964

Table 3. *The IPT division wise for the last 5 years in the Dartonfield group*

Division	Years					
	1999	2000	2001	2002	2003	2004
Dartonfield	8.5	6.8	7.2	7.1	6.6	6.4
Gallewatte	7.5	7.2	8.0	7.8	9.8	9.6
Nivitigalakele	5.6	5.0	4.6	4.4	4.6	5.9
Average	7.7	6.9	6.7	7.6	8.4	8.7

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	2004	2002	2003	2004
Dartonfield	285	147	314	15%	02%	6%
Gallewatte	5057	1739	1624	18%	11%	12%
Nivitigalakele	1027	202	278	21%	07%	16%
Total	6369	2088	2216	19%	07%	11%

One of the major problem the Dartonfield group encountered during the year was lack of required tappers. The crop and income lost owing to this problem was 19,279 kgs which amount Rs.2,524,585/05 respectively.

Rainfall

The total rainfall receive at Dartonfield, Gallewatte and Nivitigalakele divisions during the year was 4,349.7 mm, 3,485.0 mm, and 3,647.6 mm with an average rainfall 3,827.4 mm and number of wet days 235,181 and 192 respectively.

Table 5. *Annual rainfall and wet days in last five years*

	Year				
	2000	**2001**	**2002**	**2003**	**2004**
Rainfall in mm	3,586.2	4,144.5	4,153.2	3,509.7	3,827.4
Wet days	176	199	194	202	202

Tapping

Whilst the number of wet days in years 2003 and 2004 was the same, the rainfall in the year 2004 was increased by 317.7 confining number of tapping days to 180 as against 228 tapping days in 2003, manifesting higher intensity of the rainfall received during the year.

Table 6. *The number of tapping days, IPT and YPH in last 04 years*

Tapping days	**2001**	**2002**	**2003**	**2004**
Normal tapping	193	252	204	168
Late tapping	32	36	24	12
Double tapping	(19)	(32)	-	-
No tapping	140	77	137	186
I.P.T. kg.	8.6	9.6	8.4	8.7
Y.P.H. kg.	1015.0	1357.7	1002.0	863.0

Rainguard

During the year 2004, the Dartonfield division was fully rain guarded and Gallewatta division only a part was rain guarded. The performances of rain guarding are as follows:

Table 7. *Additional income generator by fixing of rainguard*

	Dartonfield division	**Gallewatte division**
Revenue area hec.	36.92	139.28
No. of rain guards fitted	9,297.00	19,586
No. of tapping done on rainy days	77.00	34.00
Total number of tapping days	275.00	219.00
Additional income from rain guards (Rs.)	912,665.03	634,678.93
Additional profit per hectare	24,720.07	4,556.86
Total cost per rain guard (Rs.)	16.08	16.08

Sealant for fixing rain guards were prepared by the workers of Dartonfield Group.

Table 8. *Comparative statement of mature area- profit/Hect.*

	2001	2002	2003	2004
Mature area extent	189.17	186.59	186.59	184.71
Total profit (in million)	(0.11)	(2.27)	(9.86)	09 Million
Profit/Hect. (Rs.)	594.87	12,182.45	52,026.85	48,728.66

Table 9. *Labour rates and breakdown of cost of production (Rs./kg.) for last 04 years*

	2001	2002	2003	2004
1. Labour wages	119.70	147.35	147.35	178.75
2. C.O.P.	48.90	54.25	57.16	74.50
2. 1. Tapping	18.07	19.35	20.41	23.65
2. 2. Manufacture	9.35	11.12	12.66	17.14
2. 3. General charges	13.20	16.87	36.77	52.32
2. 4. Up-keep	8.28	6.91	7.27	12.37
3. N.S.A.	48.19	68.11	109.07	130.95
4. Profit	(0.71)	13.86	51.91	56.45

Manufacture

Latex crop was continued to be manufactured as crepe rubber. The net sale average for the year 2004 was Rs.130.95 and out turn of crepe No.01 was 81%.

Table 10. *Details of crop manufactured during the year 2004*

Grade	Quantity	Grade %
Crepe No.01	117,529	81
Crepe No.03	27,347	19
Total	144,876	100
Scrap crepe No.01	10,584	73
Scrap crepe No.02	3,692	25
Scrap crepe No.03	293	02
Smoked sheet No.01		
Smoked sheet No.02		
	14,569	100

KURUWITA SUB STATION

S A R Samarasekera

SUMMARY

A crop of 61,677 Kg. was harvested during the year which is an increase of 16.4% over the estimated crop for the same period.

The actual yield per hectare (YPH) and the average intake per tapper were 1,393 Kg. and 8.5 Kg. respectively.

The annual rainfall was 4,556.3 mm with 120 wet days as against 3,981.0 mm with 89 wet days during the last year.

The average number of normal, late, double and no tapping days were 214, 14, 11 and 28 respectively.

The cost of production and the net sale average for the year were Rs.55.11 and Rs.104.89 per Kg. respectively. The profit per Kg. was Rs.49.78 and profit made for the year was Rs.3,070,281.06. The total profit inclusive of sundry income was Rs.4,595,650.52.

DETAILD REVIEW

The Visiting Superintendent Mr Anusha S Perera over looked the activities of the Sub Station throughout the year.

Staff

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 cadre stood at 05 at the end of the year, made as follows:

Intermediate staff	- 1
Assistant staff	- 1
Minor staff	- 3

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	44.25
Immature area	40.04
Nurseries	1.42
Tea revenue area	1.75
Paddy area	1.00
Building gardens and roads	9.13
Water tank	.01
Unsuitable for planting	2.00
	99.60

Crop

A total crop of 61,677 kg. was harvested from an extent of 44.25 hectares during the year.

When compared with the estimated crop there is an increase of 8,677 Kg. at the end of the year.

A monthly breakdown of the actual YPH (Kg) in the estate is given in table 2.

Table 2. *The yield per hectare (Kg) recorded for each month during the year*

Month	Y.P.H.
January	168.9
February	111.9
March	80.7
April	69.6
May	91.8
June	118.8
July	117.9
August	134.7
September	87.0
October	111.3
November	136.6
December	164.7

Table 3. *Yield per hectare (Kg) recorded from 2000 to 2004*

	Year				
	2000	**2001**	**2002**	**2003**	**2004**
Estimate	855.0	867.2	819.0	1,080.0	1,197.7
Y.P.H.	1,012.2	1,015.0	1,357.7	1,371.5	1,393.9

Tapper productivity

The average intake per tapper for the last 5 years of the estate are given in Table 4.

Table 4. *The average intake per tapper (Kg.) for the last 5 years*

	Year				
	2000	**2001**	**2002**	**2003**	**2004**
Intake per tapper	8.6	8.6	9.6	9.4	8.5

The intake per tapper could have improved if not for adverse wet weather prevailed throughout the year.

Rainfall

The total rainfall during the year is higher than the previous year (Table 5).

Table 5. *Annual rainfall and the number of wet days for the last 5 years*

	Year				
	2000	**2001**	**2002**	**2003**	**2004**
Annual rainfall (mm)	3,068.4	3,324.2	2,743.0	3,981.0	4,556.3
Wet days	134	165	70	89	120

Tapping days

There were 327 tapping days during the year. This was possible merely due to the rainguards (Table 6).

When compared with last year the number of non tapping days have decreased from 75 to 28.

Tapping cost

The tapping cost of the estate has increased by 33% over the last year due to the increase of labour wages.

Table 6. *The number of tapping days for the last 5 years*

	Year				
	2000	**2001**	**2002**	**2003**	**2004**
Tapping days	240	224	289	248	327
Normal	195	193	224	226	214
Late	23	16	36	14	14
Double	(45)	(19)	(32)	(46)	(11)
Rain interference	22	15	02	08	07
No tapping	122	134	70	75	28
Holidays	03	07	05	10	11
Rainguards	-	-	28	32	92

Table 7. *A break down in total tapping cost for last 5 years*

Cost item	**Cost/Kg. (Rs.) and year**				
	2000	**2001**	**2002**	**2003**	**2004**
Tapping	14.85	15.41	14.42	14.67	21.10
Double tapping	.61	.35	.47	1.33	.54
Overtime on tapping	.15	.16	.11	.18	.22
Overkilos	.46	.46	.68	.48	.31
Extra pay to Kangany	.01	.01	.02	.03	.03
Tapping Kg.	.08	-	-	-	-
Scrap pay	.20	.18	.22	.36	.39
Incentive pay to field staff	-	-	-	.09	.20
	16.36	16.57	15.92	17.14	22.79

Cost of production and profitability

C.O.P. for the season was Rs.55.11 and N.S.A. Rs.104.89. The estate made a profit of Rs.49.78 per kilo (Table 8).

Table 8. *Labour rate (Rs.) and the break down of the cost of production (Rs./Kg)*

	2000	**2001**	**2002**	**2003**	**2004**
Labour rate	98.00	98.00	109.00	109.00	125.00
Total COP	36.49	34.02	31.94	34.25	55.11
Tapping	16.36	16.57	15.92	17.14	22.79
General charges	14.39	12.01	12.37	11.39	23.20
Upkeep	3.92	3.58	3.14	4.95	8.37
N.S.A.	49.75	46.68	53.93	83.12	104.89
Profit	13.26	12.66	21.99	48.87	49.78

Labour rate per day for the year was Rs.125/- plus an additional incentive of Rs.35/- per day depending on the attendance.

Table 9. *Comparative statement of the nature extent profit per Kg. and profit per hectare*

	Year				
	2000	**2001**	**2002**	**2003**	**2004**
Nature extent (ha.)	43.25	43.83	48.83	48.83	44.25
Total profit (Rs.)	580,509.54	563,357.34	1,437,640.23	327,2921.64	307,0281.06
Profit/ha, (Rs.)	13,422.18	12,853.24	29,441.74	670,26.86	69,384.88

During the year 2004 a profit of Rs.49.78 on a kilogram and Rs.69,384.88 per revenue hectare were recorded.

Tea

A crop of 21,406 Kg. was harvested during the year. The cost of production and the net sale average for the year were Rs.25.98 and Rs.26.36 per kg. respectively. The profit per kg. was cents 38 and the profit made for the year was Rs.8,142.46.

Fertilizer

Fertilizer application for mature and immature fields were carried out as scheduled.

Meteorological Summary – 2004
Dartonfield Station

Wasana Wijesuriya

The total annual rainfall experienced during 2004 was, 4350 mm, a slight decrease of rainfall compared to the previous year (4454mm). This is a deviation of 190mm from the long-term average of 4160mm. Like in year 2003, the distribution showed a considerable departure from the usual bimodal pattern; especially during the mid year dry period as shown in Fig.1.

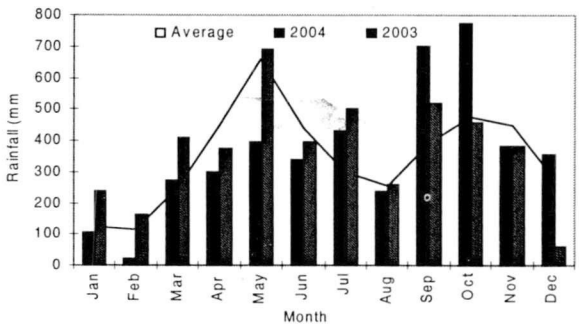


Fig.1. Monthly variation in rainfall

In the year under review, highest monthly rainfall of 775 mm was observed during October, which coincided with Northeast inter monsoon period. It is a deviation of 299 mm from the long-term average of the month. Fairly low rainfall figures were observed in April, May and June where heavy showers are expected during the period of Southwest monsoon. Compared to the previous year, heavy showers were observed during Northeast monsoon in 2004.

Fairly dry weather prevailed in February with lowest monthly rainfall of 21 mm which is below the long-term average for the month. Rainfall observed during January, February, April, June, October and November were below compared to their long-term averages.

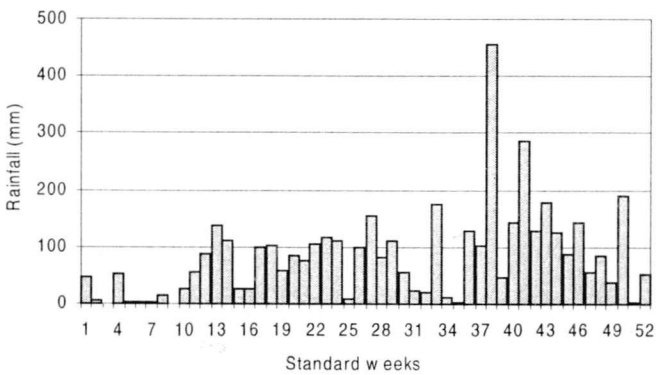


Fig. 2. Weekly variation in rainfall

The distribution of weekly rainfall is illustrated in Fig. 2. Six 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 38th standard week (Mid October), which coincided with the Northeast 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 SW and NE rains, respectively. For the year under review, SW rains commenced successfully by 14th of March, which is an early onset of rains, compared to the 80% expected. The onset of NE rains for this year cannot be clearly identified.

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 13th January 2005.

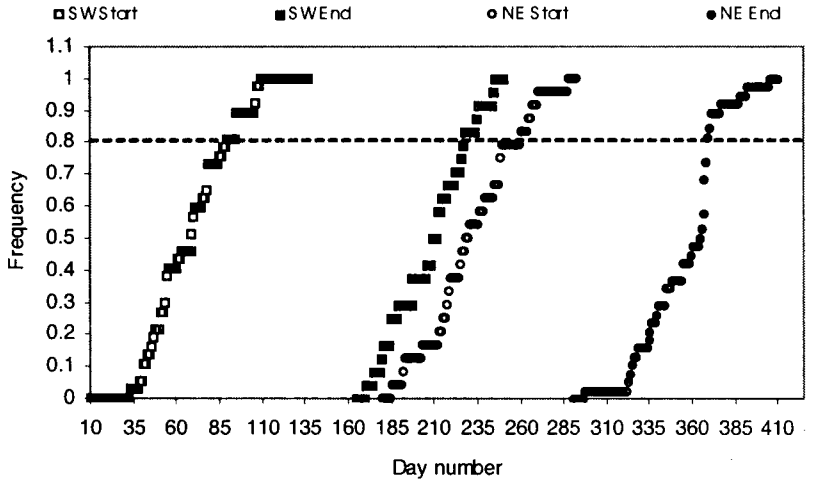


Fig.3. Cumulative probability of the start and end of rains in the two major rainy seasons at Dartonfield

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.

During the past 41 years, in 15 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 cannot 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 235, which is higher compared to the long-term average (229 days).

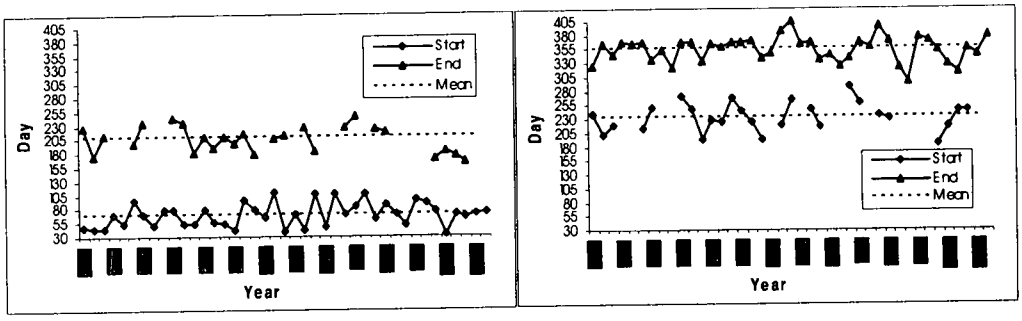


Fig. 4. The start and the end of the SW rains (a) and NE rains (b) over 41 years

Intensity of rainfall

Like in 2003, in this year high intensity showers were observed during NE monsoon, whereas high intensity showers are generally common in Dartonfield during the SW monsoon. This is a significant deviation of the usual rainfall pattern at Dartonfield. The highest rainfall intensity recorded was 84 mm/hr in May and September, but both incidents lasted only for 1 minute. 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 20^0C in 4 months; January (1 day), February (5 days), March (2 days) and December (4 days) where only three such days observed in December 2003. The highest mean maximum temperature of 34.3^0C was observed in March. The lowest mean minimum temperature of 22 was observed in February and December. The lowest value for sunshine hours was observed in July due to overcast conditions resulted by unexpected heavy rains. The average morning RH was in the range of 65 to 92%. The soil temperatures measured at 3 different depths are given in Table 4.

Table 1. *Monthly variation of rainfall and rainy days in 2004*

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	106.3	(121)	10	(10)	05	05	-	75.7
February	21.2	(116)	05	(09)	02	03	-	82.4
March	273.5	(252)	13	(17)	01	10	02	67.5
April	297.9	(449)	19	(21)	04	14	01	53.3
May	397.3	(659)	28	(24)	05	22	01	46.4
June	339.9	(440)	25	(24)	05	19	01	59.3
July	429.1	(299)	28	(22)	04	22	02	52.8
August	235.5	(257)	17	(21)	04	12	01	67.3
September	735.9	(391)	23	(22)	02	16	05	41.3
October	774.5	(476)	29	(22)	03	22	04	46.7
November	383.2	(448)	20	(20)	02	17	01	47.7
December	355.4	(282)	18	(17)	03	12	03	57.9
Total	4349.7	(4160.0)	235	(229)	40	174	21	698.3

* A rainy day is defined as a day with a rainfall $\geq$ 0.3 mm
** Average values for 1980-1992 are shown in parentheses

Table 2. *Rainfall intensity recorded at Dartonfield Meteorological station – 2004*

Month	Date	Intensity (mm/hour)			
		3 highest records	Time of occurrence	Duration (min)	Mean for the month
January	28	24.0	14.52-15.00	8	5.90
	09	9.6	18.15-18.30	15	
	11	4.0	07.30-07.45	15	
February	11	24.0	19.45-19.46	1	5.19
	22	5.3	05.30-07.00	90	
	14	3.2	17.30-18.30	60	
March	24	48.8	15.00-16.00	60	10.56
	31	34.1	16.02-17.15	7	
	24	24.0	14.15-14.37	24	
April	06	30.4	14.30-15.45	75	6.79
	25	23.6	17.00-18.15	75	
	01	22.3	14.17-15.30	73	
May	14	84.0	02.15-02.16	1	13.73
	26	72.0	02.44-02.45	1	
	28	72.0	20.44-20.45	1	
June	07	60.0	13.45-13.47	2	14.65
	29	40.0	15.45-15.52	7	
	30	40.0	08.45-08.47	2	
July	29	36.0	04.28-04.30	2	8.94
	07	27.4	09.30-09.37	7	
	04	24.0	14.45-14.46	1	
August	08	26.4	15.10-15.30	20	8.97
	16	19.2	11.45-12.00	15	
	05	17.6	05.20-05.35	15	
September	19	84.0	10.15-10.16	1	8.46
	15	40.8	03.30-04.00	30	
	22	39.0	12.22-12.30	8	
October	03	36.8	15.00-15.15	15	9.34
	17	36.0	16.00-16.30	30	
	11	27.2	18.22-19.37	15	
November	22	72.0	12.45-12.47	2	9.35
	12	30.4	16.45-17.30	45	
	28	24.0	17.37-18.00	23	
December	02	57.2	15.10-16.15	65	8.14
	15	25.8	18.00-20.00	120	
	03	21.1	15.35-16.00	25	

Table 3. *Variation of observed meteorological factors at Dartonfield - 2004*

Dartonfield	(Latitude 6° 32′N; Longitude 80°.09′ E Altitude 65.50mm)								
	Temperature (°C)					Relative Humidity (%)			Mean wind speed ($kmhr^{-1}$)
Month	Mean Max	Mean Min	Mean	No of days Min Temp<20	Sunshine hours	9.00 am	No. of days 9.00am>90%	4.00 am	
January	33.7	22.5	28.1	01	6.5	90 (87)	18	65 (67)	2.0
February	33.7	22.0	27.9	05	6.8	89 (85)	13	65 (64)	2.0
March	34.3	22.6	28.5	02	6.7	88 (84)	14	78 (66)	2.1
April	33.4	23.5	28.5	-	5.4	90 (84)	18	78 (66)	1.7
May	31.2	24.1	27.7	-	4.1	92 (87)	21	76 (73)	2.0
June	31.2	23.3	27.3	-	5.2	93 (88)	28	74 (77)	1.8
July	30.3	23.4	26.9	-	2.0	94 (88)	28	75 (76)	2.3
August	30.8	23.3	27.1	-	5.6	90 (87)	19	75 (74)	2.3
September	30.4	22.9	26.7	-	3.4	92 (86)	21	78 (74)	2.0
October	31.0	22.6	26.8	-	4.0	92 (85)	21	83 (77)	1.7
November	31.7	22.6	27.2	-	4.1	91 (84)	13	80 (77)	1.4
December	32.4	22.0	27.2	04	4.3	92 (84)	24	81 (74)	1.5

** Average values for 1980 – 1992 are shown in parentheses

Table 4. *Soil temperatures recorded at different depths at Dartonfield - 2004*

Month	09.00 hrs				16.00 hrs			
	5cm	10cm	20cm	30cm	5cm	10cm	20cm	30cm
January	27.4	26.8	27.8	28.5	35.9	33.2	30.8	29.3
February	27.9	27.5	28.6	29.3	36.2	34.0	31.7	30.1
March	28.2	27.5	28.6	29.4	36.9	34.4	32.0	30.3
April	28.6	27.6	28.5	29.1	35.0	33.2	31.3	30.0
May	28.2	27.6	28.3	29.0	32.9	31.6	30.2	29.5
June	27.5	26.8	27.7	28.5	34.2	32.0	30.4	29.3
July	27.2	26.4	27.3	28.1	33.1	31.2	29.4	28.7
August	27.4	26.8	27.7	28.4	33.7	31.8	30.0	29.0
September	26.8	25.9	26.7	27.6	32.8	31.1	29.3	28.4
October	27.6	26.0	26.7	27.6	31.8	30.7	29.3	28.5
November	27.6	26.3	27.0	27.9	31.1	30.7	29.3	28.6
December	26.6	25.8	26.8	27.7	32.4	30.9	29.1	28.2

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