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RUBBER RESEARCH INSTITUTE OF SRI LANKA

ANNUAL REVIEW 1994

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Cover – Main photograph: Intercropping of Rubber (clone RRIC 121) with Tea.

Insert : Sundrying of Rubber – Latest environmental friendly recommendation of the RRISL.

Photographed by – Wimal Amaratunga.

Rubber Research Institute of Sri Lanka

Annual Review - 1994
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February 1995

Headquarters & Laboratories
Dartonfield
Agalawatta

Colombo Office & Laboratories
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* On study leave overseas

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RUBBER RESEARCH INSTITUTE OF SRI LANKA

DIRECTOR'S REVIEW

L M K Tillekeratne

Natural Rubber (NR) prices remained at a very attractive level in 1994 except during the very early months of the year. These price signals have inspired the smallholders in particular to expand the extent of rubber without diversifying into other crops. In many areas, *viz* Matara, Galle and Kamburupitiya; most farmers have uprooted marginal tea lands and replaced with rubber. If the present trend continues, with the planting of high yielding RRIC 100 series clones in new plantations as well as in replantings, the target of increasing the NR production to the 200 000 MT mark by year 2000 will not be a difficult task. It is heartening to note that, according to reports from RRI of Malaysia, the clone RRIC 100 developed by Sri Lankan scientists has been identified as the most potential yielder among the high yielding clones exchanged between rubber producing countries in 1979. The statistics released by the Rubber Development Department further signifies the popularity of RRIC 100 and 121 among the smallholders even above the expected level.

Under the prevailing high prices of raw rubber, the estate sector too has recorded good profits. For example, the Dartonfield Estate with a mature rubber extent of 156 hectares (55% of the rubber extent) and presently under the management of the RRI scientists, has registered a profit of well over 2 million in 1994 while running the factory only at 35% capacity. The factory has been successful in curtailing the COP of unfractioned unbleached rubber it produces to Rs.33.11. The Dartonfield Estate, in general, has shown an average profit of Rs.18.50 per kilogram till end of November 1994 despite having a labour surplus of over 100 even at present. Moreover, in the months of September to December, profits have exceeded over Rs.35.00 per kilogram. If sufficient crop had been available to operate the factory at full capacity, the profit could have increased further while lowering the COP to a much lower level. Nevertheless, it is unfortunate that the other better quality rubber estates in the country cannot generate similar profits as recorded in Dartonfield. A detailed study to identify the course for this may be of immense value.

In 1994, the rainfall was very high in Sri Lanka and many tapping days were lost due to rain interruption in the Kalutara District alone compared to the year 1993. The few estates and smallholders who fitted rainguards in 1994 have got very attractive returns for their investment. If all the estates in Sri Lanka had gone for

rainguards at the beginning of 1994, as is being done in India, the total production would have increased at least by another 25%. It is, therefore, of paramount importance that the estate sector uses rain guards at least from early 1995 to reap the maximum benefit of the prevailing high rubber prices.

The problem of shortage of tappers was very severe in this year too. The RRI introduced the S/2,d/3 tapping system as a partial solution to this problem. This system was recommended only for the A and B tapping panels of high yielding clones, *viz* RRIC 100, 102 and 121; where a highly diluted (2.5%) ethrel stimulant is applied twice a year to obtain the same yields as in the case of the conventional S/2,d/2 system. This exercise is, however, not recommended for low yielding clones like PB 86, PB 28/59 and PB 217. Nevertheless, on a request made by the World Bank, further experiments are being done to investigate the effect of this S/2,d/3 system on low yielding clones, also.

In general, the rubber products industries in the country have performed well throughout the year. A leading solid tyre manufacturer, Bergougnan Lanka Ltd, started a new process line to manufacture chlorobutyl rubber based tubes. The name of the company was also changed to Trelleborg (Lanka) Ltd towards the end of 1994. However, during the election period there were a few labour disputes in some of the BOI approved factories. These disputes were settled by the government very promptly and production recommenced within a short period. Also, with the increase of the rubber prices in the local market, the rubber products manufacturers found it difficult to operate their factories profitably. Some manufactures were compelled to substitute NR with cheap grades of synthetic rubber (SR) such as SBR 1502 and SBR 1712 for making shoes and certain other finished products. These grades of SR have the special ability to be loaded with more fillers while taking precautions to prevent shrinkage and die swell. However, towards the last quarter of 1994, even the price of this particular grade of SR went up with its increasing world wide demand. Nevertheless, if this scarcity of NR prevails in the world market for a prolonged period, the prices of NR may be pushed up further. As a result, synthetics can become more economical compared to NR and thereby could create an unhealthy situation once gain for NR.

In the world arena, 72% of the total NR production has been exported (of which 93% is from Asia) in 1994. Thailand, as the leading NR producer, accounted for 35% of the world exports whereas the share of other major NR exporters has been; Indonesia 30%, Malaysia only 19% and Sri Lanka nearly 2%. With regard to SR, only 39% of the total production has been exported in year 1994 with USA in the lead closely followed by Japan, France and Germany.

In general, regional consumption of SR and NR has followed a 2:1 ratio in the Asia Pacific and in North America. This ratio has been changed in two regions. Firstly in Asia where the proportion of NR used is about 60%. Secondly in the former Eastern Europe, 90% of the consumption consisted of SR. However, the indications

are that an excess demand for NR may prevail in the global market at least for a few more years particularly due to certain dramatic structural changes that are taking place in many parts of the world. The Agricultural Economics Unit of the RRI has done an in-depth study on this issue and the preliminary results strongly suggest that, in general, the NR prices will remain at a highly remunerative level probably up to end of this decade.

The 35th Annual symposium and the meeting of the Executives of the International Rubber Study Group (IRSG) was held in Sri Lanka in mid May 1994. Distinguished delegates from both rubber producing and consuming countries participated at these meetings.

Biology

A selection from germplasm collection continued to give very high yields. RRISL 201, RRISL 202, RRISL 217, RRISL 218 and RRISL 219 registered under new RRISL 200 series have been recommended for experimental scale planting on state sector estates. Budwood of RRISL 201 and RRISL 202 was distributed to a few estates for establishment of multiplication nurseries.

Work on *Hevea* molecular biology has been started in collaboration with the Biochemistry and Molecular Biology Department of the Medical Faculty, Colombo. Two DNA probes were obtained from the Laboratory of Plant Molecular Biology, University of Birmingham, UK, for this purpose. The initial work such as extraction of rubber DNA, digestion with restriction enzymes, separation of DNA agrose gel, Southern transfer of DNA onto nitrocellulose membranes and probe labelling with P^{32} dcTP has been completed.

Low frequency tapping system, *ie* half spiral third daily (½s d/3) with stimulation gives annual yield comparable to ½S d/2. This system may be adopted to reduce tapping cost and tapper requirement whilst increasing the tapping cycle. High intensity tapping, *ie* ½S d/1 and ½S d/2 + Stimulation, gives poor g/t/t yields with modern clones. Trees opened at higher girths have been found to give high yields and are more vigorous in girthing. Actual tapping time is about a third of the total time taken for a tapping task and is similar with both Jebong and Push Knives. Yields from upward tapping of higher virgin bark and from downward tapping of panes BI-1 are similar. Clonal and stimulation effect significantly influences the incidence of tapping panel dryness. Establishment rate and growth rate are similar in two whorled young buddings and two whorled brown buddings in polybags. Increasing planting density beyond 500 trees/ha results in lower g/t/t yield and girthing whilst increasing the incidence of tapping panel dryness. Different spatial arrangements such as cluster and double row planting tested to facilitate intercropping, do not appear to retard the growth of rubber plants. Intercropping rubber with sugarcane and timber appears to be promising.

Wintering and refoliation have been uneven and protracted over several months due to the wet weather that prevailed at the beginning of the year. This favoured the spread of *Oidium heveae* on susceptible clones causing secondary leaf fall. However, the incidence of abnormal leaf fall caused by *phytophthora* spp. and bark rot caused by the same fungus was very light during the S.W. monsoon period.

Observations made for the 3rd year reaffirmed that 2% PCP in bitumen is effective in the management of white root disease provided that fungicide is applied at the early stages of the infection. It was also found that phenol, a less hazardous chemical, could be used as an alternative to PCP at 10% concentration. Four fungicides, *viz* tebuconazole, oxadixyl 10% + mancozeb 56%, tridemorph and triadimonol; have been found to be effective in the management of foot canker caused by *Nattrassia mangiferae*. It has also been found that benomyl, pencycuron, propineb and tebuconazole could be successfully used in controlling target leaf spots and hypocotyl death of *Hevea* seedlings caused by *Thanatephorus cucumeris*. Four other fungicides, *viz* benomyl, mancozeb, metalaxyl 8% + mancozed 64% and oxadixyl 10% + mancozeb 56%; were identified as potential fungicides against *Cylindrocladium quinqueseptatum*.

Residual effect of mulching with rice straw on girthing and latex production was seen even at the 6th year after discontinuation of mulching. The savings on fertilizers by mulching in comparison with the conventional practice of growing creeping leguminous covers amount to Rs.5 275/= per hectare for the first 8 years of mature phase. Clone RRIC 102 with mulching reached the tappable girth approximately one and a half years earlier than clone PB 86. Further, it appears that incorporation of paddy straw into the soil releases more nutrients than surface mulching.

Experimental results further suggest the possibility of using Eppawela rock phosphate as a source of phosphate for immature rubber plants also in some soils. Agronomically, the conventional fertilizer mixtures have been found to be as effective as the liquid formulations when both were tested at weekly intervals for young budding plants. It has also been found that these formulations can be applied effectively once in two weeks and thereby reduce the cost of fertilizer application by almost half. Accordingly, the recommended frequency of application of liquid formulations to young budding plants is now, once in two weeks.

The soil and foliar based discriminatory fertilizer recommendation continues to be popular in the state sector estates. In general, as in the past, N and K fertilizers were recommended to most of the plantings. An economic analysis of the soil and foliar survey programme based on the last 12 years data indicates that approximately a saving of Rs.1 400/= per hectare per year is possible under this scheme.

Several run–off models were estimated using standard econometric procedures to determine the soil loss in immature rubber holdings under different agro–management and physiographic conditions.

Adaptive Research Programmes in smallholdings on intercropping with annual and perennial crops continue to be useful in extending this technique to this sector. Programme on the use of rainguards further confirms that rubber production in the smallholder sector could be increased by about 15 to 20% if this technology is adopted in all the smallholdings. Use of organic manures such as poultry litter, dead mulch of rice straw, bush/tree legumes *etc* are being encouraged in this sector.

Models were developed to forecast the world economic growth as well as to project the growth rates per individual country/region. Some alternative scenarios for the future economic growth were also designed as a preliminary prerequisite in developing the simulation model for the rubber economy. A simulation model was also developed to link different biological aspects to production and also to explain the effect of different aspects of local and foreign market trends on production pattern.

Rubber Chemistry and Technology

Analysis of leachable proteins in examination and surgical gloves using Bradford Assay has been successfully introduced as there is a worldwide fear that such proteins are likely to cause skin irritations and eczematices reactions mainly among the health care workers wearing latex gloves at the work place. It also appears possible to lower the percentage of leachable proteins in rubber gloves by chlorination and leaching in water under different conditions.

A new technology has been developed to blend incompatible polymers such as natural rubber and nitrile rubber, as the mixing of these polymers has been found to be difficult under normal conditions and hence the properties of the resulting blends have been poorer than expected. The use of about 10% of a compatibilizer such as MG rubber, a speciality rubber based on natural rubber or chlorinated rubber, has been found to give encouraging results. The NR/NBR blends with a compatibilizer gave favourable physical properties including tensile strength and modulus and improved oil resistance.

High level of epoxidation of natural rubber latex has also been obtained using deproteinized latex. The possibility of using epoxidised natural rubber in tyre tread compounds in the rubber industry is being explored. The performance of rubber seed oil based vulcanisates has been found to be better than the normal rubber processing oil based vulcanisates as tyre tread compounds based on NR in relation to some important technical properties such as resilience, compression set and abrasion resistance.

It has been possible to develop a non toxic grade of Constant Viscosity rubber, a good natural rubber based adhesive formulation to stick vulcanized rubber, a latex based compound with good adhesion properties suitable for carpet backing, a compound based on NR/SR suitable for constructing collapsible tanks which are resistant to extreme conditions of weather such as temperature, rain humidity *etc* and a casting technique suitable for making artificial flowers from NR latex.

Work on the use of latex bitumen emulsion in road construction indicates the possibility of using inorganic salts as density modifiers and thickeners in improving storage stability of latex/bitumen blends.

The Mooney Viscosity of latex crepe rubber has been found to depend very much on different processing conditions such as the dosage of peptisers used, processing and drying temperature *etc*. However, dilution of latex has been found to have little effect on viscosity reduction in rubber.

Effluent treatment plants, based on anaerobic/aerobic treatment principle, to treat effluents generating from palm oil manufacturing factories and rubber factories have been designed by the RRISL and some of them are in operation now. Treatment plants were also designed for various other industries such as ceramics and pesticide plants to treat the waste water prior to their disposal in order to comply with the CEA standards. Associate Agreement between the BHK environmental consultants from Netherlands and the RRISL has been signed for the execution of the treatment plants proposed for three other rubber factories.

Preparation of draft Quality Manuals and Procedure Manuals of the ISO 9000 Quality Assurance scheme has now been completed for six crepe rubber processing companies. A few of them have already begun reorganization of the factory and of the processes of manufacture to suit the ISO guidelines, aiming at ISO 9000 accreditation subsequently.

The Raw Rubber and Chemical Analysis Department continued to provide technical services to the rubber industry by analyzing, grading and issuing shipping certificates for all TSR produced in the country, analyzing and certification of concentrated latex manufactured in the country for local industries and for exports, analyzing chemicals and water used in the NR industry, testing for SPP content in finished products such as rubber gloves and for rubber content in vulcanized products for exports, analyzing and certification of masterbatch and reclaimed rubber for exports. They have also been engaged in organizing demonstrations on preparation of rain guard sealent.

TPNR Coagulating pans worth over Rs.450 000 have been distributed throughout the island to be used in RSS manufacture. This has solved a major problem faced by the RSS manufacturers due to non availability and the high cost of the aluminum pans used for latex coagulation, traditionally.

ACKNOWLEDGEMENTS

The financial support for research, by way of contract research programmes, provided by the Council of Agricultural Research Policy (CARP) and also other supporting facilities such as housing for staff, equipment, accessories and spares for equipment, vehicles, office equipment and also support for improvement of the technical capacity of researchers through manpower development provided by the Agricultural Research Project (ARP) are acknowledged with appreciation. If not for the support from CARP, it would not have been possible to carry out most of the research programmes due to the poor financial situation of the Institute during this year.

OVERSEAS VISITS

Dr L M K Tillekeratne, Director attended the Research Management Enhancement course held in Philippines and Malaysia during the period 01.08.1994 to 26.08.1994. He also participated in the IRRDB Director's Meeting and the symposium on *Hevea* diseases held in Cochin, India during the period 21.11.1994 to 25.11.1994.

OVERSEAS VISITORS

Mr Hoeff Todd, International Research Ltd., Newzealand
Mr Olester Sarchiear, International Research Ltd., Newzealand
Mr Joan Seget, Stateville, NC, USA
Mr Rotay Cultand, Stateville, NC, USA
Mr Victor Teandel, KTH, Sweden
Mr Adrian Henshall Neiob, Berkshire, England
Mr Ivan Serejski, World Bank, Washington, D.C.,USA
Mr Russ Freed, Michigan State University, USA
Mr Roy Kekwick, University of Birmingham, UK
Mr V Miristeehkin, Ministry of Industry, Ukraine
Mr E Sinozniakao, Giant Tyre Research Sc. Institute, Ukraine
Mr Adrian Barziku, Dept. of Trade & Industry, UK
Mr Maurico Chin, International Rubber Study Group, Wembley, UK
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GENETICS AND PLANT BREEDING

N E M Jayasekera

SUMMARY

Due to very unusual wet weather during the year under review, test-tapping was very badly affected. Therefore in this review only the field experiments from which sufficient test-tappings data are available for a statistical analysis are reported. A research project on *Hevea* molecular biology was initiated. This is funded by the Council of Agricultural Research Policy and is carried out at the Bio-chemistry and Molecular Biology Department of Colombo Medical Faculty.

Budwood of some clones, newly registered under RRISL 200 series, was distributed among few estates for establishment of multiplication nurseries.

A germplasm selection continued to give exceptionally high yields.

Observation plots of some RRISL 200 series clones were established.

A trial was initiated, in collaboration with Soils and Plant Nutrition Department, to study the interaction between nutrients and clones.

General

Issue of budwood - RRISL 200 series.

Budwood of some clones in the newly registered RRISL 200 series was distributed among company managed estates. This was done through the Plant Science Department which handles the distribution of authentic material for the establishment of multiplication nurseries.

Elston, Dalkeith and Talduwa Estates received 5 meters each of RRISL 201, RRISL 202 and RRISL 203 while Pallegama Estate received 4 meters each.

DETAILED REVIEW

Staff

Head of the Department, Dr N E M Jayasekera, Dr D P S T G Attanayake, Assistant Geneticist and Plant Breeder, Mr K B A Karunasekera, Development Officer, Mr K W Rupatunge, Experimental Officer, Mr B M S G Peries and Mr A K M S Senaratna, Senior Experimental Assistants Mr I D M J Sarath Kumara and Mr R A S K Ranatunge, Technical Officers were on duty throughout the year. Mrs S Herath, Asst. Geneticist and Plant Breeder was on duty up to 23rd November 1994 and went on maternity leave from 23rd November 1994.

Dr D P S T G Attanayake was granted permission to work in the laboratories of the Bio-chemistry and Molecular Biology Department of the Colombo Medical Faculty. He will use the laboratory facilities to carry out the research project on Molecular Biology of *Hevea*. This project is funded by the Council for Agricultural Research Policy (CARP).

Meetings and Seminars

Head of the Department and Dr D P S T G Attanayake Assistant Geneticist and Plant Breeder attended Scientific committee meetings.

Dr N E M Jayasekera attended the International Rubber Study Group Technical Sessions.

Head of the Department addressed the mini estate owners in Pimbura area. Title of the talk was "Recommended rubber clones for private estate owners".

Training

NDT students from Hardy Institute underwent a training in the Department.

Head of the Department and Dr D P S T G Attanayake served as lecturers for the Diploma course conducted by the National Institute of Plantation Management.

Publications

Jayasekera, N E M, Karunasekera K B A and Kearsey M J (1994). Genetics of Production traits in rubber (*Hevea brasiliensis*) I. Changes in genetical control with age. *Heredity*, **73**, 650 - 656.

Reports

Jayasekera N E M (1994). Annual Review of the Department for 1993.

LABORATORY INVESTIGATIONS

Isozyme studies for clone identification (GPB/ISO/91/2)

Discontinuous starch gel electrophoresis was tried using the new batch of potato starch received from Sigma Chemicals, and the work was suspended as this lot of starch was found to be not suitable. Arrangements have been made to procure these chemicals (D P S T G Attanayake, S Herath and K B A Karunasekera).

Molecular Biology of *Hevea* (CARP Project 12/192/165)

A gel tank for electrophoresis, and UV transilluminator and a micro-centrifuge were purchased through CARP funds. Arrangements have already been made to purchase a polaroid camera system.

Two DNA probes were obtained from the Wolfson Laboratory for plant molecular biology in Birmingham, UK. These DNA probes were cloned in plasmid PREF1 and PGREF1.

Large scale plasmid DNA preparations were carried-out from PREF1 recombinant plasmid. An aliquot of this DNA was digested with *Bam* HI restriction enzyme and the 681 bp REF gene was then purified by preparative gel electrophoresis.

PCR method was also used to amplify the REF gene as approximately 450 bp fragment. Conditions for the basic steps involved in this project have been worked out. These steps involve extraction of rubber DNA, digestion with restriction enzymes, separation of DNA on agarose gel. Southern transfer of DNA onto nitrocellulose membranes and probe labelling with P^{32} dCTP.

The few DNA blots probed so far showed no clear banding pattern. Initial experiments suggested that the amount of DNA used in blots was not enough to detect

REF gene which might presumably present as a low copy number gene in the *Hevea* genome.

Further 681 bp *Bam* HI fragment from PREF 1 plasmid gave better signals on blots than the PCR amplified product (480 bp). The genomic probe gave a high background effect on blots.

Experiments are now under way to produce genomic blots with increased amount of rubber DNA (10 μg/lane) using 681 bp *Bam* HI fragment as the probe (D P S T G Attanayake, S Herath and Eric Karunanayake of the Colombo Medical Faculty).

FIELD EXPERIMENTS

Hand pollination programme 1994 (GPB/BST/HPS/94/1)

Hand pollination programme was carried out on Clyde Estate and at RRI nursery on Neuchatel Estate. On Clyde estate crosses were done on female flowers in matured trees where as on Neuchatel estate nursery plants of foreign clones received from Thailand under SRRP II were ring barked and bent to initiate flowering in order to get male flowers. In addition germplasm clone (42–559) was used as a mother tree.

Crosses attempted, number of pollinations per each cross are given in Table 1a and Table 1b for Clyde and Neuchatel respectively.

Table 1a. *Details of Hand pollination programme done at Clyde Estate in 1994*

Cross	No. of pollinations
RRIC 102 x RRII 105	1210
RRIC 102 x PB 235	372
RRIC 102 x PB 260	702
RRIC 102 x RRIC 110	260
RRIC 121 x RRIC 110	32
RRIC 110 x 42 - 559	89
RRIC 121 x 42–559	19
Total	2682

Table 1b. *Details of hand pollination programme done at Neuchatel Estate in 1994*

Cross	No. of pollinations
42–559 x RRIC 121	13
RRIC 121 x 42 – 559	41
Total	54

Due to high incidence of *Oidium* on flowers it was not possible to obtain any seeds from hand pollinations (K B A Karunasekera, S Herath and N E M Jayasekera).

Evaluation of selections from 1974 hand pollinated (HP) seedlings – Kuruwita Sub–station (GPB/BST/HPS/74/3)

Out of 13 new genotypes tested in the small scale clone trail girth and yield data of 8 selected promising clones and the best control clone, RRIC 121, have been subjected to an analysis of variance. Results of the analysis of variance are presented in Table 2 for the two traits. Yield was recorded as grams per tree per tapping (g/t/t).

Table 2. *Analysis of variance of girth and yield of 1974 H.P. selections*

	Girth			Yield	
Source	DF	MS	P	MS	P
Clones	7	1731.36	***	4975.33	***
Error	144	82.93		527.72	

Probability = P

<0.001 = ***

Results show highly significant differences between clones for both characters. Means of these clones were subjected to a Duncan's Multiple range test to group the clone means.

In the case of girth, 8 clones fell into 4 groups with group A over lapping with B and group D over lapping with C. With respect to yield also clones fell into 4 groups. Group A had only one clone, RRIC 121 and it didn't over lap with the next,

group B while Group C overlapped with B as well as D. Results of the Duncan Multiple Range test (DMRT) are given in Table 3.

Table 3. *Results of DMRT done on 1974 H.P. selections.*

Clone	Girth (cm)	DMRT Grouping
RRIC 121	86.37	A
74–41	83.20	A B
74–135	78.42	B
74–12	77.62	B
74–205	68.75	C
74–180	64.86	C D
74–193	64.57	C D
74–139	60.50	D
	LSD for 5% level 5.78	

Clone	Yield (g/t/t)	DMRT Grouping
RRIC 121	95.68	A
74–41	72.97	B
74–135	64.16	B C
74–12	63.23	B C
74–205	56.77	C D
74–193	55.46	C D
74–180	50.02	C D
74–139	43.55	D
	LSD for 5% level 14.62	

Percentage of trees affected with brown bast is given in Table 4 along with the total number of experimental trees (N E M Jayasekera and B M S G Peries).

Table 4. *Brown bast incidence among 1974 H.P. selections*

Clone	Total No. of trees	Brown bast incidence (%)
74–12	20	10.0
74–135	19	31.5
74–139	18	16.6
74–180	20	10.0
74–193	20	15.0
74–205	20	15.0
74–41	17	23.5
RRIC 121	20	5.0

Evaluation of 1976 H.P. Selections – Tempo Division of Hill Stream Estate.

In this trial 29 new selections are tested along with three control clones, RRIC 121, RRIC 100 and RRIC 102. Table 5 gives the results of the analysis of variance of girth and yield data of 1976 H.P. selections.

Table 5. *Analysis of variance of girth and yield of 1976 H.P. selections.*

	Girth			Yield		
Source	DF	MS	P	DF	MS	P
Clone	31	413.61	***	31	1502.36	***
Block	3	178.89	**	3	317.32	**
Error	333	49.60		333	121.31	
			Probability = P			
			< 0.001 = ***			
			0.01–0.001 = **			

Duncan's Multiple Range analysis grouped the clones into 11 groups. Group A and B didn't over lap. New selection 76–8 (HP 8) was the solitary clone in group A with the highest mean girth 84.4. Group B had 12 clones. RRIC 121 was in group B and had the highest mean among the clones in this group.

With respect to yield there were 16 groups. 76–52 (HP 52) was the only clone in group A which didn't over lap with the next group (B). RRIC 121 occupied the group B. Table 6 shows the grouping, according to DMRT, of some promising clones and RRIC 121 (N E M Jayasekera and K W Rupatunga).

Table 6. *Grouping of some promising 1976 H.P. selections and RRIC 121 according to DMRT.*

Clone	Girth (cm)	DMRT Grouping
76 – 8	84.40	A
RRIC 121	77.76	B
76 – 82	77.31	B
76 – 52	74.80	B C
76 – 164	73.19	B C D
	LSD for 5% level 5.99	

Clone	Yield (g/t/t)	DMRT grouping
76 – 52	65.22	A
RRIC 121	52.78	B
76 – 82	49.09	B C
76 – 8	47.51	B C D
76 – 182	43.19	B C D E
	LSD for 5% level 9.408	

Evaluation of 1980 H.P. Seedlings – Eladuwa Estate (GPB/BST/HPS/80/2)

Mean girth and mean yield of seedlings from which some of RRIC 200 series clones originated are given in Table 7 with the clone number in parenthesis.

Table 7. *Mean yield and girth of mothers trees of some RRISL 200 series clones* (N E M Jayasekera, K B A Karunasekera and I D M J Sarath Kumara)

	Girth (cm)		Yield (g/t/t)		
Seedling/Clone	1993	1994	1992	1993	1994
80–2 (RRISL 212)	79.0	80.0	56.7	60.9	65.6
80–9 (RRISL 213)	80.5	83.0	51.1	52.2	65.2
80–287 (RRISL 214)	72.0	72.5	58.8	41.1	62.7
80–312 (RRISL 215)	95.0	98.0	67.2	40.4	65.6
80–343 (RRISL 216)	81.0	83.0	49.6	51.5	89.8

Evaluation of 1981 H.P. seedling progeny. Eladuwa Estate (GPB/BST/HPS/81/2).

This progeny too has mother plants of some RRISL 200 series clones. Mean girth and yield of these mother plants are given in Table 8 with the RRISL 200 series clone number in parenthesis (N E M Jayasekera and W D Armon).

Table 8. *Mean girth and yield of mother trees of some RRISL 200 series clones.*

	Girth (cm)		Yield (g/t/t)		
H.P. No./Clone	1993	1994	1992	1993	1994
81– 8 (RRISL 217)	79.5	79.5	85.8	75.1	69.1
81– 30 (RRISL 218)	90.0	92.5	74.0	60.9	76.6
81– 50 (RRISL 219)	75.0	76.0	77.1	64.4	90.7
81–111 (RRISL 220)	82.0	85.0	89.6	49.5	68.7
81–178 (RRISL 221)	83.0	85.0	71.3	64.1	81.0
81–192 (RRISL 222)	76.0	76.5	93.8	59.1	89.1
81–207 (RRISL 224)	75.0	75.0	86.3	48.4	68.0

Evaluate of 1982 H.P. Selections - Clyde Estate. (GPB/BST/HPS/82/2)

Sixty six clones are tested in this trial including control clones. Analysis o variance of girth data showed highly significant differences between clones. (Table 9

Table 9. *Analysis of variance of girth data of 1982 H.P. selections*

Source	DF	MS	P
Clones	65	818.37	***
Blocks	3	48.03	N.S.
Error	1162	38.93	
	Probability	= P	
	<0.001	= ***	
	Not significant	= N.S.	

New selection 82-110 had the highest mean girth of 62.86 followed by 82.51. Duncan's Multiple Range Test have produced 10 groups. DMRT grouping of promising vigorous selections along with two control clones are given in Table 10.

Table 10. *DMRT Grouping of some 1982 H.P. selections*

Clone	Girth (cm)	DMRT Grouping
82-110	62.86	A
82-51	61.62	A B
RRIC 102	61.13	A B C
82-132	60.31	A B C D
82-163	60.31	A B C D
82-140	60.21	A B C D
82-15	59.40	A B C D E
RRIC 110	59.13	A B C D E
LSD for 5% level 4.01		

This trial will be tapped in 1995 (N E M Jayasekera and I D M J Sarath

Evaluation of 1985 H.P. selections - Tempo Division of Hill Stream Estate (GPB/BST/HPS/85/2)

In this trial 50 new clones developed from promising seedlings of 1985 H.P. seedlings are evaluated in a randomized block design with 4 replicates. RRIC 100, RRIC 102, RRIC 110, RRIC 121 and BPM 24 have been included as control clones. Annual girth measurements were subjected to an analysis of variance and results are presented in Table 11.

Table 11. *Results of the Analysis of variance of girth data collected from 1985 H.P. selections*

Source	DF	MS	P
Clone	54	649.43	***
Blocks	3	366.43	***
Error	932	33.19	

Probability = P

<0.001 = **

DMRT was carried out and the grouping of 10 clones with highest mean values are given in Table 12 (N E M Jayasekera and K W Rupatunga).

Table 12. *DMRT grouping of 10 clones with highest means in 1985 H.P. selections*

Clone	Girth (cm)	DMRT Grouping
85-82	54.00	A
85-60	53.45	A B
85-25	53.17	A B
85-59	52.47	A B C
85-26	52.13	A B C D
85-14	51.52	A B C D E
RRIC 110	51.44	A B C D E
85-33	51.02	A B C D E F
RRIC 102	50.78	A B C D E F G
85-5	50.52	A B C D E F G H

LSD for 5% level 3.76

Evaluation of clones exchanged under Multilateral Exchange programme in 1974 – Hewagam Estate (GPB/BST/ICT/79/2).

Mean girth and yield of the clones tested in this trial are given in Table 13. RRIC 121 has recorded highest mean girth of 73.4 cm. followed by RRIM 722. With respect to yield again RRIC 121 is the highest yielder while 117 occupies the second position. Ranking of clones on the yield are given in the last column of Table 12 (N E M Jayasekera and R S K Ranatunge).

Table 13. *Mean girth and yield of clones tested in 1974 Multilateral clone exchange trial*

Clone	Girth (cm)	Yield (g/t/t)	Rank
RRIC 121	73.4	45.8	1
RRIM 722	68.8	14.7	11
RRIC 110	67.5	32.8	5
RRIC 100	65.0	33.6	4
BPM 22	64.4	28.3	8
PR 306	64.1	30.4	7
RRIM 703	61.9	21.0	10
RRIM 717	61.4	26.0	9
BPM 24	57.6	31.8	6
RRIC 117	57.6	34.8	2
RRIM 712	56.1	33.9	3

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

First girth measurement of this trial was recorded in 1994 when the plants were 3 years old. In large scale trials at Eladuwa and Salawa where 300 plants per plot per clone have been planted randomly selected 50 plants were measured. In small scale trials where three 25 tree plots per clone have been planted in each site all the plants were measured. Out of small scale trials at Atale, Bentota and Kuruwita sites

were measured during S.W. Girth measurements of Yatawatta, Matale site was recorded in 1994 N.E. as this site was planted in 1991 N.E. Two out of 3 replicates at Bibile site were destroyed by a natural fire and the girth measurements of this replicate will be taken towards end of December 1994.

Mean girth of Eladuwa and Salawa is given in Table 14 (N E M Jayasekera, K W Rupatunge and B M S G Peries).

Table 14. *Mean girth of clones in large scale trials at Salawa and Eladuwa*

	Girth (cm)	
Clone	Salawa	Eladuwa
PB 217	17.03	21.1
RRIM 712	14.36	22.0
PB 235	19.50	25.7
RRIC 100	18.88	24.1
PR 255	15.07	17.8
PR 261	15.21	14.7
RRIC 121	19.13	25.0
RRIC 110	20.47	25.3
PB 260	18.58	23.5
BPM 24	17.51	22.8

Mean girth of clones in small scale trials at Bentota, Atale, Kuruwita and Yatawatta is given in Table 15 (N E M Jayasekera, K W Rupatunge, B M S G Peries and K B Karunasekera).

Table 15. *Mean girth of clones in small scale trial*

Clone	Girth (cm)			
	Bentota	Atale	Kuruwita	Yatawatta
RRIC 121	24.3	30.0	20.6	21.8
RRIM 712	17.7	27.7	14.8	18.6
PB 235	27.3	30.5	22.0	19.7
PB 260	25.0	29.2	20.4	20.0
PR 255	16.5	25.0	14.0	17.8
PR 261	16.5	25.4	11.0	11.2
BPM 24	20.0	27.2	15.0	17.8

Evaluation of IRRDB germplasm collection (GPB/GP/85/2)

Two batches each with 300 seedlings that reached tappable girth were test tapped. But no promising genotypes were identified during year 1994. The two promising genotypes that were identified in 1993 were test tapped in 1994. Yield of one genotype (GPS 2) dropped during 1994 while the other genotype (GPS 1) continued to give high yield. Mean yield of these 2 genotypes and the number of test-tappings done in 1994 are given in Table 16 (N E M Jayasekera and K B Karunasekera).

Table 16. *Mean yield and number of test tappings*

Clone	Yield (g/t/t)	No. of test tapping
GPS 1	91.7	40
GPS 2	40.2	36

Observation plots of new RRISL 200 series clones

Observation plots of some new RRISL 200 series clones from which sufficient budwood was available were established and details are given in Table 16 (N E M Jayasekera and K B Karunasekera).

Table 17. *Details of observation plots established in 1994*

Clone	Estate/Site	No. of tapping task
RRISL 208	Dartonfield	01
RRISL 211	- do -	03
RRISL 216	- do -	01
RRISL 219	- do -	01
RRISL 220	- do -	02
GPS 1	- do -	01
RRISL 201	Kuruwita S.S.	02
RRISL 202	- do -	02

Nutrient x Clone interaction studies

Three levels of each of N,P,K and Mg were used in a factorial design to study the interaction between nutrients and clones. 0.8, 1½ and 2 times the present recommended levels of the 4 nutrients were used to get 81 nutrient combinations. RRIC 121, RRIC 110, PB 260 and BPM 24 have been used as clones. Two replicates were planted during N.E. of 1994 at Paiyagala Estate and Tempo Division of Hill Stream Estate (N E M Jayasekera, S Dharmakeerthi, K B Karunasekera, K W Rupatunga and I D M J Sarath Kumara).

PLANT SCIENCE DEPARTMENT

A Nugawela

SUMMARY

Low frequency tapping system, *ie* half spiral, third daily (½S d/3) with stimulation gives annual yields comparable to ½S d/2. This system may be adopted to reduce tapping cost and tapper requirement whilst increasing the tapping cycle. High intensity tapping, *ie* ½S d/1 and ½S d/2 + Stimulation, gives poor g/t/t yields with modern clones. Trees opened at higher girths give high yields and are more vigorous in girthing. Actual tapping time is about a third of the total time taken for a tapping task and is similar with both Jebong and Push knives. Yields from upward tapping of higher virgin bark and from downward tapping of panel BI–1 are similar. Clonal and stimulation effect, significantly influences the incidence of tapping panel dryness. Establishment rate and growth rate are similar in two whorled young buddings and two whorled brown buddings in polybags. Increasing planting density beyond 500 trees/ha results in lower g/t/t yield and girthing whilst increasing the incidence of tapping panel dryness. Insect damage to polythene rainguards can be controlled successfully by fortnightly spraying of neem seed extract. Different spatial arrangements tested, *ie* cluster and double row planting to facilitate intercropping do not appear to retard the growth of rubber plants. Intercropping rubber with sugarcane and timber appears to be promising, so far. A total of over 2000 bare root budded stumps were distributed to the Plantation and Smallholder Sectors to establish budwood nurseries.

DETAILED REVIEW

Staff

The Head of Department, Dr A Nugawela, Dr (Mrs) P Seneviratne, Botanist, Mr V H L Rodrigo, Research Officer (Intercropping), Mr R B Gunaratne and Mr L S Kariyawasam, Experimental Officers, Mr R P Karunasena, Mr K A G B Amaratunge and Mrs G A S Wijesekera, Senior Technical Officers, Mr S Wilbert, Senior Experimental Assistant, Mrs C W Ranasinghe, Mr U S Weerakoon, Mrs R K

Samarasekera, Mr M K P Perera, Mr S M A Samarakoon, Mr T U K Silva, and Mr M de Alwis, Technical Officers, Mrs D E Jayawardena, Clerk/Typist were on duty throughout the year.

Mr L S S Pathiratna, Assistant Botanist, reported for duty on the 28th September after successfully completing his Master's Degree at University of Reading, UK. Mrs M S de Silva, Assistant Botanist, continued her post graduate studies at University of New England, Australia.

Miss G M de Zoysa, Technical Officer, resigned from the post with effect from 9th March 1994.

Research Students

Mr E M A P Ekanayaka, an undergraduate student from the University of Ruhuna, completed his final year project on "Variation in *in vitro* axillary shoot proliferation of juvenile *Hevea brasiliensis* (Muell Arg.)" under the supervision of Dr (Mrs) P Seneviratne.

Miss T Shiromala, student of Aquinas University College, Colombo, completed her project on "Rooting of micro propagated plants of *Hevea*" under the supervision of Dr (Mrs) P Seneviratne.

Miss M K T K Amerasinghe, an undergraduate student from the University of Ruhuna, completed her final year project on "The diurnal variation in latex flow pattern in *Hevea brasiliensis* Muell. Arg. plants" under the supervision of Dr A Nugawela.

Mr A L C de Silva, an undergraduate student from the University of Ruhuna, completed his final year project on the "Effect of shade on performance of photosynthesis and other related parameters of Banana (*Musa spp*)" under the supervision of Mr V H L Rodrigo.

Meetings and Conferences

The Head of Department addressed at the following meetings and conferences:

* Scientific Committee Meetings. Dr (Mrs) P Seneviratne and Mr V H L Rodrigo also participated.
* Estate Committee Meetings.
* Field day for field staff of Namunukula Plantations Ltd.
* Field day for field staff of Kotagala Plantation Ltd.
* Superintendents' meeting, Pussella Plantations Ltd.

* Superintendents' meeting, Namunukula Plantations Ltd.
* Visiting lectures for final year Agriculture Students, University of Peradeniya.

Staff Training

Mr L S Kariyawasam, Experimental Officer and Mr M K P Perera, Technical Officer, participated in a 3 day training programme on "Agroforestry for sustainable development" organized by the University of Sri Jayawardenapura.

Mr L S Kariyawasam attended a workshop on "Agroforestry" organized by the Faculty of Agriculture, University of Peradeniya and held at Plant Genetic Resources Centre, Gannoruwa.

Training Programmes

The Department staff were involved in the following programmes:

* Young Budding technique for Private Management Companies and Private Commercial Nursery owners.
* Field days for Field staff of Namunukula and Kotagala Plantations Ltd.
* Lectures and field demonstrations for Private Medium Size Estate Owners.
* Lectures for the Diploma Course in Plantation Management.

Publications

Seneviratne P, Wijesekera, G A S and de Zoysa, G M (1994). Acclimatization of micropropagated plants of *Hevea*. *Jl. Rubb. Res. Inst. Sri Lanka*, **73**: 20–30.

Seneviratne P, Nugawela, A and Samarakoon, S M A (1994). Factors affecting the bud grafting success and the scion growth of young buddings of *Hevea*. *Jl. Rubb. Res. Inst. of Sri Lanka,* **74** : 24–41.

Seneviratne, P and Wijesekera, G A S (1994). The growth phase and its effect on axillary bud culture of *Hevea brasiliensis*. *Jl. of Natiol. Sci. Council of Sri Lanka* (In press).

Seneviratne, P and Flegmann, A W (1984). Incorporation of 14C–Acetate and 14C–Mevalonate into rubber in stem slices of *Hevea*. *Indian J. of Nat. Rubb. Res.* (In Press).

Rodrigo, V H L, Herath, P H M U and Nugawela, A (1993). An economic evaluation of the use of rainguards. *Jl. Rubb. Res. Inst. Sri Lanka*, **73:** 1-19.

Rodrigo, V H L and Stirling, C M (1993). Quantification of the seasonal light and water use of banana based interculture systems. In "Compendium of Current Research in Plant Sciences 1993" Eds. J R Whitcombe and D Wright. ODA. P73.

Pathiratna, L S S (1994). Cinnamon as a prospective intercrop for rubber in Sri Lanka. MSc. Dissertation, University of Reading, England.

Publications of the Department

* Advisory Circular 1994/01 - Young budding**
* Advisory Circular 1994/02 - Root stock nurseries
* Advisory Circular 1994/03 - Budwood nurseries
* Advisory Circular 1994/04 - Polybag plants**
* Advisory Circular 1994/05 - Tapping**
* Advisory Circular 1994/06 - Rainguards**
* Advisory Circular 1994/07 - Intercropping
* Advisory Circular 1994/08 - Ethrel Stimulation

** Published also in Sinhala.

Reports

Nugawela, A (1993). Annual Review of the Plant Science Department.

LABORATORY INVESTIGATIONS

Tissue Culture

Juvenile *Hevea*: Studies on individual variation in juvenile tissues showed a significant difference among the individuals with respect to axillary bud proliferation. Investigations to improve shoot proliferation rate of juvenile tissues are being continued.

Clonal *Hevea*: Rejuvenation experiments with clonal Hevea are being continued. Explants obtained from branches of mature trees, during refoliating period, were established successfully in culture. Nevertheless, the cultures did not survive for longer than 3 months.

A comparative study in aerial and root growth of tissue and embryo cultured plants of same age and growing in the field was made.

Cardamon: Shoot proliferation and rooting was obtained and a few acclimatized plants are growing well in the glass house (P Seneviratne and G A S Wijesekera).

FIELD EXPERIMENTS

Tapping

Low Frequency Tapping

The objective of these trials is to find out whether it is more economical to exploit newly introduced clones with low frequency tapping with stimulation than the presently recommended ½S d/2 system. Low frequency tapping systems can have the advantage of low tapping costs, low tapper requirement and longer tapping cycles.

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

The ½S d/3 + E system has given significantly high dry rubber yields per tree per tapping (g/t/t) when compared with the conventional ½S d/2 and other low frequency systems tested (Table 1). Nevertheless, the estimated total annual yield per tree (kg/t/year) based on theoretical maximum possible tappings per tree per year, is high in the conventional ½S d/2 system. The treatment differences are not significant in either the girth or girth increment (Table 1).

Table 1. *Effect of tapping systems on dry rubber yields and growth of clone RRIC 100*

Tapping system	Yield		Growth	
	g/t/t	kg/t/year	Girth (cm)	Girth increment (cm)
½S d/2	37.8	6.88	76.0	2.4
½S d/3 + E*	48.8	6.00	78.1	2.7
½S d/4 + E*	39.6	3.60	77.6	3.3
¼S d/2 + E*	33.0	6.00	81.7	2.9

E* 2.5% ET, Ba 0.8 (2.5) 4/y
(A Nugawela, S Wilbert and T U K Silva)

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

The dry rubber yield per tree per tapping is highest in tapping system ½S d/4 +E. Tapping system ½S d/3 + E gives higher g/t/t yield than the conventional ½S d/2 system. Nevertheless, the estimated total annual yield, based on the theoretical maximum possible days of tapping per year, is highest in the conventional ½S d/2 system (Table 2).

The treatment differences are not significant in either the girth or girth increment.

Table 2. *Effect of tapping systems on dry rubber yields, growth and total dry trees (TPD) of clone RRIC 121.*

Tapping system	Yield		Growth		TPD
	g/t/t	kg/t/year	Girth (cm)	Girth increment (cm)	No.
½S d/2	42.7	7.77	73.5	3.5	5
½S d/3 + E*	49.5	6.04	70.8	4.5	3
½S d/4 + E*	65.5	5.96	71.1	2.4	5
½S d/3	35.3	4.31	72.1	3.5	4

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

The number of dry trees in different treatments is not significantly different (A Nugawela, S Wilbert and T U K Silva).

RRIC 102, 1981 Replanting - Neuchatle (LFT/88/2)

The annual mean dry rubber yield per tree per tapping (g/t/t) is highest in tapping systems ½S d/3 and ½S d/4 with stimulation. Nevertheless, the estimated total annual yield based on the maximum number of possible tappings per tree per year is highest in the conventional ½S d/2 system (Table 3). The treatment differences in girth are not significant (Table 3).

Table 3. *Effect of tapping systems on dry rubber yields, growth and mean number of dry trees (TPD) per plot of clone RRIC 102.*

Tapping system	Yield		Girth	TPD
	g/t/t	kg/t/year	cm	No.
½S d/2	42.1	7.66	67.0	3.3
½S d/3 + E*	50.2	6.12	69.8	2.1
½S d/4 + E*	49.4	4.50	69.2	5.8
½S d/3	43.5	5.31	69.9	1.5
¼S d/2 + E*	32.0	5.82	70.1	2.5

Incidence of tapping panel dryness is relatively high in trees tapped on ½S d/4 +E (A Nugawela, K A G B Amaratunge).

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

Three tapping systems are being tested on three different genotypes *ie* RRIC 100, RRIC 101 and PB 86.

Though the g/t/t yield in ½S d/4 +E system is significantly high, the estimated total annual yield based on maximum possible days of tapping is high in the conventional ½S d/2 system of tapping (Table 4). All clones tested behaved similarly for the different tapping systems tested.

Table 4. *Effect of different tapping systems on the mean yield and estimated yield per tree per annum (Mean of all 3 clones).*

Tapping system	Yield	
	g/t/t	kg/t/year
½S d/2	27.5	5.0
½S d/3	27.7	3.3
½S d/4 + E*	35.0	3.2

E* 2.5% ET, Ba 0.8(2.5) 4/y
(A Nugawela, T U K Silva and C W Ranasinghe).

High Intensity Tapping of Virgin Panels

Trials on the above were initiated with the objective of finding out whether total yields obtained during the presently recommended 24 year tapping cycle could be realized during a shorter tapping cycle and if so, whether such tapping systems are more economical.

RRIC 100, 102, 121 and 130, 1988 Replanting – Dartonfield (HIT/93/1)

Four clones are being tapped at high intensity with currently recommended and double the currently recommended levels of the conventional fertilizer mixture. Mean yields of test tappings done during the second year of tapping are given in Table 5.

Table 5. *Effect of fertilizer and tapping systems on dry rubber yields of different clones.*

Tapping system	Fertilizer level	Yield (g/t/t)			
		RRIC 100	RRIC 102	RRIC 121	RRIC 130
½S d/1	Level –1	18.8^{AB}	15.1^{BC}	20.2^{AB}	33.7^{AB}
	Level –2	14.7^{B}	12.4^{C}	19.0^{B}	29.7^{B}
½S d/2	Level –1	22.4^{AB}	22.8^{A}	24.4^{AB}	57.2^{AB}
	Level –2	21.5^{AB}	15.3^{BC}	26.9^{AB}	49.0^{AB}
½S d/2 +E*	Level –1	28.4^{A}	21.2^{AB}	29.2^{A}	53.6^{A}
	Level –2	26.9^{A}	17.3^{ABC}	25.5^{AB}	51.5^{A}
½S d/3+E*	Level –1 Level –2	27.8^{A}	22.7^{A}	22.2^{AB}	73.2^{A}

(Within a clone, means with same letter are not significantly different)
E* 2.5%ET, Ba 0.8(2.5) 4/y

Clones behaved differently for the tapping systems tested. Generally, the g/t/t yield was highest in the tapping system ½S d/3 +E. It was lowest in the ½S d/1 system. Doubling of the fertilizer level did not have a significant effect on yields in

any of the tapping treatments. Three dry trees were evident S in ½S d/2 +E (N) and in ½S d/2 (N) systems (A Nugawela and R P Karunasena).

Girth at Opening

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

RRIC 100, 1985 Replanting - Dalkeith (TG/91/1)
RRIC 100, 1985 Replanting - Kiriwanaketiya (TG/91/3)
RRIC 100, 1985 Replanting - Eladuwa (TG/91/4)
RRIC 121, 1984 Replanting - Perth (TG/91/2)

The experimental details are described in the Annual Review 1991.

The mean dry rubber yield per tree per tapping (g/t/t), girth and girth increment for different treatments in both clones are summarized in Table 6.

Table 6. *The mean dry rubber yield per tree per tapping the girth and girth increment of RRIC 100 and RRIC 121 trees opened at different girths.*

Girth Class	Yield (g/t/t)		Girth (Girth increment) cm	
	RRIC 100	RRIC 121	RRIC 100	RRIC 121
T_1 40–44.9	24.9	18.8	48.6 (1.9)	49.9 (2.9)
T_2 45–49.9	27.1	26.6	55.8 (2.4)	55.5 (3.4)
T_3 50–54.4	33.3	33.8	61.8 (2.6)	59.3 (2.6)
T_4 55 and above	40.9	48.9	73.0 (3.6)	66.9 (3.0)

Both clones behaved similarly with regard to yield and girthing.

Trees opened at higher initial girths continue to give significantly high yields. The girth increment during the year appears to be similar in all treatments. Also there is no evidence for treatment differences with regard to tapping panel dryness (A Nugawela, S Wilbert, T U K Silva and C W Ranasinghe).

Height of Opening (TH)

The objective of these trials is to study the possibility of increasing the height of opening and reducing the tapping time with the use of Jebong knife. Increasing the height of opening will give more time for bark renewal.

RRIC 100, 1985 Replanting - Dalkeith (TH/91/1)
RRIC 100, 1985 Replanting - Kiriwanaketiya (TH/91/2)

The trials were initiated in 1991 and the experimental details are given in Annual Review 1992.

Information on yield, bark consumption rate and girth for the year 1994 are summarized in Table 7.

Table 7. *Mean yield (Y,g/t/t), rate of bark consumption (BCR,cm/y) and girth increment (GI,cm/y) on trees opened at 60" using Jebong knife and 48" using Push knife.*

Treatment	TH/91/1			TH/91/2		
	Y	BCR	GI	Y	BCR	GI
T_1 - 60" Jebong knife	46.0	27.7	3.5	27.5	22.5	3.2
T_2 - 60" Jebong and 48" Push knife	48.3	27.4	3.8	28.3	23.6	2.6
T_3 - 48" Push knife	49.3	25.2	3.8	30.1	21.9	2.9

Though the bark consumption rate was higher with the Jebong knife during the initial year of tapping, it is now similar to that of the push knife. The quality of tapping is also similar in both knives.

The actual tapping time to tap 256 trees is 57 and 56 minutes with the Jebong and Push knife respectively (Table 8).

Table 8. *The time taken to tap a 256 tree tapping block with the Jebong and Push knife.*

Factors	Time (minutes)	
	Jebong	Push
Total	170	110
Tapping	57	56
Cleaning cups, removing laces, walking	113	104

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

Exploitation of Renewed Bark

The objective of this trial is to identify suitable bark for tapping once the virgin panels, *ie* BO–1 and BO–2 are tapped.

PB 86, 1971 Replanting – Payagala Estate (ERB/93/1)
PB 86, 1971 Replanting – Perth Estate (ERB/93/2)

The experimental details are reported in Annual Review 1993. The annual mean yield, *ie* g/t/t in the two trials for different tapping treatments are given in Table 9.

Table 9. *Effect of treatments on annual mean rubber yield in trials ERB/93/1 and ERB/93/2.*

Treatment	Dry Rubber Yields (g/t/t)		
	ERB/93/1	ERB/93/2	Mean
T_1 – Panel BI–1	38.7^{A}	35.1^{AB}	36.9
T_2 – 6" above BI–1	30.8^{B}	30.7^{B}	30.8
T_3 – Upper Virgin Bark (↑)	27.8^{BC}	42.0^{A}	34.9
T_4 – Upper Virgin Bark (↓)	29.9^{B}	33.3^{AB}	31.6
T_5 – Upper Virgin Bark (Puncture Tapping)	24.3^{C}	31.5^{B}	27.9

(Means with same letter are not significantly different)

Treatment differences are different in the two trials. Nevertheless, it is apparent from both trials that upward tapping of virgin bark and down-ward tapping of panel BI-1 give similar yields. Puncture tapping of higher virgin bark gives the lowest yield (A Nugawela and R P Karunasena).

Tapping Panel Dryness

The objective of this study is to identify factors that may be associated with the incidence of tapping panel dryness.

RRIC 100, 1986 Replanting - Eladuwa Estate (TPD/93/1)
RRIC 110, 1986 Replanting - Eladuwa Estate (TPD/93/2)

The effect of clone and other agronomic practices, *ie* yield stimulation, rainguarding and manuring; on development of Tapping Panel Dryness (TPD) is investigated.

From each replanting, about 30 trees were selected and 15 trees were given the currently recommended and the other 15 trees were given double the currently recommended levels of the conventional fertilizer mixture. Trees were tapped at ½S d/2 system and following treatments were introduced randomly on individual trees. A test tapping is done once a month to record the latex volume (ml), dry rubber content (DRC) and yield (g/t/t) of individual trees.

T_1 Gutter type rainguards
T_2 Gutter type rainguards and stimulation*
T_3 Stimulation*
T_4 Control

(Stimulation* - 2.5% ET, Ba 0.8(2.5),4/Y)

The percentage incidence of TPD, in different clones and agronomic practices tested are summarized below (Table 10).

Table 10. *Effect of different agronomic practices on the percentage incidence of TPD in different clones.*

Practice	Treatment	TPD (%)
Rainguarding	With	10.0
	Without	13.3
Stimulation	With	16.7
	Without	6.7
Fertilizer	Normal	10.0
	Double	13.3
Clone	RRIC 100	16.7
	RRIC 110	6.7

The effect of clone and stimulation appear to be significant with regard to the incidence of TPD (Table 10).

During the year 1994, two (02) trees have fallen dry (TPD) and another has recovered after partial dryness. Their monthly variation in latex volume and dry rubber yield are given in Table 11.

Table 11. *Monthly variation in dry rubber yields and latex volume in trees fallen dry during the year.*

Tree	Parameter	Month								
		F	M	A	M	J	J	A	S	O
1	Latex Vol.(ml)	84	85	90	62	103	–	75	30	dry
	Yield (g/t/t)	28	22	26	23	46	–	33	10	dry
2	Latex Vol.(ml)	35	22	55	10	110	–	131	119	108
	Yield (g/t/t)	12	6	16	4	49	–	57	40	28
3	Latex Vol.(ml)	30	15	32	10	52	–	dry	–	–
	Yield (g/t/t)	10	3	10	4	21	–	dry	–	–

Trees appear to go dry during the latter part of the year, *ie* during peak yielding months. When falling dry, the yield may decline gradually (Tree No.1) or may increase relatively before drying (Tree No.3) (A Nugawela and C W Ranasighe).

Planting Techniques

The objective of these experiments is to compare the performance, *ie* establishment rate and early growth of different types of planting material, in different agroclimatic conditions where rubber is grown in Sri Lanka.

Padukka (PT/91/1)

This trial was established during SW 1991. The establishment rates and girth after 3 years of planting are given in Table 12.

Table 12. *The different types of planting material tested and their mean establishment success (%) and girth (cm) after 3 years of growth.*

Planting material	Establishment Success (%)	Girth (cm)
Two whorled young buddings	100	25.0^{A}
Two whorled brown buddings	100	25.1^{A}
Bare root brown buddings	88	23.7^{B}
Green buddings in polybags	96	23.0^{B}

(Means with same letters are not significantly different)

The growth rates of young buddings and two whorled brown buddings continue to be superior to other material being tested (A Nugawela and S M A Samarakoon).

Mohamadi (PT/92/1)

The trial was established during SW 1992. Five types of planting material mentioned in Table 13 are being tested and the establishment rates and girth after two years of growth are given in Table 13.

Table 13. *The different types of planting material tested and their establishment success (%) and girth (cm) after 2 years of growth.*

Planting material	Establishment Success (%)	Girth (cm)
T_1 Bare root green budding	93	11.6
T_2 Bare root brown budding	99	10.9
T_3 Green budding polybags	94	11.8
T_4 Young budding	100	12.2
T_5 Brown budding polybags	98	13.4

Girthing of young buddings and brown buddings in polybags is comparable but superior to other materials tested (A Nugawela and S M A Samarakoon).

Pallegama (PT/93/1)

The trial was established during SW 1993. The experimental details are discussed in Annual Review 1992. The establishment success (%) of the different types of planting material and the mean diameter after a year's growth are given in Table 14.

The establishment success and early growth is superior in polybag planting material. Among the polybag planting material, young buddings are superior to other polybag planting materials tested (A Nugawela and K A G B Amaratunge).

Table 14. *The different types of planting material tested and their establishment success and early growth.*

Planting material	Establishment Success (%)	Diameter (cm)
T_1 Bare root green budding	91.0	2.9^{B}
T_2 Bare root brown budding	82.3	2.8^{B}
T_3 Green budding polybags	99.2	3.0^{AB}
T_4 Young budding	100.0	3.2^{A}
T_5 Brown budding polybags	98.8	2.9^{AB}

(Mean with same letters are not significantly different)

Dartonfield (PT/92/2)

Though deep planted young buddings were superior to shallow planted young buddings, the difference in girth diminished with time. Mean girth after 2 years of planting is 17.77 cm, 17.04 cm and 14.06 cm for shallow planted young buddings, deep planted young buddings and bare root green buddings respectively.

The root systems of 2 year old deep planted young buddings were examined to check whether any roots were formed above the graft union. Only 1 plant out of about 60 examined had such roots (P Seneviratne, A Nugawela and S M A Samarakoon).

Young Budding

Long snag with leaves proved to be superior to long snag without leaves or short snag as indicated by the diameter and the height of the scion at field planting. Data on growth are being collected to see for how long this effect will last in the field (P Seneviratne, A Nugawela and S M A Samarakoon).

Root Stock Nurseries

Two different spacing systems (conventional double row spacing and a single row system) were tested and data on growth of seedlings are being collected.

An experiment to see the correlation between the seed germination time and the growth of the stock plant was initiated. The objective of this is to check the effectiveness of the current recommendation of seed selection at the germination bed stage (P Seneviratne, A Nugawela, K A G B Amaratunge and D Ramawickrama).

Crown Budding (Three - Part trees)

The main objective of this study is to find out the possibility of introducing disease resistant canopies, particularly resistant to South American Leaf Blight (SALB), to the presently recommended clones. Two year old RRIC 130 plants were crown budded with *Hevea spruciana*. The success rate was only 40% and this was partially due to the poor quality of budwood. Budwood nurseries were established with *Hevea spruciana* and *Hevea nitida* and the budwood will be available from the year 1995 for grafting (P Seneviratne, A Nugawela, R B Gunaratne and M Alwis).

Planting Density

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

Millawa, 1977 Replanting - CD/77/1

The experimental details were described in the Annual Review of 1992. The yield (g/t/t) and data on girth and incidence of tapping panel dryness (TPD) for different treatments are given in Tables 15 and 16.

The two clones, RRIC 101 and PB 86 differ with respect to the variation in yield (g/t/t) with the planting density and spacing (Table 15).

Table 15. *The yield of clones RRIC 101 and PB 86 planted at different densities.*

Spacing (m)	Density (trees/ha)	Yield (g/t/t)	
		RRIC 101	PB 86
1. 2.5 x 10	400	12.3^{B}	14.3^{A}
2. 2.5 x 7.5	533	14.9^{A}	14.0^{A}
3. 2.5 x 6	666	12.0^{B}	11.1^{A}
4. 2.5 x 5	800	12.4^{B}	9.6^{C}
5. 3.87 (Triangular)	771	9.0^{C}	13.8^{AB}
6. 3.54 (Triangular)	920	10.3^{BC}	7.9^{C}

(Means with same letter are not significantly different)

In the clone PB 86, the g/t/t declines with the increase in number of plants per hectare. At high densities the triangular spacing appears to be advantageous. Though the trend is similar in clone RRIC 101 it is less marked than in Clone PB 86.

The pattern of variation in girth and incidence of tapping panel dryness with planting density is similar in both clones (Table 16).

Table 16. *The mean girth and mean number of dry trees per plot of clones RRIC 101 and PB 86 planted at different densities.*

Spacing (m)	Density (trees/ha)	Girth (cm)	TPD (No. trees/plot)
2.5 x 10	400	68.2^{A}	2.0^{B}
2.5 x 7.5	533	67.8^{A}	2.8^{B}
2.5 x 6	666	59.9^{B}	2.2^{B}
2.5 x 5	800	58.3^{BC}	3.8^{B}
3.87 (Triangular)	771	61.4^{B}	6.0^{A}
3.54 (Triangular)	920	55.4^{C}	4.8^{AB}

(Means with same letter are not significantly different)

As with regard to yield, the girth drops with increase in number of trees per hectare. At similar densities triangular spacing appears to be advantageous (Table 16).

It is also apparent that the incidence of tapping panel dryness is high at high planting densities (Table 16) (A Nugawela, V H L Rodrigo, L S S Pathiratna and K A G B Amaratunge).

Kuruwita 1992 Replanting - PD/92/1

Experimental details were reported in Annual Review 1992.

Plant girth and girth increment during the year indicate that planting density have so far not affected the growth of plants (Table 17).

Table 17. *Girth and girth increment of rubber at different planting densities (mean of all clones tested).*

Density (plants/ha)	Girth (cm)	Girth increment (cm)
500	15.5	7.0
600	15.4	7.1
700	15.6	7.3
800	15.7	7.2

Girth of clone RRIC 121 is better than in other clones at all densities (Table 18).

Table 18. *The girth and girth increment of different clones (The mean of all densities)*

Clone	Girth (cm)	Girth Increment (cm)
RRIC 121	16.4^{A}	7.7^{A}
RRIC 100	15.2^{B}	6.8^{B}
RRIC 110	14.9^{B}	7.0^{B}

(Means with same letter are not significantly different).
(V H L Rodrigo, A Nugawela and L S Kariyawasam in collaboration with the Genetics and Plant Breeding Department)

Rainguards

Apron type rainguards were fixed in 7 smallholdings in the Kalutara region. The number of extra tapping days recorded in each holding is given in Table 19.

The number of extra tapping days is recorded for a single tapping block. In some holdings there are less or no extra tapping days recorded and this is due to the lack of interest by the land owner or the tapper. Incidence of insect attack to the polythene was controlled by spraying Kohomba (Neem) seed extract, fortnightly (A Nugawela, R P Karunasena). The project is funded by the CARP Research Grant 12/176/150).

Table 19. *Monthly distribution of extra tapping days recorded in holdings fixed with rainguards.*

	Month and No. of extra days tapped					
Holding	May	June	July	August	September	October
1	1	5	5	3	3	4
2	5	3	4	5	6	4
3	6	3	3	3	4	4
4	2	7	5	–	–	–
5	–	–	–	–	–	–
6	1	6	3	–	2	7
7	–	–	–	–	–	–

Nursery Inspection Unit

Inspections

Seventy two (72) private commercial nurseries were inspected and reports were submitted to the Rubber Development Department for the issue of permits.

Further, all nurseries of the Rubber Development Department were inspected and reports were submitted.

Budded Stumps for Multiplication Nurseries

For the above purpose 1 380 bare root budded stumps from 12 clones were distributed to the Plantation Sector as indicated Table 20.

Table 20. *Bare root budded stumps distributed for different regions from the recommended clones for establishing budwood nurseries.*

	Region				
Clone	Avissawella	Ratnapura	Galle	Kalutara	Kegalle
RRIC 100	–	–	–	200	–
RRIC 102	–	50	–	–	–
RRIC 110	–	150	–	–	–
RRIC 117	25	–	–	–	100
RRIC 121	–	75	–	125	–
RRIC 130	–	25	–	–	–
RRIC 133	100	250	–	–	–
PB 28/59	–	–	–	25	–
PB 217	–	–	–	25	100
PB 260	30	–	–	–	200
BPM 24	–	25	–	–	200
RRIM 717	75	–	50	50	–

For the purpose of establishing private commercial budwood nurseries 809 bare root budded stumps were distributed as indicated in Table 21.

Table 21. *Bare root budded stumps distributed for Private Nursery Owners for establishing budwood nurseries.*

Clone	No. plants issued
RRIC 100	684
RRIC 102	115
RRIC 121	10

Intercropping

Spatial Arrangements

Different spacing systems for the rubber crop are tested to identify systems that will provide more light for a longer period to facilitate intercropping.

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

Experimental details were reported in the Annual Review 1992.

The growth of rubber plants, as indicated by the girth at 90cm from the union, is significantly higher in system 4 than that in systems 2,3 and 5 (Table 22).

Differences in light availability to the intercrop are not apparent yet.

Table 22. *The mean girth and girth increment during 1994 in different spacing systems.*

Treatment	Mean girth (cm)	Duncan Grouping	Girth increment (cm)
4	16.84	A	8.41
1	16.59	A B	8.04
5	15.76	B C	8.49
3	15.61	C	7.60
2	15.36	C	7.21

(Means with same letter are not significantly different)
(V H L Rodrigo and L S Kariyawasam)

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

The objective and the experimental details are discussed in the Annual Review 1992.

The growth of the rubber plants are not affected by the spatial arrangement of rubber, *ie* row and contour plantings and by the intercrops (Table 23).

Differences in light availability to the intercrops, due to spatial arrangements of rubber, are not apparent at this stage.

Table 23. *Effect of treatments on the mean girth of rubber plants (cm).*

Intercropping system	Row planting	Contour planting
1. Rubber + Grass	10.61	11.52
2. Rubber + Cinnamon	12.12	11.28
3. Rubber + Coffee	12.36	10.14
4. Rubber only	11.04	11.52

Harvesting of grass was commenced at the beginning of the year (L S S Pathiratna and M K P Perera).

Intercropping Systems

Rubber and Timber

In this study the feasibility of growing timber species with rubber is investigated.

Usk Valley, 1992 Replanting - IC/RT/92/1
Ambatenna, 1992 Replanting - IC/RT/92/2

Details of the experiments were reported in the Annual Review 1992. Mean girth of rubber plants at 90 cm from the union of different systems is given in Table 24.

Growing of timber species in the interrow has so far not affected the growth of rubber plants (V H L Rodrigo and L S Kariyawasam).

Table 24. *The girth of rubber plants measured at 90 cm from the union.*

Intercropping System		Usk Valley IC/RT/92/1	Ambatenna IS/RT/92/2
1. Rubber (8'x27')	No Timber	16.10	17.94
	Halmilla	15.14	18.00
	Havarinuga	15.67	17.16
	Teak	15.06	16.51
	Mahogani	15.71	17.51
2. Rubber planted in double rows	No Timber	16.31	16.9
	Halmilla	17.61	19.31
	Havarinuga	15.94	18.41
	Teak	16.95	18.12
	Mahogani	16.77	19.31
3. High density rubber (8'x17')		14.86	18.72
4. High density rubber (8'x15')		15.29	18.88

Rubber and Sugarcane

Details of the experiment are given in Annual Review 1992.

Harvesting of sugarcane in the experimental sites planted during NE 1992 was completed. Growth measurements of the rubber plants, *ie* height and girth at 3 and 5 feet, were also made at this stage.

The sugarcane crop, given as kg per meter for different varieties and planting densities is given in Table 25.

Table 25. *Sugarcane yield for different varieties under different planting densities.*

Variety	Crop (kg/meter)	
	4 Row System	5 Row System
SL 7103	8.9	11.3
CO 775	6.4	6.8
SL 38/2915	12.3	7.3
SL 8306	8.4	7.7

With regard to sugarcane, yield differences between varieties and planting densities are not apparent.

Growth measurements of rubber plants, given below in Table 26, indicate no retardation in growth due to intercropping with sugarcane at both densities. The height of rubber plants in sugarcane intercropped areas appears to be more, probably due to competition for light.

Table 26. *Growth of rubber plants, ie height – H(m), girth at 3 feet – 3G(cm) and 5 feet – 5G(cm) under two densities of sugarcane, ie S_1 (4 rows), S_2 (5 rows) and C(with no intercrop).*

Density	S_1			S_2			C		
Growth parameter	H	3G	5G	H	3G	5G	H	3G	5G
Site No.1	3.6	8.3	7.3	3.6	9.6	8.8	3.9	10.6	9.5
2	3.5	8.5	7.6	2.7	7.6	6.6	1.2	5.1	4.6
3	3.5	9.7	8.4	4.0	9.3	8.4	2.9	9.2	8.0
4	3.0	8.7	7.2	3.7	11.0	9.9	3.5	10.5	9.2
Mean	3.4	8.8	7.6	3.5	9.4	8.4	2.9	8.9	7.0

(A Nugawela, V H L Rodrigo in collaboration with SRI, Udawalawe and Rubber Development Department. This project is being funded by the CARP Research Grant 12/106/95).

Rubber and Grass/Legume

Neuchatle – IC/GL/91/1

The trial was commenced in 1991 and the experimental details are reported in the Annual Review of the same year.

The dry matter production of grasses is declining probably due to shade effect. No difference is observed between grass species with regard to the amount of dry matter produced (Table 27).

There is no evidence for the growth of the rubber plants being affected by the intercrop, *ie* grasses (Table 27).

Table 27. *Effect of treatments on dry matter production of grasses, legumes and growth of rubber.*

Treatments	Mean dry matter yield (kg/ha)	Mean girth of rubber (cm)
1. Rubber only	–	31.8
2. Rubber + PM	4924	27.3
3. Rubber + BB	4465	27.3
4. Rubber + Gliricidia	–	29.6
5. Rubber + Ipil Ipil	–	30.8
6. Rubber + PM + Gliricidia	4653	31.6
7. Rubber + PM + Ipil Ipil	5013	28.7
8. Rubber + BB + Gliricidia	4141	30.9
9. Rubber + BB + Ipil Ipil	4673	26.2

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

Rubber and Cocoa/Cinnamon

Dartonfield - IC/CC/91/2

In this trial the possibility of intercropping rubber grown in wet regions, with Cinnamon and Cocoa, is investigated. Cocoa and Cinnamon were planted during SW 1992 and experimental details are described in the Annual Review of same year.

The growth of the rubber plants is not affected significantly by the intercrop at this stage (Table 28). Cinnamon has grown satisfactorily and will be ready for harvesting in a few months.

Table 28. *Effect of treatments on girth of rubber plants.*

Treatments	Girth (cm)
1. Rubber only	19.1
2. Rubber + Cinnamon (spacing 1)	18.4
3. Rubber + Cinnamon (spacing 2)	16.4
4. Rubber + Cinnamon (spacing 3)	20.5
5. Rubber + Cocoa (spacing 1)	16.6
6. Rubber + Cocoa (spacing 2)	13.9
7. Rubber + Cocoa (spacing 3)	19.8

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

Rubber x Banana

Details of the experiment appear in Annual Review 1993. Growth of both crops is good. Detailed studies on growth and gas exchange parameters were carried out in both crops. Also light interception in different treatments was monitored continuously.

In general, the growth of rubber plants in all treatments is comparable. However, plant height and stem weight tend to be relatively higher in treatments with the intercrop than in sole crop treatments.

Growth of banana plants, particularly leaf area, stem weight and plant height, was found to be higher in sole crop and treble row intercrop than in other treatments.

Of rubber, canopy CO_2 assimilation rate of sole crop was higher than that of other systems. However, no difference in CO_2 assimilation rate of banana was found among treatments. Irrespective of the treatment, mean CO_2 assimilation rate of a rubber whorl decreases towards the bottom of the canopy. Similarly, CO_2 assimilation rate of banana decreases from second leaf onwards with the increase in leaf number down the canopy.

Fractional light interception was highest in sole crop banana and treble row intercrop and followed by double row system, single row system and sole crop rubber in that order.

This project is jointly funded by the Council for Agricultural Research Policy and Overseas Development Administration (V H L Rodrigo, R K Samarasekera and L S Kariyawasam).

PLANT PATHOLOGY AND MICROBIOLOGY

C K Jayasinghe

SUMMARY

Wintering and refoliation were uneven and protracted over several months due to the wet weather that prevailed at the beginning of the year. This wet weather condition favoured the spread of *Oidium heveae* on susceptible clones causing secondary leaf fall. However, the incidence of abnormal leaf fall caused by *Phytophthora* spp. and bark rot caused by the same fungus was very light during the S.W. monsoon period. White root disease was found to be spreading at an alarming rate in new clearings due to negligence,in RRISL recommendations during uprooting old clearings and planting new clearings.

Observations made for the 3rd year reaffirmed that 2% PCP in bitumen is effective in management of white root disease provided that fungicide is applied at early stages of infection. Further, it was shown that phenol, a less hazardous chemical, could be used at 10% concentration as an alternative to PCP.

Four fungicides namely tebuconazole, oxadixyl 10% + mancozeb 56%, tridemorph and triadimenol proved to be effective in the management of foot canker caused by *Nattrassia mangiferae*.

In vitro and *in vivo* screening programmes showed that benomyl, pencycuron, propineb, and tebuconazole could be successfully used in controlling target leaf spots and hypocotyl death of *Hevea* seedling caused by *Thanatephorus cucumeris*.

A total of sixteen fungicides were tested against *Cylindrocladium quinqueseptatum* using three screening techniques. Four fungicides *viz* benomyl, mancozeb, metalaxyl 8% + mancozeb 64% and oxadixyl 10% + mancozeb 56% were identified as potential fungicides.

Observations made during the S.W. monsoon period revealed that RRIC 132 is highly susceptible to corynespora leaf fall caused by *Corynespora cassiicola*.

Free water was found to be essential for spore germination and germination dropped to 2.5% even at high humidities like 96% in conidiospores of *Cylindrocladium quinqueseptatum*, a fungus identified as a potential pathogen of *Hevea* in Sri Lanka. The temperature also greatly influenced the spore viability and germination. Spore germination occurred above 10° and below 35°C and the largest lesions on leaves resulted at 25°C and at room temperature (28 ± 2°C) when inoculated as wet smears.

DETAILED REVIEW

Staff

Mr C K Jayasinghe, Head of Plant Pathology and Microbiology Department and Dr A H R Jayaratne, Plant Pathologist were on duty throughout the year. Mr K E Jayasuriya, Asst. Plant Pathologist returned to Sri Lanka on 29th November 1994 after successfully completing a MPhill degree in Plant Pathology from the University of Edinburgh, UK. Miss W P K Silva, Asst. Plant Pathologist, who was on study leave at the University of Sydney, Australia commenced her field studies in Sri Lanka on 10th October 1994. Mr W Amaratunge, Experimental Officer was appointed as the Audio Visual Aids Production Officer with effect from 19th April 1994.

Experimental Officers Messers D S Wettasinghe and E B Fernando were on duty throughout the year. Senior Technical Officer, Mrs J L P C Wettasinghe, Technical Officers, Misses T H P S Fernando, B I Fernando, and D Siriwardene and Clerk/Typist Mrs P Amarasekera were continued to work in the Department. Miss C Ariyaratne, Technical Officer resigned from the Rubber Research Institute on 1st of March 1994 and Miss U M S Priyanka assumed duties as a Technical Officer with effect from 3rd January 1994.

Mr J A D C S Gunaratne and Miss I G Munasinghe were recruited to the Department as Temporary Technical Assistants on 21.9.94 to work in research projects funded by CARP.

Mr C K Jayasinghe attended the Annual Meeting and the disease symposium of the International Rubber Research and Development Board (IRRDB) held in Cochin, India from 21st to 25th November 1994. Dr R Jayaratne participated in the Training Course on South American Leaf Blight and other diseases of rubber held in Selangor, Malaysia from 25th to 30th September 1994.

Visits

The Departmental staff made 42 visits for advisory purposes, 204 for experimental and 136 for other purposes.

Training/Lectures/Seminars

Mr C K Jayasinghe and Dr R Jayaratne were involved in training Superintendents, Asst. Superintendents, Rubber Development Officers and

Smallholders in all aspects of *Hevea* diseases. Field day programmes were conducted to estate clusters on the management of white root disease.

Committees

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

Mr C K Jayasinghe and Dr R Jayaratne attended the Scientific Committee Meetings of the Rubber Research Board.

Publications

Jayasinghe, C K, and Silva, W P K (1994). Foot canker and sudden wilt of *Hevea brasiliensis* associated with *Nattrassia mangiferae. Plant Pathology*, **43**: 938 - 940.

Jayasinghe, C K and Jayaratne, R (1994). Phytophthora Epidemics - History, Management strategies and possible threat to future rubber industry in Sri Lanka (Review) (Sent for Publication).

Jayasinghe, C K, Jayasuriya, K and Fernando, S (1994). Penta Chloro Phenol - Effective and economical fungicide for the management of white root disease in Sri Lanka. *Proceedings of the IRRDB disease symposium held in Cochin, India*. 1994.

Jayasinghe, C K and Wijesundera, R L C (1994). In vitro evaluation of fungicides against clove isolate of *Cylindrocladium quinqueseptatum* in Sri Lanka. (Sent for publication).

Jayasinghe, C K, Jayasuriya, K E and Fernando, T H P S (1994). Chemical control of white root disease of rubber. *Proceedings 50th SLAAS Annual Sessions*, 1994: 58.

Jayasuriya, K E (1994). Studies on biological control of *Rigidoporus lignosus* the cause of white root disease of rubber tree (*Hevea brasiliensis*) Thesis submitted for the degree of Master of Philosophy, University of Edinburgh, UK.

Jayasuriya, K E and Deacon, J W (1994). Biological control of *Rigidoporus lignosus* mycelial cord growth in soil. (sent for publication).

Jayaratne, A H R and D Siriwardene (1994). Effect of mycorrhizal (VA) and non-mycorrhizal *Pueraria* plants on the spread of white root disease (*Rigidoporus lignosus*). Submitted for publication in RRISL Journal.

GENERAL

The wet weather that prevailed at the beginning of the year delayed the occurrence of wintering. Refoliation was uneven and protracted over several months. Wet weather conditions favoured the spread of *Oidium heveae* on susceptible clones causing secondary leaf fall.

The incidence of abnormal leaf fall caused by *Phytophthora* spp. and of bark rot caused by the same fungus was very light during monsoon period presumably due to the low pod set and low rain fall during the period under review.

White root disease, the most devastating root disease of rubber plantations in Sri Lanka, was found to be spreading at an alarming rate in immature clearings especially in wet districts. It was pointed out that main reason for these new infections is the negligence in not to following the RRISL recommendations during uprooting of old clearings and planting of new clearings despite of the fact that frequent seminars and educational programmes have been conducted. Appeal was made to all Estate Managing Companies, and Director General of the Rubber Development Department to be vigilant of this deadly disease and give the highest priority when they conduct seminars and field days.

Further, an interim circular was sent to all rubber estates through Managing Companies in November 1994 requesting them to follow the RRISL recommendations in the management of white root disease.

Unusual disease symptoms were detected on the clone RRIM 712 in Bentota and Eladuwa estates in the international clone trials established to evaluate the performance of foreign clones. The fungus, *Fusarium* sp. is suspected to be the causative agent of this unusual disease.

Rubber Development Officers of the all regions were addressed on the symptomatology and management strategies of recently discovered nursery diseases namely, target leaf spots, collar rot, foot canker and root knot nematode infections.

The series of seminars initiated in the year 1993 to increase the awareness on South American Leaf Blight among responsible officers was completed.

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

A. *Screening of fungicides against Rigidoporus lignosus*

Field experiments initiated in the year 1992 were continued and observations were made upto 30 months on already established trials. The results reaffirmed that 2% Penta Chloro Phenol in bituminous base is effective in the management of white root disease provided that fungicide is applied at early stages of infection (Table 1). However, the degree of infection at collar appeared critical to treatment success (C K Jayasinghe, K E Jayasuriya and T H P S Fernando).

B. *Screening of four more fungicides against Rigidoporus lignosus.*

(a) Screening of three systemic fungicides *viz* Bayleton, Bayfidan and Calixin under field conditions done at Padukka estate was concluded. For details of the experiment refer Annual Review 1993, page 50. (Tables 2 and 3) (R Jayaratne, C K J Jayasinghe and P C Wettasinghe).

Table 2. *Curative effect of fungicides on one year old trees. (1992 R.P. – Menerigama Div., Padukka Estate)*

Fungicide	Percentage recovery after 40 weeks
Bayleton	33%
Bayfidan	76%
Calixin	7.6%
Control (water)	0%

Table 1. *Effect of different concentrations of PCP on the control of WRD on naturally affected Hevea plants*

Fungicide	Disease severity index (from collar inspection)	Foliage symptoms of the plants in each category	Total number of trees treated	Number of trees reinfected/dead	% of treatment success	Duration of the experiment (months)
PCP	A	0(1);+(4);++(−);+++(−)	5	2	60	20
(0.6% ai)	B		9	5	44	20
(Site a)	C	0(2) ;+(3);++(1);+++(3) 0(−);+(1);++(1);+++(3)	5	3	40	20
PCP	A	0(2);+(−);++(1);+++(4)	7	4	43	22
(0.6% ai)	B	0(−);+(4);++(2);+++(1)	7	4	43	22
(Site b)	C	0(−);+(1);++(−);+++(2)	3	1	67	22
PCP	A	0(4);+(8);++(1);+++(−)	13	0	100	20
(2.0% ai)	B	0(−);+(6);++(2);+++(1)	9	2	78	20
(Site c)	C	0(−);+(−);++(7);+++(2)	9	6	33	20
PCP	A	0(2);+(7);++(2);+++(−)	11	0	100	30
(2.0% ai)	B	0(2);+(1);++(1);+++(1)	5	1	80	30
(Site d)	C	0(−);+(−);++(1);+++(1)	2	1	50	30

Disease severity index:

I. collar inspection: A, collar slightly infected; B, collar moderately infected; C, collar severely infected, Mycelium right round the collar, tap root partially or completely dead

II. foliage symptoms: + slight buckling; ++ Moderate buckling & yellowing; +++ severe buckling and yellowing

* Significant treatment differences exist in recovery rates when treated with PCP 0.6% ai/PCP 2.0% ai(χ^2 = 9.68; P = 0.002)

* Significant treatment differences exist in recovery rates when the plants of disease index A are treated with PCP 2.0% ai compared to plants of disease index B and C at site C (χ^2 = 7.785; P = 0.005) and site d (χ^2 = 3.519; P = 0.064).

Table 3. *Curative effect of fungicides on 2 year old trees (1991 R.P. – Menerigama Div., Padukka Estate)*

Fungicides	Percentage recovery after 56 weeks
Bayleton	55%
Bayfidan	43%
Calixin	0%
Control (water)	0%

B1. *In vitro* studies, it was found that Benlate at 0.08 concentration (ai) gave a 100% inhibition of the *Rigidoporus lignosus*. (Table 4) (R Jayaratne, C K Jayasinghe and P C Wettasinghe).

Table 4. *Percentage inhibition of mycelial growth of Rigidoporus lignosus compared to other systemic fungicides using SFST technique (Mean of 5 replicates)*

Fungicide	Concentration in plates (ai%)			
	0.08	0.16	0.32	0.64
Benlate	100.00	100.00	100.00	100.00
Bayfidan	84.70	94.80	100.00	100.00
Bayleton	48.30	64.40	69.60	83.90
Calixin	34.60	56.80	81.40	100.00
Opus	90.70	92.10	95.40	95.90
Control	0.00	0.00	0.00	0.00

Hence, it is worth trying whether Benlate could be used as a drench application to manage white root disease as Benlate is comparatively cheaper (R Jayaratne, C K J Jayasinghe and P C Wettasinghe).

B2. The monitoring of the experiment initiated at Talduwa estate with 8% – 10% phenol was continued. For details of the experiment refer Annual Review 1993, page 53. (Table 5).

Table 5. *Effect of phenol as a collar protectant.*

Phenol concentration	Pre-treatment assessment. No. of trees with disease scores	Percentage recovery
	*1 2 3 4	
10%	1 2 6 5	70%

* Disease scores.
1. Collar slightly affected no foliar symptoms.
2. Collar half circumference rotted with light foliar symptoms.
3. Collar badly rotted with severe foliar symptoms.
4. Collar completely rotted with fully weltered leaves.

Plants with disease score 4 were not considered for % recovery calculation.

From these results it is evident that phenol at 10% concentration could be used as an alternative to Pentachloro Phenol (PCP) as a Collar protectant in managing the white root disease. However, although the phenol is less toxic than PCP, use of it may be prohibitive because of the cost factor. According to the manufacturer of Collar protectant, phenol formulation at 10% concentration will be about 5 times more expensive than PCP formulations. 8% Phenol gave 100% protective action (R Jayaratne, C K Jayasinghe and P C Wettasinghe).

B3. Calixin collar protectant (tridemorph 11.2%), a ready mix formulation provided by the agents were tested against *Rigidoporus lignosus* using painting of root pieces technique. The fungal growth inhibition was found to be very poor. Fungal hyphae tends to grow over the root pieces inspite of the application of the fungicidal collar protectant (R Jayaratne, C K Jayasinghe and P C Wettasinghe).

B4. A field experiment was laid down to establish the effectiveness of the fungicides, Bayleton and Bayfidan, at five different estates representing different agroclimatic regions of the Island. These estates were, Madeniya estate, Warakapola, Peenkanda estate, Ratnapura, Dartonfield Estate, Agalawatta. Yatadola Estate, Matugama. Artificially inoculated plants in the first 4 sites and a naturally infected plants in a field clearing at Yatadola estate were treated with fungicides Bayleton, and Bayfidan as a drench application. Recovery percentages are not available yet (R Jayaratne, C K Jayasinghe and P C Wettasinghe).

C. *Screening of fungicides against Nattrassia mangiferae.*

Seventeen fungicides were screened against *N. mangiferae*, pathogen responsible for foot canker of *Hevea* seedlings. Three techniques *viz* Poisoned Food Technique, Conidial Germination Test and Soil Fungicide Screening Test were used in the determination of the effectiveness of fungicides. Statistical analysis of the results showed that four fungicides *viz* tebuconozole, oxadixyl 10% + mancozeb 56%, tridemorph and triadimenol are effective in the management of this disease (C K Jayasinghe, T H P S Fernando and U M S Priyanka).

D. *Screening of fungicides against Thanatephorus cucumeris*

In vitro and *in vivo* screening programmes were conducted to find an effective fungicide in the management of target leaf spots and hypocotyl death of *Hevea* caused by *T. cucumeris*.

Four fungicides *viz* benomyl, pencycuron, propineb and tebuconazole were identified as potential fungicides in management of *T. cucumeris*. These are the only fungicides out of the sixteen chemicals tested, that reached ED 100 in both Poisoned Food Technique and Soil Fungicide Screening Technique (C K Jayasinghe, E B Fernando and B I Fernando).

E. *Screening of fungicides against Cylindrocladium quinqueseptatum.*

A total of 16 fungicides were screened against *C. quinqueseptatum* employing three screening techniques; a conidial germination test (CGT), poisoned food technique (PFT) and a soil fungicide screening test (SFST) to evaluate respectively, the efficacy of inhibiting conidial germination, mycelial growth and rendering microsclerotia non viable.

Eleven fungicides *viz* benomyl (ED 100 = 0.0025% ai), daconil (ED 100 = 0.0025% ai) mancozeb (ED 100 = 0.0025% ai), metalaxyl 8% + mancozeb 64% (ED 100 = 0.0025% ai), propineb (ED 100 = 0.0025% ai), thiram (ED 100 = 0.0025% ai), oxadixyl 10% + mancozeb 56% (ED 100 = 0.01% ai), tebuconazole (ED 100 = 0.02% ai), copper oxichloride (ED 100 = 0.08% ai) were found to be effective in CGT whereas only six fungicides were effective in the PFT. They are benomyl (ED 100 = 0.005% ai), copper oxichloride (ED 100 = 0.08% ai), mancozeb (ED 100 = 0.16% ai), metalaxyl 8% + mancozeb 64% (ED 100 = 0.08% ai), oxadixyl 10% + mancozeb 56% (ED 100 = 0.16% ai) and propineb (ED 100 = 0.32% ai). This number was further reduced in SFST and only five fungicides *viz* benomyl (ED 100 = 0.32% ai), chlorothalonil (ED 100 = 0.64% ai), mancozeb (ED 100 = 0.32% ai), metalaxyl 8% + mancozeb 64% (ED 100 = 0.32% ai) and oxadixyl 10% + mancozeb 56% (ED 100 = 0.64% ai) reached ED 100 at tested concentrations.

However, only four *viz* benomyl, mancozeb, metalaxyl 8% + mancozeb 64% and oxadixyl 10% + mancozeb 56% can be identified as potential fungicides in the management of *Cylindrocladium quinqueseptatum* as these are the only fungicides which attained ED 100 in all screening tests.

Further, it was found that incubation period after treatment is critical in CGT as low incubation periods provide misleading observations on efficacy of fungicides. It was also shown that one should be cautious in SFST in selecting the concentrations of test fungicides as all the fungicides tested required a very high concentration to obtain ED 100 using SFST (C K Jayasinghe, R L Wijesundera, T H P S Fernando and U M S Priyanka).

F. *An economic feasibility study on spraying of copper fungicides for control of Phytophthora leaf fall disease.*

Due to the severity of the leaf fall that was experienced over the last two years caused by *Phytophthora*, the above feasibility study was carried out in 3 estates in small blocks.

Spraying of CuOCl at the rate of 3.5 kg ai/25 litres of oil (30–40/ha) were carried out in Eheliyagoda estate, Neuchatel estate and Halwatura estate where the incidence of Phytophthora leaf fall was very severe last year, just before the onset of South West monsoon rains. The carrier spray oil used was diesolene as the properties were very similar and was very much cheaper compared to imported Indian spray oil.

However, it was not possible to do a proper evaluation of the efficacy of the fungicide spraying as the *Phytophthora* incidences in these fields were very mild this year. From this exercise it was estimated that the expenses involved to spray a around of CuOcl is around Rs.2500/= per hectare (R Jayaratne, C K Jayasinghe, S Wettasinghe).

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

A. *Natural occurrence of Geotrichum on Hevea roots.*

Our attention was drawn in July, 1992 to an incident where purchase of *Hevea* budded stumps has been refused from a commercial nursery by the Regional Advisory Officer. The reason given for the rejection of plants was that the seedlings in the nursery are affected with white root disease, a deadly root disease of rubber caused by *Rigidoporus lignosus*. This commercial nursery was situated in Ratnapura, a wet rubber growing district of Sri Lanka and consisted of around 20 000 seedlings. It was

reported that more than 75% of the plants were affected by this disease. Subsequently during the year 1993, the same problem was brought to our notice from a large scale commercial nursery situated in Gampaha District.

The suspected fungus was isolated from surface of affected tap roots and sent to CAB International Mycological Institute, UK for authentification. The fungus was identified upto the generic level as a species of *Geotrichum* Link. (IMI NO 354411).

The infectivity of the fungus was tested on *Hevea brasiliensis* seedlings grown in a seedling nursery. To bulk up the mycelium for use as inoculum, four agar plugs, 12 mm in diameter, were removed from 7-day old culture of the isolate of *Geotrichum* growing on PDA medium and introduced on to 100 g of sterilized woodowels in 500 ml conical flasks. After incubation at 28 ± 2°C for 30 days, the contents of the flasks were introduced on to the roots of 14 months old 15 *Hevea* seedlings. Each seedling was inoculated with the contents of one flask.

The characteristic symptoms of *Geotrichum* infections were observed on examination of the roots of the inoculated plants after 35 days. Reisolates from surfaces of roots constantly yielded *Geotrichum* sp.

This is the first report of the occurrence of *Geotrichum* sp. on *Hevea brasiliensis* roots in Sri Lanka. Further, there appears to be no previous record of this unusual association with *Hevea* root in any other rubber producing country (C K Jayasinghe and P C Wettasinghe).

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

A. *Susceptibility to Corynespora cassiicola.*

Observations made during the S.W. monsoon period revealed that RRIC 132 was highly susceptible to Corynespora Leaf Fall at Padukka, Frocester and Culloden Estates. Further it was observed that the clone RRIC 133 was also moderately susceptible to *C. cassiicola* in Padukka and Frocester. However, mid rib lesions were observed on RRIC 133 instead of characteristic railway track appearance. A mild attack of *C. cassiicola* was noticed on RRIC 102, 121, 130, RRII 105 and RRIM 600 at Frocester, Bentota and Padukka (C K Jayasinghe and D S Wettasinghe).

B. *Screening of Hevea clones against bark rot caused by Phytophthora spp.*

Thirty three clones were screened during the South West monsoon period at five localities *viz* Padukka, Frocester, Rilhena, Bentota and Madeniya against bark rot. This experiment was initiated in 1991 and has been repeated for four years. Experiment is in progress (C K Jayasinghe and D S Wettasinghe).

Genetic Variation in the Fungus *Corynespora cassiicola*

Five isolates of *Corynespora cassiicola* were collected from different parts of Queensland, Australia. Random amplified polymorphic DNA based on polymerase chain reaction (RAPD – PCR) was used in the study. Genomic DNA of mycelial cultures was prepared. Eighty 10 – mer primers from operon technologies (Alameda, california) were screened for amplification of polymorphic segments of genomic DNA. Amplification products were resolved by electrophoresis, and 14 of the primers found to be produced reproducible, clear bands. The patterns of amplified segments of genomal DNA were compared and they were placed in three genetic groups.

The preliminary observations indicated that the random amplified DNA markers could be utilized to fingerprint different isolates of the fungus *Corynespora cassiicola*. Studies are in progress with the collaboration of the University of Sydney, Australia (W P K Silva and B R Lyon).

Biological Control of White Root Disease (BC/89/1)

A. Fungi potentially antagonistic to *R. lignosus* were isolated by following different methods. Most of such fungi isolated from soil were identified as *Gliocladium*, *Trichoderma*, *Penicillium*, *Aspergillus* and *Fusarium* species. *Schizophyllum commune* and species of polypores were also isolated from basidiocarps which had similar effects to *R. lignosus*. Modes of action of those against *R. lignosus* were assessed by production of volatile or non–volatile inhibitory metabolites, ability to overgrow colonies of *R. lignosus* on agar, ability to cause pre–or–post–contact damage to *R. lignosus* hyphae in video taped interactions on thin water agar films and ability to displace *R. lignosus* from established woody substrate. *Trichoderma longibrachiatum, T. koningii, T. viride* (TV 62). *T. harzianum* (TV 12b), *T. hamatum* and *Gliocladium virens* were the most potential antagonist groups against *R. lignosus*. However, antagonistic basidiomycetes (*S. commune* and species of Polypores) instead caused hyphal interference similar to that of *Phlebiopsis gigantea*, a commercial biocontrol agent of *Heterobasidion annosum* of Pine stumps.

In a different approach to development of biocontrol methods, the effect of soil fumigation with furfuraldehyde and addition of *Trichoderma* spores with a food base to soil were tested. A 45% of suppression of *R. lignosus* mycelial cord growth *in vitro* was achieved by soil fumigation. Combination of different soil treatments were not often suppressive than single treatments. However, addition of *T. harzianum* (TV 12b) spores to soil gave almost complete control of *R. lignosus* mycelial cord growth *in vitro*. Treatment of soil with sulphur at recommended dose also markedly suppressed *R. lignosus* mycelial cord growth from burried inocula.

Some antagonistic basidiomycetes completely or partially displaced *R. lignosus* from established woody inocula, which is highly important in successful biocontrol. However, the persistence and modes of action of such fungi in soil against *R. lignosus* should be studied.

In view of these results, it may be possible to achieve a control of *R. lignosus in vitro* conditions by using antagonistic species of *Trichoderma* or other potentially antagonistic fungi. However, in field conditions, this approach may not be successful due to various soil and/or climatic factors. Competition of micro-organisms in soil may be eliminated by soil fumigation or by drenching chemicals which selectively act on competitive organisms in soil. Production of strains resistance for chemicals may be important to achieve combine effects.

To weaken the pathogen population on established food base, a fumigant or a fungicide may be used and the biocontrol agent can be introduced thereafter. These techniques would help to minimize addition of hazardous chemicals into soil. Experiments towards such a control of *R. lignosus* would be conducted in future, in which many identified antagonistic fungal species isolated from local soils will be used in different forms (K E Jayasuriya and J W Deacon).

B. A comparative study on the rate of wood decay between *Rigidoporus lignosus, Lentinus squarrosulus* and *Gloeophyllum straiatum* was carried out using 1 cm^2 freshly cut rubber wood dowels under laboratory conditions (Table 6).

Table 6. *Weight loss(g) in wood dowels under aseptic condition.*

Duration	Lentinus sp	Gloephyllum sp	Rigidoporus sp	LSD P = 0.05
After 2 months	11.05A ±0.309	11.57A ±0.165	4.15B ±0.300	0.923
After 3 months	14.17B ±0.106	15.00A ±0.206	9.36C ±0.333	0.811
After 4 months	17.64B ±0.166	19.69A ±0.265	9.56C ±0.416	1.040
After 5 months	22.39A ±0.936	21.47A ±0.606	10.09B ±0.017	2.228

Means with same letter are not significantly different.

C. A preliminary field experiment was carried out to investigate the possibility of the introduction of above mentioned fungi in competition with *Rigidoporus*.

The treatmer· were as follows.

1. Fomes only.
2. Fomes + Gloeophyllum
3. Control (Natural decay)

Table 7. *Weight loss of roots after 6 months (g)*

Treatment	Weight loss (g)
Fomes only	719 A ± 46.90
Fomes + Geophyllum	1080 A ± 253.45
Control	394 B ± 55.69
LSD (P = 0.05) = 467.94	

Means with the same letter are not significantly different.

D. *Trichoderma harzianum* which is an effective antagonistic fungi to *Rigidoporus* was grown in the following different growth media under aseptic conditions to evaluate the best media to be used as an artificial inoculum.

1. Coir dust
2. Rice bran
3. Straw

Trichoderma grew equally well in all three medium. These were inoculated together with *Rigidoporus lignosus* inoculum into pots with *Hevea* seedlings along with and without amendment of soil with sulphur.

The results of this experiment is not available yet (R Jayaratne, D Siriwardene and P C Wettasinghe).

VA mycorrhizal studies (M/86/1)

A. A pot experiment was initiated with the collaboration of soils and Plant Nutrition Dept. to study the effect of VA – mycorrhizal association in uptake of Phosphorus from different sources of rock phosphate. Only one assessment of shoot dry matter

production was taken. (For details see Annual Review of Soils and Plant Nutrition Dept.) (R Jayaratne, A Dissanayake and D Siriwardene).

B. A preliminary glass-house experiment was carried out to determine the effect of *Pueraria* plants under mycorrhizal and non-mycorrhizal conditions, on the spread of the white root disease.

From this experiment it was revealed that *Pueraria* roots under mycorrhizal condition resist the superficial growth of *Rigidoporus lignosus* fungus and therefore no chance of spreading the rhizomorphs.

Whereas in non-mycorrhizal condition the hyphae of *Rigidoporus lignosus* could be spread over considerable distances *via* the *Pueraria* root systems (R Jayaratne and D Siriwardene).

MISCELLANEOUS

A. *Ustulina and borer attack on rubber trees under Hypodermic Latex Extraction (HLE) trial*

It was noticed that 17 plants in the 200 plant block and 4 plants in the 1000 plant block of above trial at Elston estate, Avissawella were severely affected with Ustulina stem rot. In addition to the *Ustulina* infection, 15 and 63 trees were found to be subjected to borer attack in 200 plant block and 1000 plant block respectively. It seems that the natural defence mechanism of the plants has been severely affected due to hypodermal latex extraction system as both these pests invade only the dead or weak trees (C K Jayasinghe and D S Wettasinghe).

B. *Target leaf spot disease caused by Thanatephorus cucumeris*

A leguminous cover plant *Pueraria phaseoloides* and two common, weed species *viz Mikania* sp. and *Ipomea* sp. were identified as the alternative hosts for *T. cucumeris*, the causative agent of target leaf spot disease of *Hevea*. Arrangements have been made to prove the Koch's postulates. The experiment is in progress (C K Jayasinghe and E B Fernando).

C. *Effect of Rainguards on the Development of Bark Rot.*

An experiment is in progress at Neuchatel Estate to find the effect of rainguards on Bark Rot. Results of the initial experiments showed that rain guards are effective in minimizing bark rot infections, provided that they are fixed properly at the correct time (C K Jayasinghe and E B Fernando).

D. *Factors affecting the production, germination and viability of Cylindrocladium quinqueseptatum spores, a potential pathogen of Hevea.*

Cylindrocladium quinqueseptatum is identified as a serious pathogen of *Eugenia caryophylata* and a potential pathogen of *Hevea brasiliensis* in Sri Lanka.

Four clove isolates of *C. quinqueseptatum* produced spores freely when grown on artificial media under a normal dark and light regime and under continuous dark. Czepek Dox Agar and Lima Bean Agar were found to be the best media for sporulation and the highest number of spores were produced 10 day incubation period. Spore production in culture was commenced at 20°C and inhibited at 35°C with an optimum temperature of 30°C for all isolates tested.

The maximum spore germination observed was around 90% after 5 and 7 incubation as wet smears on *Hevea* leaves and glass slides respectively.

A period of 10 min. exposure of spores as wet smears to UV (2537 A°) inactivated the spores significantly and 40 min. exposure totally inhibited spores.

The most critical factor which influenced the spore viability and germination was the humidity. Free water or a film of water (resulted as dew formation at 100% rh) was found to be essential for spore germination and germination dropped to 2.5% even at high humidities like 96%. Spores lost viability by 25% within a period of two minutes when stored as dry smears under laboratory conditions. Percent inhibition of germination increased progressively as the storing time was increased and 90% inhibition of spore germination was observed after 9 minutes.

With regard to lesion production on leaves, lesions with a reasonable size were produced only at 100% humidity and radial growth of the lesions were 17.8 and 7.1 mm when inoculated as wet smears and dry smears respectively. Size of the lesions at 96% humidity was negligible and no lesions were produced at 91% rh.

The temperature also greatly influenced the spore viability and germination. Spore germination occurred above 10°C and below 35°C and the largest lesions on leaves resulted at 25°C and at room temperature (28 ± 2°C) when inoculated as wet smears. It was found that wet smears of spores can withstand high temperatures of 40°C for 2h without loosing their viability.

Further, it was also shown that climatic factors in main rubber growing areas during heavy monsoon periods are conducive for the pathogen to spread. Considering the fact that even a short period of drying is detrimental to spores and observations

on the disease distribution in nature it was predicted that *Cylindrocladium* infections are likely to reach epidemic proportions during monsoon periods of dull, overcast, rainy weather if this disease spread to *Hevea brasiliensis* in Sri Lanka as a result of large scale planting of susceptible clones (C K Jayasinghe, R L C Wijesundara, T H P S Fernando, U M S Priyanka and I G Munasinghe).

E. *Management of Cockchafer grubs*

Possibilities of using the fungus *Metarhizum anisopliae* against the Cockchafer grubs as a biological control agent was evaluated with the assistance of the Coconut Research Institute. It was found to be fairly successful in checking the population of Cockchafer grubs through the introduction of this fungus into artificial breeding grounds (R Jayaratne, C K Jayasinghe and B I Fernando).

SOILS AND PLANT NUTRITION

Lalani Samarappuli

SUMMARY

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

Residual effect of mulching with rice straw on girthing and latex production was seen even at the 6th year after discontinuation of mulching. The benefit achieved from savings on fertilizers by mulching in comparison with the conventional practice of growing creeping leguminous covers amounts to Rs.5275/= per hectare for the first 8 years of mature stage. Clone RRIC 102 with mulching reached the tappable girth approximately one and a half years earlier than clone PB 86 with mulching. Further, it appears that incorporation of paddy straw into the soil releases more nutrients than surface mulching.

Experimental results further suggest the possibility of using Eppawela rock phosphate (ERP) as a source of phosphate for immature rubber plants in some soils.

Agronomically, the conventional fertilizer mixtures have been found to be as effective as liquid formulations for young budding plants. It has also been found that these mixtures can be applied effectively once in two weeks and thereby reduce the cost of fertilizer application by almost half. Accordingly, the recommended frequency of application of liquid formulations to young budding plants is now, once in two weeks.

The soil and foliar survey programme provided data for fertilizer recommendations for 3000 hectares. In general, as in the past, N and K fertilizers were recommended to most of the plantings. An economic analysis of the soil and foliar survey programme based on the last 12 years data indicates that approximately a saving of Rs.1400/= per hectare per year is possible under this scheme.

DETAILED REVIEW

Staff

The Head of the Department, Dr (Mrs) Lalani Samarappuli, Dr D M A P Dissanayake, Soils Chemist and Mr S Dharmakeerthi, Assistant Soils Chemist were on duty throughout the year.

The Experimental Officers Messrs A M A Perera, H D S P Perera and G de Mel were on duty throughout the year. Mrs R Hettiarachchi was on maternity leave from 7th September 1994.

Senior Technical Officers, Mrs C Maheepala and Mr S N Silva, Technical Officers Messrs P Karunadasa, U Mitrasena, T B Dissanayake, A N Yakandawela, R Gunasekara, C Jayalath, H P Dhammika, Specification Assistant Mr T M Ahamadeen and the English Stenographer Mrs L Rupasinghe were on duty. Mr T M Ahamadeen was redesignated as Senior Testing Officer with effect from 22nd December 1994.

Misses V Edirimanne and D Senaratne assumed duties as Technical Officers on 3rd January, 1994.

Research Students

Miss C Jayalath completed the project on "Impact of rubber factory effluent on soil biological and chemical properties" for her degree programme at the Open University under the supervision of Dr D M A P Dissanayake.

Visits

Mr S Dharmakeerthi visited the Macaulay Land Use Research Institute, Aberdeen, UK on a study programme in "Analytical techniques and instrumentation" from 2nd July 1994 to 30th July 1994. This programme was funded by the Agricultural Research Project.

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

Seminars, Meetings and Workshops

Dr (Mrs) Lalani Samarappuli addressed the seminar on "Land Development and Soil Degradation" organized by the Soil Science Society of Sri Lanka to mark its 25th anniversary on "Land Development and Soil Degradation in Rubber Lands".

Dr D M A P Dissanayake addressed the seminar on "Fertilizing Immature and Mature Rubber" for Asst. Superintendents of Kegalle Plantation Ltd.

Dr (Mrs) Lalani Samarappuli[1], Dr D M A P Dissanayake[2] and Mr S Dharmakeerthi[3] attended the following seminars, meetings and workshops:

* Expert Consultation of the Asian Network on Bio and Organic Fertilizers, 3–7 October, 1994, Kandy[1].
* Fertilizer Advisory Committee[1].
* The working group on fertilizer mixtures of the Sri Lanka Standards Institution[1].
* 35th Assembly of International Rubber Study Group[1]
* Central Scientific Committee[1,2,3].
* Second National Symposium on The Eppawela Phosphate Deposit, held in IFS Kandy, organized by the IFS[1,2,3].
* Seminar on Soil Quality Assessment of Degradation and Restoration, organized by the University of Kelaniya and SLFI[2].

Mr H D S P Perera participated in a workshop on "Repair and Maintenance of Nuclear Equipments" organized by the Atomic Energy Authority at the Radio Isotope Center, Colombo, from 17th January 1994 to 2nd February 1994.

Mr U Mitrasena participated in a workshop on "N 15 Analysis" organized by the Atomic Energy Authority at the Dept. of Botany, University of Colombo from 18th July 1994 to 21st July 1994.

Training Programmes

Lalani Samarappuli, D M A P Dissanayake and S Dharmakeerthi were involved in the following training programmes as trainers:

* Rubber Extension Officers of the Advisory Services Department.
* Owners and Managers of middle level estates.
* Assistant Superintendents of Plantation Management Companies.
* Field Officers of different Plantation Management Companies.

* Superintendents/Assistant Superintendents for the Diploma Course in Plantation Management.

Publications

Dharmakeerthi, R S (1994). Urease activity in soils: A review. Submitted in partial fulfillment of the MSc degree, PGIA, Peradeniya.

Dissanayake, D M A P (1994). Electron microscopic study of the natural dissolution of Eppawela rock phosphate in soil. *Proc. 50th Annual Session of the SLAAS, 1994.*

Dissanayake, D M A P (1994). Physical, chemical and mineralogical characteristics of commercially available Eppawela rock phosphate and Gafsa rock phosphate. *Bull. Rubb. Res. Inst. Sri Lanka* (in press).

Dissanayake, D M A P (1994). Role of Eppawela rock phosphate in the nutrition and productivity of *Hevea*. *Volume of Abstracts of Proc. Second National Symposium on the Eppawela rock phosphate Deposit.*

Samarappuli, L (1994). Mulching with paddy straw : To reduce immaturity and improve yields. *Bull. Rubb. Res. Inst. Sri Lanka* (in press).

Samarappuli, L (1994). Role of crop physiology to increase productivity of *Hevea brasiliensis*. *Proc. SLAAS Section D, 1994.*

Samarappuli, L and Silva, K de (1994). Rice straw: A possible source of nutrients for rubber. *Proc. 50th Annual Session of the SLAAS, 1994.*

Samarappuli, L and Yogaratnam, N (1994). Soil degradation and land development practices in *Hevea* plantations. *Ann. Jl. NIPM* (in press).

Samarappuli, L and Yogaratnam, N (1994). Rubber plantations as a self sustaining agroforestry system. *The Forester* (in press).

Samarappuli, L and Yogaratnam, N (1994). Soil and moisture conservation practices in rubber plantations. *Proc. National Seminar on Soil and Water Conservation* (in press).

Reports

Samarappuli, L (1994). Annual Review of the Soils and Plant Nutrition Department, 1993.

LABORATORY INVESTIGATIONS

Use of live and dead mulch

A laboratory incubation study was carried out to evaluate the nutrient release pattern over a period of time by paddy straw. In general, application of paddy straw increased the major soil nutrient contents. After 15 weeks, the N content was 73% higher than the initial N content and soil P content increased by 42% in the 6th week and decreased thereafter. The soil K and Mg contents significantly increased with time suggesting the presence of readily available K and Mg in rice straw. The data also suggest that incorporation of straw into the soil releases more nutrients than surface mulching (fig 1) (L Samarappuli and R Hettiarachchi).

Slow Release Fertilizers

Polymer Chemistry Department was successful in developing fertilizer encapsulated coir blocks. A joint project with Polymer Chemistry Department was commenced to study the possibility of using these fertilizer encapsulated coir blocks for poly bagged nursery plants (L Samarappuli, K G K de Silva, R Hettiarachchi and M Wijesekera).

P fixation in rubber soils

Arrangements were made to analyze soils collected to represent all the rubber growing areas for the clay and organic matter contents to study the relationship with P adsorption and desorption capacities of different soil series (A Dissanayake, T Dissanayake C Maheepala and C Jayalath).

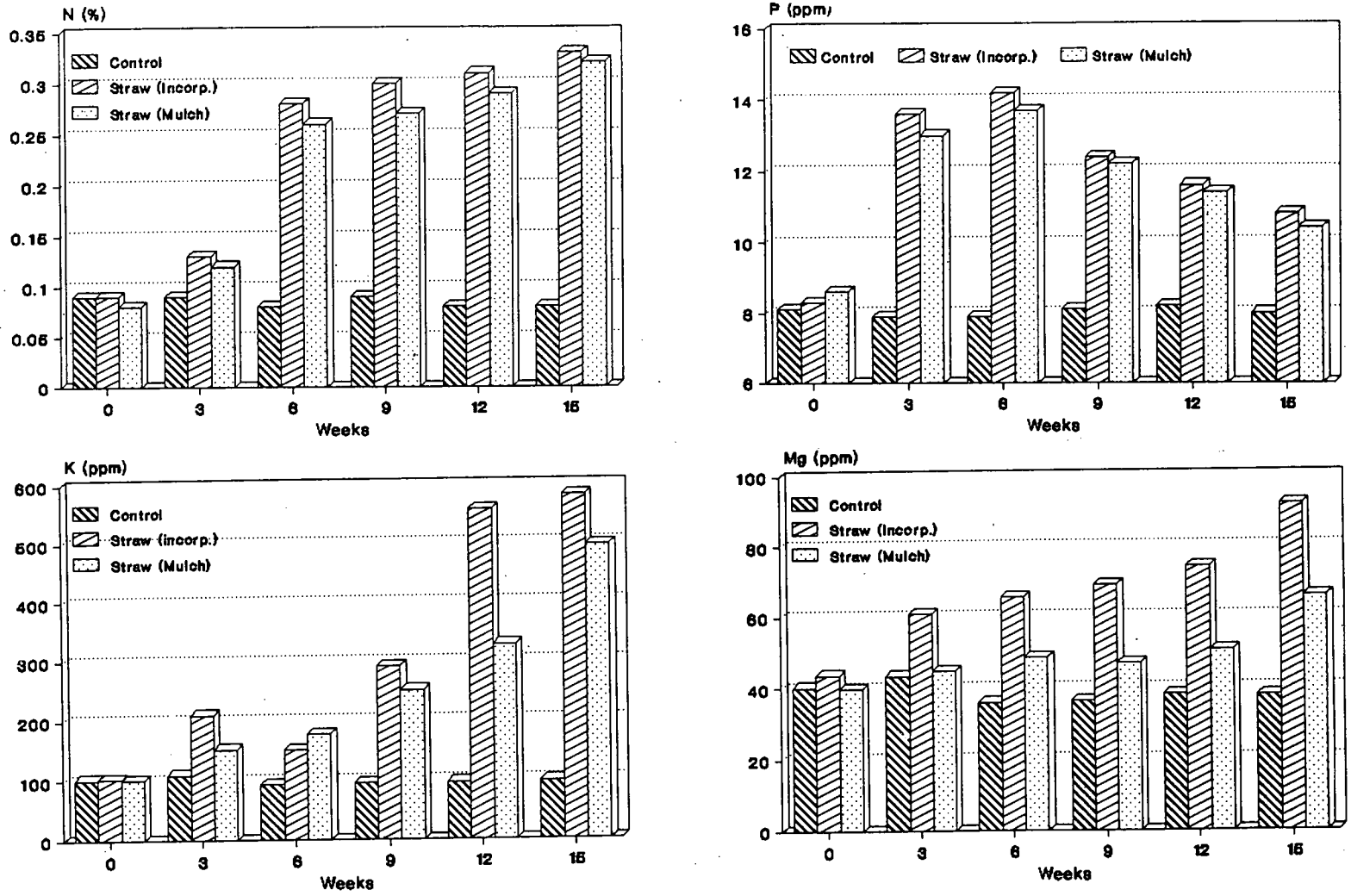

Fig. 1 Effect of rice straw on soil N, P, K and Mg content

Suitability of ERP to cover crops: mycorrhizal aspect

Pueraria plants were raised in *Boralu* series soils to study the effect of mycorrhizae on dissolution of ERP and in turn on the uptake of phosphorus. At the age of 2 months, plant shoots were harvested and dry matter contents were recorded. Chemical analysis were completed on these samples to determine the N,P,K,Ca and Mg contents. Nutrients were supplied bi-weekly and watering was done to keep the soil at the field capacity (A Dissanayake, R Jayaratne, C Jayalath and C Maheepala).

ERP with coir dust to increase availability of P from ERP

A new experiment was started to study the effect of coir dust on dissolution of ERP and its uptake by poly bag rubber plants. "Coir dust bricks" were used in this experiment and fertilizers were applied according to the treatments. Arrangements were made to analyze P fertilizers and coir dust used for the experiment. Soil moisture content of each poly bag was monitored using Gypsum Blocks. Individual calibration curves for the 24 gypsum blocks were established (A Dissanayake, L Samarappuli, C Maheepala and C Jayalath).

FIELD INVESTIGATIONS

1. Agronomic practices to overcome moisture stress

1.1 Use of live and dead mulch

1.1.1 Comparison of different management practices

Study on the residual effect of mulching on latex production was continued in experiment SM/82/5. Application of straw was discontinued after trees came into tapping. The residual effect of treatments on latex production is given in Table 1.

Yield of latex was higher in mulched plots and this beneficial effect continued to be significant even in the 6th year after discontinuation of mulching. Girthing of plants after commencement of tapping was also higher in mulched plots and this beneficial effect too continued to be significant even in the 6th year after discontinuation of mulching (Table 2).

Residual effect of mulching on leaf N,P,K and Mg was studied in order to consider these aspects in recommending fertilizers on the basis of leaf nutrient contents. Savings on fertilizers in comparison with creeping legumes during the first 8 years of mature stage is given in Table 3. It was also observed that the clone RRIC 102 under mulching with paddy straw came into tapping one and a half years earlier than clone PB 86 with mulching (Table 4).

Table 1. *Residual effect of different soil management practices on early yield of Hevea*

Treatment	Yield		Relative Increase (%)
	(g/t/t)	(kg/ha/yr)	
Naturals	28.77[a]	1814[a]	99
Legumes	29.14[a]	1835[a]	100
Dead mulch	33.00[b]	2079[b]	112

Table 2. *Residual effect of different soil management practices on girthing of Hevea*

Treatment	Girth (cm)					
	1989	1990	1991	1992	1993	1994
Naturals	44.64[a]	48.26[a]	50.76[a]	52.86[a]	53.82[a]	59.25[a]
Legumes	46.49[a]	50.37[a]	52.73[a]	54.55[a]	57.11[a]	61.15[a]
Dead mulch	53.56[b]	57.60[b]	60.06[b]	61.91[b]	63.42[b]	66.15[b]

Table 3. *Savings on fertilizers in response to mulching (up to 8th year of maturity)*

Year	Savings on fertilizers				
	Recommended fertilizers (g/plant)		Cost (Rs/ha)		Benefit (Rs/ha)
	Legumes	Mulch	Legumes	Mulch	
1	1100g 12:14:14 mix.+250g Dolomite	200g urea + 200g MOP + 150g ERP	3945	1912	2033
2	200g urea + 200g MOP	125g urea + 125g MOP	1741	1088	653
3	200g urea + 200g MOP	200g urea + 125g MOP	1741	1420	321
4	125g urea + 200g MOP	125g urea + 125g MOP	1409	1088	321
5	200g urea + 200g MOP	125g urea + 125g MOP	1741	1088	653
6	125g urea + 200g MOP	125g urea + 125g MOP	1409	1088	321
7	200g urea + 200g MOP	125g urea + 125g MOP	1741	1088	653
8	125g urea + 200g MOP	125g urea + 125g MOP	1409	1088	321
				Total	5276

MOP – Muriate of potash ERP – Eppawela rock phosphate

Table 4. *Effect of mulching on girthing of clones PB 86 and RRIC 102*

Clone	Girth (cm)				
	Year 1	Year 2	Year 3	Year 4	Year 5
PB 86	9.33	16.29	25.42	35.17	41.91
RRIC 102	15.17	30.21	38.50	46.50	53.60

1.1.2 Optimum N P K levels for rubber mulched with rice straw

In this experiment the N,P,K requirements for rubber, mulched with rice straw was studied in a 3x3x3 factorial design in which three levels of N,P and K were applied with and without mulching in the sub-plots.

Girth data up to 7th year of planting indicated that the currently recommended level of N and P appears to be sufficient irrespective of the management practice and also that when the P level was increased to double the recommended level there had been a significant reduction in yield in comparison with the currently recommended level. The K level on the other hand, has to be doubled from the 6th year onwards under both management practices. This is further confirmed by the yield data obtained during the year 1994 (Table 5) (L Samarappuli, P Karunadasa and U Mitrasena).

1.2 Fertilizer practices for overcoming moisture stress

A field experiment (SM/88/4) is in progress at Nalanda Estate, Ulpotha to study the effect of different levels of potassium on growth of *Hevea* plants in a comparatively drier area. It is too early to make any conclusions from this study (Table 6).

In another field experiment (SM/88/2) with and without K, girth and tappability data indicated a higher girthing (Table 7) and a higher % tappability (Table 8) with potassium at K1 level.

Table 5. *Effect of different P and K levels on yield of Hevea*

P Level	Yield		K Level	Yield	
	(g/t/t)	(kg/ha/yr)		(g/t/t)	(kg/ha/yr)
P_0	18.09	1140	K_0	16.26	1024
P_1	20.52**	1293**	K_1	19.46***	1226***
P_2	17.96	1132	K_2	20.85***	1314***
LSD	2.04	128		2.04	128

Table 6. *Effect of different K levels on girth of rubber plants*

K Level*	Girth (cm)
K_0k_0	36.8
K_0k_1	37.6
K_0k_2	34.4
K_1k_0	33.5
K_1k_1	31.1
K_1k_2	34.8

* K_0 and K_1 refer to levels of potassium application up to year 5
k_0, k_1 and k_2 refer to levels of potassium application from year 6

Table 7. *Effect of potassium on girthing of rubber plants*

K levels	Girth (cm)				
	1990	1991	1992	1993	1994
K_0	12.53	22.24	29.13	38.65	45.45
K_1	13.74*	25.56**	33.24**	43.63**	51.29*
LSD	0.56	0.91	1.42	1.61	1.57

Table 8. *Effect of potassium on % tappability of rubber plants*

K levels	Tappability (%)
K_0	54.62
K_1	83.10*
LSD	8.50

A site was selected at Dorset Division, Clyde Estate, Kalutara and another site at Nalanda estate, Matale to represent the wet and dry regions for an experiment to study the effect of both potassium and mulching on moisture stress, growth and latex production of *Hevea*. Treatments consisted of (a) two agroclimatic regions; dry and wet, (b) three mulching techniques; no mulch, surface mulching and sub surface mulching (incorporation) and (c) four potassium levels; half the recommended level, recommended level, one and half the recommended level and double the recommended level (L Samarappuli, P Karunadasa and U Mitrasena).

1.3 Evaluation of the performance of *Hevea* clones under soil moisture deficit situations

An experiment was initiated in collaboration with the Genetics and Plant Breeding Department to study the effect of soil moisture deficit on the performance of 10 *Hevea* clones in Bibile, Yatawatta, Bentota and Eladuwa Estates (L Samarappuli, N E M Jayasekera, P Karunadasa and U Mitrasena).

1.4 Rubber based cropping systems to increase water use efficiency of rubber plants

Access tubes were installed at 4 points in each plot in the experimental area on multicropping of rubber with tea at the RRI Sub Station in Kuruwita and monitoring of soil moisture content using Neutron Probe and Leaf Water Potential (LWP) using Pressure Bomb was done. There was no significant difference in soil moisture content (Table 9) or leaf water potential (Table 10). This may be due to the favourable weather conditions (high rainfall) that prevailed during the year (L Samarappuli, N Yogaratnam, S M M Iqbal, P Karunadasa and U Mitrasena).

Table 9. *Effect of multicropping of rubber with tea on soil moisture content*

Treatment	Moisture content (kg/M^3)				
	Location				Mean
	1	2	3	4	
Tea & rubber (rehabilitated)(8x27')	581.9	577.7	596.8	578.3	583.6
Tea & rubber (unrehab.)(8'x27')	594.1	592.9	592.7	591.9	592.9
Tea & rubber (rehab.)(8'x40')	528.7	508.6	522.0	545.4	526.2
Tea & rubber (unrehab.)(8'x40')	521.2	534.4	535.4	552.5	535.8

Table 10. *Effect of multicropping of rubber with tea on Leaf Water Potential (LWP)*

Treatment	LWP (-bars)	
	Rubber	Tea
Tea only (rehabilitated)	-	7.4
Rubber only	10.0	-
Tea and rubber (rehab.)(8'x27')	9.8	5.9
Tea and rubber (unrehab.)(8'x27')	9.4	6.0
Tea and rubber (rehab.)(8'x40')	10.1	6.1
Tea and rubber (unrehab.)(8'x40')	9.0	6.7

2. Assessment of land degradation in rubber plantations

2.1 Impact of slope and management practices

In a field experiment with two slopes *viz* 6% and 12% and four management practices, the soil degradation and development aspects were studied. The soil organic C, soil pH and soil moisture storage capacity (SMSC) were reduced over the past 10-year period in bare soils compared to soils with legumes, naturals and mulching (Table 11). In the 12% slope, soil degradation is greater compared to 6% slope (Table 12). Soil degradation and development aspects were further confirmed by girth and yield data collected after the 10-year period (Table 13 and 14)(L Samarappuli, P Karunadasa and U Mitrasena).

Table 11. *Effect of different soil management practices on soil organic C, pH, BD and SMSC*

Treatment	Org.C (%)		Soil pH		SMSC (cm)		BD (g/cm^3)	
	84	94	84	94	84	94	84	94
Bare	1.1	0.10^a	4.8	4.5^a	20.2	18.4^a	1.20	1.47^a
Legumes	1.1	1.34^b	4.7	4.9^b	20.1	23.3^b	1.21	1.08^c
Natural	1.0	1.24^b	4.7	4.8^b	20.0	21.7^b	1.21	1.27^b
Dead Mulch	1.0	1.61^c	4.8	5.0^c	20.1	27.6^c	1.20	1.00^c

Table 12. *Effect of different slopes on soil organic C, pH, BD and SMSC*

Slope	Organic C(%)	Soil pH	SMSC(cm)	BD(g/cm^3)
6%	1.52^a	4.8^a	25.2^a	1.19^a
12%	1.01^b	4.6^a	21.4^b	1.30^b

2.2 Run-off studies

Several run-off models were estimated using standard econometric procedures to determine the soil loss in immature rubber holdings under different agro-

management and physiographic conditions. This study is being done in collaboration with the Agricultural Economics Unit (L Samarappuli, N Samarappuli and N Yogaratnam).

Table 13. *Effect of different soil management practices on girth and yield of rubber plants*

Treatment	Girth (cm)	Yield	
		(g/t/t)	(kg/ha/yr)
Bare	56.01[a]	25.36[a]	1598[a]
Legumes	61.15[b]	29.14[b]	1835[b]
Naturals	59.25[b]	28.77[b]	1814[b]
Dead mulch	66.15[c]	33.00[c]	2079[c]

Table 14. *Effect of different slopes on girth and yield of rubber plants*

Slope	Girth (cm)	Yield	
		(g/t/t)	(kg/ha/yr)
6%	63.58[a]	31.06[a]	1957[a]
12%	60.23[b]	27.07[b]	1705[b]

3. Ground cover management

3.1 Comparison of different cover types

Experiment, SM/88/2 was started to study the influence of creeping, bush and tree legumes on some soil characteristics and their effects on the performance of young rubber plants in *Boralu* series soils.

Soil characteristic data indicated that in general creeping legume is superior to bush and tree legumes in enhancing the soil fertility status (Table 15). This is further demonstrated by the girth and tappability % obtained in the year 1994

(Table 16). Observations made indicate that tree legumes may not perform well in *Boralu* series soils (L Samarappuli, P Karunadasa and U Mitrasena).

Table 15. *Effect of different types of legumes on some soil characteristics under Hevea*

Treatment	Organic C (%)	Bulk Density (g/cm^3)	Soil moisture (%)
Pueraria (Creeper)	1.09[a]	1.08[a]	18.31[a]
Desmodium (bush)	0.97[b]	1.14[b]	17.18[b]
Stylosanthus (bush)	1.00[b]	1.26[b]	17.61[b]
Tephrosia (tree)	1.06[b]	1.30[b]	17.80[b]

Table 16. *Effect of different types of legumes on girth and tappability of Hevea*

Treatment	Girth (cm)	Tappability (%)
Pueraria (Creeping type)	51.07[a]	82.50[a]
Desmodium (bush type)	48.67[b]	68.67[b]
Stylosanthus (bush type)	47.00[b]	63.17[b]
Tephrosia (tree type)	45.85[c]	59.83[c]

3.2 Comparison of different tree legumes

Experiments C/92/1 and C/93/1 were started to study the performance of leguminous trees and their effect on soil and moisture conservation, growth and yield of *Hevea* plants. Leaf nutrient contents of rubber under different management practices are presented in Table 17. It is too early to make any conclusions from this study (L Samarappuli, P Karunadasa, U Mitrasena and E A T Senadeera).

Table 17. *Effect of different tree legume species on the leaf nutrient content of rubber*

Treatment	N%	P%	K%	Mg%	Ca%
Pueraria phaseoloides	3.375	0.238	0.696	0.265	0.944
Gliricidia sepium	2.973	0.229	0.711	0.250	0.857
Tephrosia vogellie	3.029	0.232	0.745	0.232	0.815
Crotolaria anagyroides	3.072	0.237	0.663	0.233	0.734
Sesbania aculeata	3.023	0.242	0.717	0.239	0.954

3.3 New cover crop species

A field experiment was started to study the comparative efficiency of *Mucuna bracteata*, a fast growing legume introduced from the North Eastern States of India, in nutrient enrichment and other desirable characteristics in comparison with *Pueraria* and on seed production under Sri Lankan conditions. According to initial observations establishment rate of this cover crop appears to be slow (L Samarappuli, P Karunadasa and U Mitrasena).

4 Nutrient recycling in rubber plantations

4.1 Organic manure

The use of organic manures in *Hevea* plantations is being studied at Elston estate (OM/86/1), Payagala estate (OM/86/2) and Hewagama Estate (OM/88/1). Results obtained show an improved girthing of trees that received organic manure supplement (Table 18) (L Samarappuli, N Yogaratnam and J de Mel).

Table 18. *Effect of different fertilizer practices on girth of rubber*

Treatment	Girth (cm)		
	OM/86/1	OM/86/2	OM/88/1
Inorganic fertilizer (1/2 normal)	56.6	51.1	38.9
Inorganic fertilizer (1/2 normal) + organic manure	56.3	52.4	40.1
Inorganic fertilizer (normal)	55.6	52.3	39.1
Inorganic fertilizer (normal) + organic manure	57.5	53.9	40.7

4.2 Sludge as a potential fertilizer for *Hevea*

Experiment (F/SL/93) was started at Payagala estate to evaluate sludge as a fertilizer for immature rubber. Different levels of fertilizers and sludge were applied according to the design. It is too early to make any conclusions from this study (L Samarappuli, A M A Perera and H P Dhammika).

4.3 Nutrient dynamics and synchronization of nutrient supply and demand

The objectives of this study are to quantify the nutrient cycles (addition/removal) in a well managed rubber plantation and development of a better short-term predictive understanding of nutrient availability to form a basis for management recommendations. This study which was done under the Tropical Soil Biological and Fertility Programme was reactivated to study the residual effect by collecting yield data (L Samarappuli, N Yogaratnam and A M A Perera in collaboration with Prof N Gunatilleke of the Botany Dept., University of Peradeniya).

5. Fertilizer Use in Rubber

5.1 Improvements to soil and foliar survey programme

Leaf nutrient values collected over the past 10 years under the soil and foliar survey programme were analyzed and the initial results further confirm that the amount of P and Mg levels recommended under the soil and foliar survey programme have always been lower than with the use of conventional mixtures. The N levels too have been comparatively lower in the soil and foliar survey programme up to the 18th year of planting but the recommended K levels have remained very much similar to the conventional method during the first 12 years of the mature phase (fig 2).

Initially, the Kegalle, Kalutara and Ratnapura districts were used for this study and there was a difference between savings on fertilizers among the districts. Moreover, it was further evident that the savings on fertilizers based on soil and foliar survey have varied according to different clones, slope classes and land qualities. Further investigations are in progress to study the long-term impact of soil and foliar survey technique on productivity in relation to clone type, management practices, physiographic and climatic conditions. Some improvements were made to the soil and foliar survey programme on the differences in soil characteristics and also age of the plants. The computer programme was revised accordingly (L Samarappuli, N Samarappuli, N Yogaratnam, W Wijesuriya, V Edirimanne, D Senaratne, D G S B Dias and C S Wickramaratne).

5.2 SUL-PO-MAG based fertilizer mixtures

An experiment (F/SPMg/94) was started in Culloden Estate, Neboda to study the effectiveness of SUL-PO-MAG based mixtures in comparison with conventional mixtures 12:14:14 and 7:9:9:3 in immature rubber. SUL-PO-MAG based treatment was formulated by adding urea, rock phosphate and muriate of potash to SUL-PO-MAG to meet the nutrient ratios of N,P,K and Mg recommended for rubber by conventional mixtures. First application of fertilizer was done according to the experimental design (L Samarappuli, N Yogaratnam, J G de Mel and P Karunadasa).

5.3 Dolomite as a source of Mg for mature rubber

An experiment (Mg/S/94) is in progress in Dorset Division, Clyde Estate to study the feasibility of using Dolomite even during the mature stage. Treatments consisted of kieserite throughout the immature and mature period, kieserite in

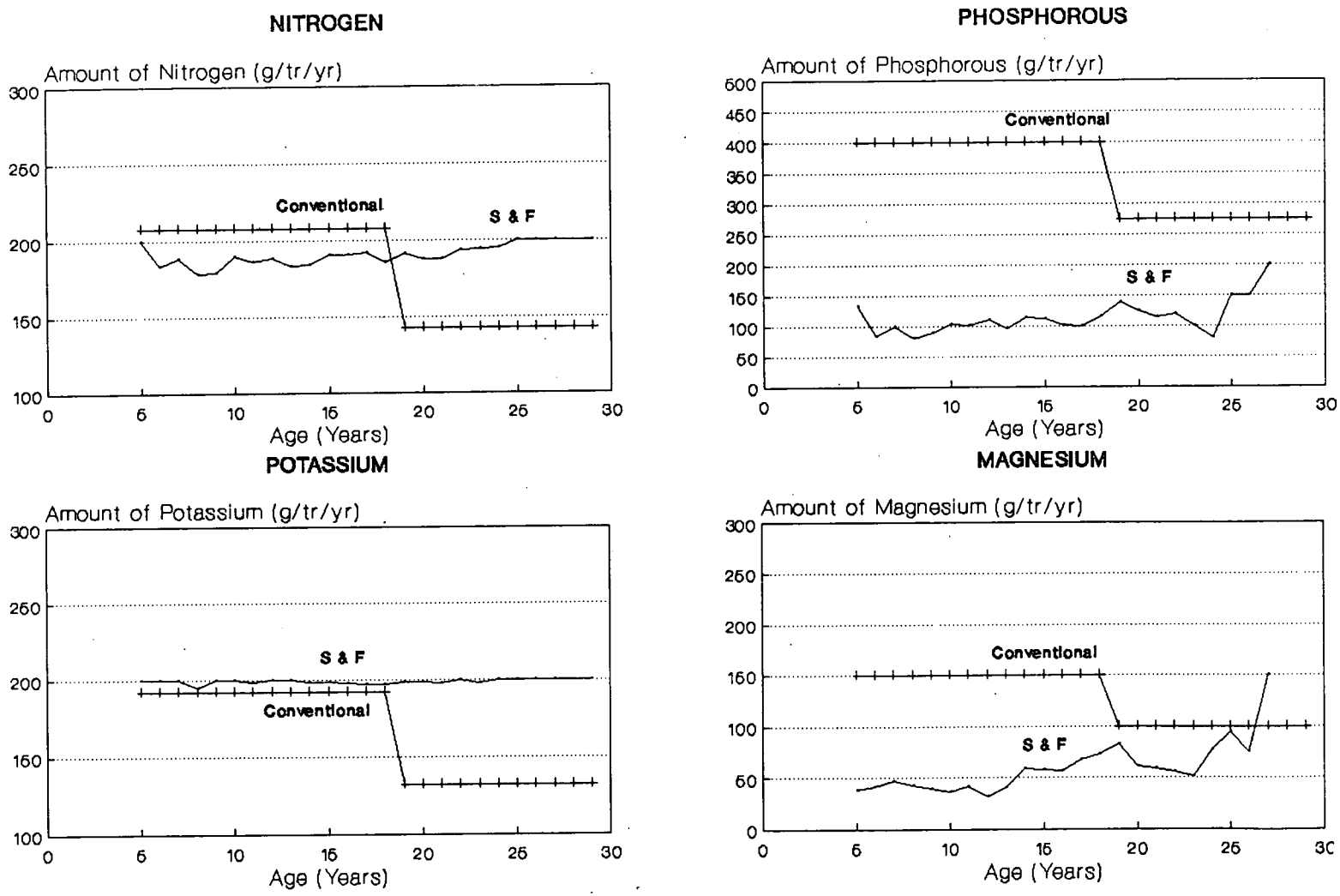

Fig. 2 Kalutara district: Recommended nutrient quantities based on Soil and Foliar Survey programme compared to conventional met

immature period and dolomite in mature period, dolomite throughout the immature and mature period, dolomite in immature period and kieserite in mature period. Fertilizers were applied according to the experimental design (L Samarappuli, N Yogaratnam, S M M Iqbal and U Mitrasena).

5.4 Economics of fertilizer use in mature rubber

Economics of fertilizer utilization by mature rubber is being investigated in an experiment (F/EC/93) at Clyde estate, Dorset Division. Following treatments were allocated to each plot in a randomized complete block design with five replicates.

T_1 No fertilizer from the first year of panel C
T_2 No fertilizer from the second year of panel C
T_3 No fertilizer from the third year of panel C
T_4 No fertilizer from the fourth year of panel C
T_5 Fertilizing throughout the panel C

Yield data obtained during the last year is given in Table 19 (L Samarappuli, N Yogaratnam and S N Silva).

Table 19. *Effect of different fertilizer treatments on the yield of Hevea*

Treatment	Yield	
	(g/t/t)	(kg/ha/yr)
T5	24.8^{a}	1562^{a}
T4	22.0^{ab}	1386^{ab}
T2	21.8^{ab}	1373^{ab}
T3	20.3^{ab}	1279^{ab}
T1	18.7^{b}	1178^{b}

6. Phosphate nutrition

6.1 Nursery plants

Two experiments conducted at Ambatenna (P/N/93-01) and Dartonfield (P/N/93-02) to study the suitability of Eppawela rock phosphate (ERP), ERP + effluent and ERP + sulphate of ammonia for nursery plants were completed and results were analyzed statistically.

Girth measurements made monthly for the period of 6 months showed that there is no significant difference between rock phosphate sources and the control treatment. Similar results were observed for plant and soil P status. This experiment will be repeated with the inclusion of selectively mined ERP and phosphate high ERP (35% P_2O_5) also as treatments (A Dissanayake, T Dissanayake and P Perera).

6.2 Immature rubber

6.2.1 Effect of different sources and levels of P

This experiment (P/IM/87) was continued. Girth measurements showed that there is no significant difference between rock phosphate sources and this suggests the possibility of using ERP as a source of P for immature rubber plants in some soils (Table 20). It also appears that the rate of P currently recommended may not be sufficient to meet the plant's demand for P in some soils (Table 21).

Table 20. *Effect of different sources of P on plant girth and yield of rubber*

Source	Girth (cm)	Yield	
		(g/t/t)	(kg/ha/t)
IRP	47.78[a]	21.087[a]	1329[a]
ERP	45.97[a]	19.550[a]	1232[a]
TSP	47.35[a]	18.708[a]	1179[a]

Leaf samples were collected and analyzed for P. There is no significant effect of P sources and P levels on leaf P content. Assessment of yield was started in November, 1994 as the plantation is now under exploitation. The yield was not significantly influenced by either the source (Table 20) or rate of phosphorus (Table 21).

Arrangements were made to divide the experimental plots into two sub plots to study the residual effect of ERP applied during the immature period on yield (A Dissanayake, T Dissanayake and P Perera).

Table 21. *Effect of different levels of P on plant girth and yield of rubber*

P level	Girth (cm)	Yield	
		(g/t/t)	(kg/ha/yr)
P_0 (No P fertilizer)	45.86	20.609	1298
P_1 (rec. level)	46.72	18.854	1188
P_2 (doub. rec. level)	48.51*	19.923	1255
LSD	1.741	NS	NS

6.2.2 Ability of different clones to utilize ERP

Experiment P/IM/93-01

The experiment started at Devalakanda Estate was continued. Fertilizers (ERP, IRP and ERP + IRP mixture) were applied according to the experimental treatments to supply phosphate at zero, normal and double the recommended level.

Girth measurements made after the completion of one year showed that there is no significant difference between rock phosphate sources and between P levels. Leaf and soil samples were also collected and analyzed. The leaf P content was not influenced by either the source or the rate of P (A Dissanayake, T Dissanayake, P Perera and C Jayalath).

Experiment P/IM/94

The experiment started at Lagos Division, Payagala Estate to study the ability of different RRIC clones (RRIC 110 and 121) in utilization of ERP was continued. Budded stumps of clones RRIC 110 and 121 were planted in August 1994. Soil samples were collected before the application of fertilizer treatments. ERP, IRP and ERP + IRP (50:50) mixture were applied according to the experimental design (A Dissanayake, T Dissanayake, P Perera, C Maheepala and C Jayalath).

Experiment P/IM/93-02

The experiment started at Vogan Estate to study the possibility of using both Eppawela and imported rock phosphates was continued. Normal fertilizer mixture (12:14:14) and Dolomite were applied up to the age of 2 years and then fertilizer treatments were applied. Soils and leaf samples were collected before applying fertilizer treatments in September 1994 in addition to girth measurements (A Dissanayake, T Dissanayake and P Perera).

6.3 Mature rubber

6.3.1 Residual effect of added rock phosphates

This experiment (P/M/76) was continued for a further period of one year. Monthly assessments of yield were not done regularly due to interference by heavy rain. But, both soil and leaf samples were collected in the month of June. No P fertilizer was applied during this year also. But, uniform application of N,K and Mg fertilizers were made. P in leaves are higher in plants that received rock phosphate indicating that there is a residual effect of added fertilizer P. However this was not observed during the year 1994. The leaf P contents were fairly higher even in plants that did not receive any phosphate and they were in medium to very high level range of threshold values established for rubber in Sri Lanka (Table 22) (A Dissanayake, T Dissanayake, P Perera and C Maheepala).

6.3.2 Evaluation of clonal differences in rock phosphate utilization

The experiment (P/M/93) on clonal effects on P utilization were continued at Sorana, Perth and Clyde estates. Fertilizers were applied according to the experimental treatments. Annual girth measurements were made and soil and leaf samples were

taken for analysis. Yield measurements were not done regularly due to interference by heavy rain (A Dissanayake, T Dissanayake and P Perera).

6.4 Sources of P for ground covers during the immature period of rubber

A field experiment (P/C/94) was started to study the effectiveness of Eppawela rock phosphate as a source of P for leguminous ground covers, both creeping and bush/tree types. Treatments consisted of three P sources: no P, ERP and IRP and four cover types: *Pueraria phaseoloides, Tephrosia vogellie, Crotolaria anagyroides and Flemingia congesta*. Planting of leguminous covers and first application of fertilizers were completed (L Samarappuli, A Dissanayake, N Yogaratnam and G de Mel).

Table 22. *Residual effect of rock phosphate fertilizers on leaf P content (%)*

P Source	Leaf P%	
	June '93	June '94
Nil	0.198[b]	0.301[a]
IRP – Level 1	0.257[a]	0.344[a]
IRP – Level 2	0.246[a]	0.314[a]
ERP – Level 1	0.271[a]	0.316[a]
ERP – Level 2	0.269[a]	0.365[a]

6.5 Agronomic practices to increase availability of P from ERP

This experiment (P/Ag/93) was started at Culloden estate to study the effect of different agronomic practices on availability of P from ERP. Fertilizers were applied according to the experimental treatments. Application of rice straw and lime were also done around the base of rubber trees. Girth measurements were made at the age of one year and soil and leaf samples were collected for analysis. Leaf P content was not significantly influenced by either the source of P or management practices after a period of one year (A Dissanayake, L Samarappuli, T Dissanayake and P. Perera).

7. Evaluation of fertilizer mixtures for young buddings

This experiment (F/YB/94) was continued and agronomically, the conventional mixtures have been found to be as effective as liquid formulations for young budding plants. It has also been found that these mixtures can be applied effectively once in two weeks and thereby reduce the cost of fertilizer application by half. There was no significant difference between cost in raising poly bags using conventional mixtures and liquid formulation at 14 days intervals (Table 23).

However, the required quantities of conventional mixtures are so small (*ie* 1g of 12:14:14 or 1.6g of 7:9:9:3 before bud grafting) that it is very difficult to apply evenly. There is a possibility of applying high concentrations of nutrients which will lead to low budding success and high die back percentages (Table 24)(R S Dharmakeerthi, S N Silva and A N Yakandawela).

8. Fertilizer requirement of new clones

Two experiments (F/CL/92-01 & 02) were started in 1992 to investigate the fertilizer requirement of the newly developed clones, RRIC 121, RRIC 110, PB 260, 74-193 and RRIM 712. Application of fertilizer at ½ the recommended level increased girthing significantly ($P<0.001$) in comparison with the control (no fertilizer treatment). Increasing the fertilizer to the currently recommended level although did not give a significant increase in comparison with ½ the recommended level, yet, a further significant ($P<0.001$) increase in girthing was observed with 1½ times the currently recommended level (Table 25). However, this phenomenon was not observed in the pot experiment, where, ½ the recommended level of fertilizer gave a significant ($P<0.001$) increase in girthing and no further increase was observed with the increase in the level of fertilizer mixture (Table 26) (R S Dharmakeerthi, S N Silva and A N Yakandawala).

9. Soil and Foliar Survey

The soil and foliar survey programme for 1994 commenced in July and approximately 3000 ha were surveyed this year. Fertilizer recommendations based on this survey were sent to all the estates in December. In general, as in the past, N and K fertilizers were recommended to most of the plantings (L Samarappuli, A M A Perera, V Edirimanne, D Senaratne and T M Ahamadeen).

Table 23. *Comparison of the cost fertilizing, 1000 young budding plants upto planting stage, using different formulations*

Item	Cost (Rs)	
	Material	Labour
1. Manuring		
a. Current liquid formulation(weekly)	614.39(8.73%)	734.92(10.45%)
b. Current liquid formulation(fortnightly)	614.39 (9.21%)	367.57 (5.51%)
c. Conventional mixture 7:9:9:3(fortnightly)	539.94 (8.11%)	428.72 (6.44%)
d. Conventional mixture 12:14:14(fortnightly)	518.30 (7.81%)	428.72 (6.46%)
2. All other	1627.71	4058.85
		Total
a. Current liquid formulation(weekly)		7035.87
b. Current liquid formulation(fortnightly)		6668.45
c. Conventional mixtures 7:9:9:3(fortnightly)		6655.22
d. Conventional mixtures 12:14:14(fortnightly)		6633.58

Per plant basis

1. Current liquid formulation (weekly) – Rs.7.03
2. Current liquid formulation (fortnightly) – Rs.6.67
3. Conventional mixture 7:9:9:3 (") – Rs.6.65
4. Conventional mixture 12:14:14 (") – Rs.6.63

Table 24. *Effect of fertilizer mixtures on plant girth, buddability, budding success and die back*

Treatment	Girth (cm)	Bud. (%)	budding success (%)	Die back (%)
T_1 Current recommendation(liquid)	6.23^{ab}	89.7^{a}	70.2^{b}	43.6^{ab}
T_2 50g RP+SA, TSP, MOP, Kieserite	6.23^{ab}	90.9^{a}	76.9^{ab}	30.8^{b}
T_3 75g RP+SA, MOP, Kieserite	6.29^{a}	84.9^{a}	79.5^{ab}	28.9^{b}
T_4 50g RP + 12:14:14	6.35^{ab}	92.5^{a}	79.5^{ab}	27.1^{b}
T_5 50g RP + 7:9:9:3	6.26^{a}	96.8^{a}	90.6^{a}	11.4^{b}
T_6 Doubled the level of T_2	6.17^{ab}	93.0^{a}	85.8^{ab}	16.9^{b}
T_7 Doubled the level of T_4	5.95^{bc}	84.2^{a}	60.8^{b}	64.9^{a}
T_8 Doubled the level of T_5	6.29^{a}	80.1^{a}	68.6^{b}	60.9^{ab}
T_9 SA,TSP,MOP,Kieserite	5.65^{d}	86.6^{a}	73.5^{b}	38.1^{ab}

RP – Rock phosphate; SA – Sulphate of Ammonia;

TSP – Tripple Super Phosphate; MOP – Muriate of potash.

10. Chemical Analysis

Routine chemical analysis of soil, leaf, latex and fertilizer samples collected for experimental and advisory purposes were carried out. Samples from other Departments and Organizations were also analyzed (L Samarappuli, A M A Perera, V Edirimanne and D Senaratna).

Table 25. *Effect of fertilizer on girth of clones RRIC 121, RRIC 110, PB 260, 74–193 and RRIM 712 after 2 years of planting (field experiment)*

Treatment	Mean Girth (cm)
Control (no fertilizer)	11.05
½ Current recommendation	15.07 ***
Current recommendation	15.80***
1½ current recommendation	16.82***
LSD	0.76

Table 26. *Effect of fertilizer on girth of clones RRIC 121, RRIC 110, PB 260, 74–193 and RRIM 712 after 2 yrs of planting (pot experiment)*

Treatment	Mean Girth (cm)
Control (no fertilizer)	11.03
½ Current recommendation	13.25***
Current recommendation	13.39***
1½ Current recommendation	14.24***
Double the current recommendation	14.37***
LSD	1.22

11. Adaptive Research Programme

11.1 Effectiveness of bush/tree legumes

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

11.2 Use of poultry manure

Use of poultry manure as a substitute for inorganic fertilizer in immature and mature rubber smallholdings is also being studied under Adaptive Research Programme (L Samarappuli, F P W Silva, W C Dayaratne and E A T Senadeera).

11.3 Mulching with rice straw

A new set of experiments was started to evaluate the effectiveness of mulching with rice straw in smallholdings (L Samarappuli, F P W Silva, W C Dayaratne and E A T Senadeera).

11.4 Use of *Vetiver* grass

A site was selected to grow *Vetiver* grass as hedges in inter row area as a substitution for drains and stone terraces (L Samarappuli, W C Dayaratne and E A T Senadeera).

11.5 Evaluation of ERP

A new set of experiments was started in smallholdings to evaluate the effectiveness of ERP and IRP mixture (50:50) on the performance of immature rubber (A Dissanayake and F P W Silva).

Experimental details and results of the above experiments are discussed in the Review of the Adaptive Research Unit.

BIOCHEMISTRY AND PHYSIOLOGY

N Yogaratnam

SUMMARY

Studies on the effectiveness of rubber factory effluent as a source of nutrients to mature rubber, the influence of soil/plant nutritional status on the incidence of tapping panel dryness and the effectiveness of biological systems in the treatment of rubber factory effluent had been the main research programmes of this department.

DETAILED REVIEW

Staff

Mr M T Warnakula and Mrs Neelamanie Yapa, Assistant Biochemists, continued their postgraduate studies in Australia and PGIA Peradeniya respectively. Dr N Yogaratnam, Deputy Director (Research) overlooked the work of this Department. Mr M D C Seneviratne, Miss S Kudaligama and Mr D Ramawickrama, Technical Officers were transferred on a temporary basis to the Soils and Plant Nutrition Department, Biometry Section and Plant Science Department respectively. Mr P D J Rodrigo, Specification Assistant and Mr W A Themis, were on duty throughout the year.

Training

Miss Wasantha Dissanayake, a final year student from the University of Sri Jayawardenapura carried out project work on "Deproteinized Natural Rubber" as part of her BSc special degree programme in Botany.

Laboratory and Field Experiments

Effluent Utilization

Rubber factory effluent (serum) is known to be rich in several important nutrients. The nutrients that are likely to be added to the soil by the effluent under Sri

Lankan conditions are Nitrogen – 217, Phosphorous – 224, Potassium – 258, Magnesium – 127, Calcium – 29 and Sodium – 31, metric tons/year. When used as a source of nutrients to plants, it can also help in minimizing environmental pollution. This study is therefore in progress at Culloden Estate, Neboda to investigate the effectiveness of rubber factory effluent as a source of nutrients to rubber with special reference to N, P, and K. This experiment is being conducted in an area of about 6 acres on clone PB 86 in a 1986 replanting. The following treatments are being tested.

TREATMENTS :	T_1	:	Normal fertilizer mixture (12:14:14) recommended for mature rubber.
	T_2	:	Half the normal fertilizer + 1:1 diluted serum.
	T_3	:	1:1 diluted serum.
	T_4	:	Undiluted serum.
	T_5	:	Control (Water).

The following analyses were done:

* Latex yield per tree and dry rubber content (DRC) per 50 ml of latex.
* Soil pH and moisture measurements.
* N, P, K, Mg and Ca contents of soil and leaf samples.

(Neelamanie Yapa, S Dharmakeerthi, N Yogaratnam, M D C Seneviratne and P D J Rodrigo).

Tapping Panel Dryness (Brown Bast)

Studies were continued at Eladuwa Estate to study the incidence of tapping panel dryness in relation to soil/plant nutritional status of mature rubber using a completely randomized design. One hundred and forty (140) trees of clone RRIC 100 which were affected by brown bast were selected and 20 healthy trees from the same location were also selected for comparison.

TREATMENTS	T_1	:	Control (no fertilizer application)
	T_2	:	800g of appropriate N, P, K mixture/plant/year+150 g of kieserite.
	T_3	:	1200g of appropriate N, P, K mixture/plant/year+150g kieserite.

T_4 : 100g of appropriate N, P, K mixture/plant/year+150g kieserite.

T_5 : 2400g of appropriate N, P, K mixture/plant/year+150g kieserite.

T_6 : 1:1 diluted serum, weekly, 2 gallons/application

The following assessments were made:

* Leaf analysis for N, P, K Mg and Ca.
* Dry rubber content in latex.
* Latex, bark and leaf analysis for proline, sugars and sugar alcohols.
* Density of active latex vessels in the bark.
* Trunk girth

(Neelamanie Yapa, A Nugawela, M D C Seneviratne, S Kudaligama and D Ramawickrama).

Effluent Treatment

Research scale model of an effluent treatment plant installed at Dartonfield was used to study the effectiveness of biological processes in the treatment of rubber factory effluent. The rotating coir belt system was used in this process. Different rates of rotation and depth were considered in this study.

The following analytical tests on the biologically treated serum were done: COD, BOD, Total N, sludge content, volatile matters, K, Ca, P and Mg content.

Data on latex production and rainfall were collected from three estates in each rubber growing districts in order to devise suitable effluent treatment systems that could be adopted in these areas (M T Warnakula, M D C Seneviratne, S Kudaligama, P D J Rodrigo and D Ramawickrama).

Centrifuge Unit

The centrifuge unit that functioned under the Biochemistry and Physiology Department was transferred to the Polymer Chemistry Department with effect from May 1994.

RUBBER TECHNOLOGY AND DEVELOPMENT

N M V Kalyani Liyanage

SUMMARY

The main thrust of the department has been in industrial trouble shooting and development of new products. A new project to make artificial flowers from NR latex was initiated and a casting technique suitable for this purpose has also been developed.

A latex compound with good adhesion properties suitable for carpet backing has been developed.

Work on the use of latex bitumen emulsions in road construction was continued. The use of inorganic salts as density modifiers and thickeners in improving storage stability of latex\bitumen blends has been looked into.

Some work on the use of controlled release fertilizers has been initiated.

Trials on the development of a NR/SR based compound suitable for constructing a collapsible tank which is resistant to extreme conditions of weather such as temperature, rain, humidity *etc* have been done to meet a request made by the Sri Lanka Air Force. A compound which may serve the purpose has been produced from one of these trials.

Work on the use of oil – extended natural rubber in tyre tread compound was continued. Some important technical properties such as resilience, compression set and abrasion resistance of rubber seed oil based vulcanisates were found to be better than those of natural rubber processing oil based vulcanisates.

The applicability of vein quartz powder as a filler in the rubber industry has been looked into.

Some work on the use of epoxidised natural rubber in tyre tread compounds has been carried out.

DETAILED REVIEW

Staff

Dr (Mrs) N M V Kalyani Liyanage was on duty throughout the year except from 22nd April to 1st June, when she was on medical leave. Dr B P Weeraratne was in charge of the Polymer Chemistry Department until 25th February. He vacated his post on 12th April 1994.

Mrs Dilhara Edirisinghe, Assistant Rubber Chemist left for UK on 22nd October, 1994 for higher studies at the University of Loughbourgh, UK.

Mrs Madhupani M Jayasuriya was on duty throughout the year.

Mr D D Medagama, Experimental Officer, retired from the services of the Institute on 6th September, 1994. Mrs Manel Mahanama, Senior Technical Officer and Mr K M U Mithrananda and Mrs Sriyani I Yapa, Technical Officers were on duty throughout the Year.

Mr D P Wettasinghe, Technical Officer, resigned from the services of the Institute on 5th October,1994.

Research Students:

Mr Rajiv Gunawardene and Miss Manel S Bandara from the University of Moratuwa, were trained under the National Apprenticeship Scheme.

Mr Pradeep Jayasuriya, an undergraduate from the University of Colombo, was trained under a vacation training programme.

Meetings, Seminars and Lectures:

Dr N M V Kalyani Liyanage[1], Madhupani M Jayasuriya[2] and Dilhara G Edirisinghe[3] participated in the following:

Progress control meetings of Road Development Authority to discuss the latex/ bitumen project.[1,2]

Scientific Committee meetings of the RRI.[1]

The first meeting of the "Working group on Tyres" held at Sri Lanka Standards Institute.[1]

The Diploma Course in Plantation Management as lecturers.[1,2,3]

Meeting held at the Ministry of Plantation Services to discuss as to how best the RRI can serve the rubber based industries in Sri Lanka in collaboration with the CISIR and IDB.[1]

The Diploma Course in Rubber Technology and the MSc Course in Polymer Science and Technology conducted by the Plastics and Rubber Institute and Sri Jayawardenapura respectively, as a lecturer.[1]

The "National Executive Management seminar on Radiation Vulcanization of Natural Rubber Latex" held at the Institute of Engineers.[3]

Meeting held at the Planters Association Auditorium to discuss the views of the overseas buyers on latex crepe presented in TSR form.[3]

Seminar on "ISO 9000" for rubber product manufactures organized by the Export Development Board.[3]

Meeting with some CARP representatives held at Dartonfield to discuss the research activities of RRI.[3]

Two meetings of Sectorial Committee on Polymers and Polymer Products held at the Sri Lanka Standards Institute.[1]

Presented two papers at the Annual sessions of SLAAS held at the University of Colombo.[1,2]

Publications

Liyange, N M V K, Jayasuriya, M M, Mithrananda, K M U, Mahanama, M, Wettasinghe, D P and Yapa, S I (1994). "Evaluation of performance of a white filler containing silica in tyre tread compounds". Proceedings of the 50th Annual sessions of the SLAAS, December 1994.

Liyanage, N M V K, Edirisinghe, D G, Wettasinghe, D P, Mahanama, M and Mithrananda, K M U (1994). "Use of oil – extended natural rubber in tyre retreading industry". Proceedings of the 50th Annual sessions of the SLAAS, December 1994.

Reports

Liyanage, N M V K (1994). Annual Review of the Rubber Technology and Development Department, 1993.

LABORATORY INVESTIGATIONS

1. Latex Technology

1.1 Artificial flowers out of NR latex:

Trials have been carried out to develop a suitable method to manufacture artificial flowers out of natural rubber latex which would almost be identical to natural flowers. A casting technique which appears to be most suitable for this purpose has been developed. Several latex compounding formulations including heat sensitive formulations to suit this technique have been tested (S W Karunaratne, N M V Kalyani Liyanage, Manel Mahanama and Dilhara G Edirisinghe).

1.2 NR latex in carpet backing

Some work on the development of a suitable latex compound for carpet backing has been done on a request made by Chemanex Ltd. A latex compound with good adhesion properties has been developed. Further experiments are in progress to improve the appearance of the latex backings (N M V Kalyani Liyanage, Dilhara G Edirisinghe and Sriyani I Yapa).

1.3 Latex bitumen emulsions in road constructions

It was evident that the use of modified positex in the preparation of latex/bitumen blends further improves the softening point and penetration level of bitumen. Also, the storage stability of resultant blends was found to improve with the addition of inorganic salts such as density modifiers and thickeners as viscosity enhancers (N M V Kalyani Liyanage, Madhupani M Jayasuriya, Manel Mahanama, D P Wettasinghe, and Sriyani I Yapa).

2. Dry Rubber Technology

2.1 Collapsible rubber tanks for storing aircraft fuel

The Sri Lanka Air Force is interested in fabricating collapsible tanks made from single ply nylon cloth coated on both sides with a fuel resistant elastomer.The tank and the components are to be suitable for operational deployment at temperature from $+51^0$C to -31^0 C. Further, the tank should resist exposure to extreme temperature, rain, fungal growth, high humidity conditions *etc*. The Sri Lanka Air Force sought the assistance of the RRI to develop an elastomer compound with the above characteristics. A few trials have been conducted and a compound which is suitable for this purpose has been developed. Experiments are being done to ensure that the compound is resistant to the above mentioned extreme conditions (N M V Kalyani Liyanage, Pushpa Gunatilleka, Madhupani M Jayasuriya, H N K K Chandralal and S S Warnapura).

2.2 Use of White carbon as a filler in the rubber industry

A series of laboratory trials on the use of white carbon as a filler in solid tyre formulations were performed. It was evident that the introduction of a small quantity of white carbon as a filler improved the ageing resistance of the vulcanisates. A report entitled "Effects of a white filler containing silica on rheological and technological properties of tyre tread compounds" was submitted to the Plastics and Rubber Institute as partial fulfillment of the Diploma in Rubber Technology (N M V Kalyani Liyanage, Madhupani M Jayasuriya, K M U Mithrananda, Manel Mahanama, D P Wettasinghe and Sriyani Yapa).

2.3 Vein quartz powder as a filler in the rubber industry

Technological properties of natural rubber vulcanisates containing various combinations of vein quartz powder and silica as fillers were evaluated. Some combinations of the two fillers were found to improve certain physical properties of NR vulcanisates such as resilience and hardness (N M V K Liyanage, Madhupani M Jayasuriya, Anoma Gunawardene, K M U Mithrananda, D P Wettasinghe, Manel Mahanama and Sriyani I Yapa).

2.4 Oil – extended natural rubber

Technological properties of the tread compounds prepared by using rubber seed oil (RSO) extended RSS were compared with those prepared by using normal rubber processing oil (PO) extended RSS. Resilience, compression set and abrasion resistance of RSO based vulcanisates were found to be better than those of PO based vulcanisates. Vulcanization behaviour of the raw OENR samples prepared with RSO was improved to a considerable extent (N M V Kalyani Liyanage, Dilhara G Edirisinghe, Manel Mahanama, D P Wettasinghe, K M U Mithrananda and D D Medagama).

2.5 Technological properties of tyre tread compounds based on epoxidised natural rubber

The use of epoxidised natural rubber(ENR)/NR blends in tyre tread compounds has been evaluated by using both 25% and 50% ENR. Blending of the two materials has been affected in the dry rubber stage as well as in latex stage to various compositions. Rheological and technological properties of tyre tread compounds based on these blends have been determined and the results clearly indicate that there is a significant improvement in resilience. Further work is in progress (N M V Kalyani Liyanage, Madhupani M Jayasuriya, Manel Mahanama, Sriyani I Yapa and K M U Mithrananda).

2.6 Controlled Release Fertilizers

It is known that use of controlled release concept in fertilizer applications, minimizes most of the known fertilizer losses and also the adverse effects of excess fertilizers to plants, environment and health. In this study, the matrix concept(the fertilizers are made into low soluble form by incorporating into polymers) has been selected to prepare control release nitrogen, phosphorous and potash fertilizers.

The required chemicals and raw materials were collected and the purity of all the chemical were tested using their melting point, density, FTIR spectra and TLC. Five grades of NR samples were selected and characterized for this study (B P Weeraratne, in collaboration with the Soils and Plant Nutrition Department).

INDUSTRIAL EXTENSION

The following industrialists have requested the services of this Department in product development and testing:

Central Industries Ltd.,	Testing of fusion behaviour and 'G "9cm heat and shear stability of PVC samples
Associated Motor Ways Ltd.	Testing of tread and cushion gum compounds
Midland Retreads (Pvt.) Ltd.	Development and testing of retread and cushion gum compounds for precured retreads
Road Development Authority	Testing of latex bitumen emulsions
Export Development Board	Development of tufting of foam on coir carpets
Central Rubbers (Pvt.) Ltd	Testing of examination gloves
Lanka Puthra Rubber Industries	Development of cushion gum compounds
Lanka Tyre Retreaders	Testing and development of tread and cushion gum
Plymouth Industries	Testing of masterbatches
Bata Shoe Co. Ltd.	Preparation of chemical dispersions
RRIATSCO (Pvt.) Ltd.	Testing of cure characteristics of rubber compounds
S-Lon Lanka (Pvt.) Ltd.	Testing of fusion behaviour and heat and shear stability of PVC samples
State Engineering Corporation	Preparation of nitrile rubber compounds
Double fashon	Development of latex compounds for screen printing
Sri Lanka Standards Institution	Testing of radiator hoses for adhesion strength and ageing characteristics
St. Anthony's Hardware Co. Ltd	Testing of hardness properties of various rubber seals
Hemas Manufacturing (Pvt.) Ltd.	Testing of toothpaste samples
Tootal Thread Manufacturing Co.	Testing of threads for colour fastness.
Various small individual industrialists	Advice on castings, dipped products, rubberized coir, *etc*

POLYMER CHEMISTRY

K G Karnika de Silva

SUMMARY

High priority was given to develop a suitable method (Bradford Assay) to analyze soluble proteins in latex examination, surgical and household gloves. The soluble proteins may cause skin irritation and eczematous reactions mainly among the healthcare workers wearing latex gloves at the workplace. Details of this work are reported in the review of Raw Rubber and Chemical Analysis Department.

Over 12 000 Coagulating pans have been produced with TPNR and distributed among the RSS manufacturers. This work has solved a major problem faced by them with regard to non availability and high cost of the aluminum pans normally used for latex coagulation. Use of recycled polypropylene upto 50% has been possible without adversely affecting the properties, when natural rubber is blended.

A new approach has been made to blend incompatible polymers (*eg* NR,NBR). Mixing of these polymers has been difficult under normal conditions and hence the properties of the blends have been poorer than expected. The use of 5–10% of a compatibilizer such as MG 30 or chloroprene rubber has shown encouraging results by giving improved physical properties and oil resistance. The compatibilizers can reduce the phase sizes of the components as shown in morphological studies and hence mixing of elastomers and chemicals has been achieved, effectively.

A non toxic grade constant viscosity (CV) rubber has been developed. Initial semi commercial scale trials have shown encouraging results.

A good natural rubber based adhesive has been developed to stick vulcanized rubber. This department assisted two private companies in developing rubber based adhesives for various applications.

Trials have been successful in using depolymerized rubber to replace processing oil and part replace natural rubber in compounding formulations. It was found that polymerized rubber, despite being a processing aid, can act as a non extractable and vulcanizable processing aid.

High level of epoxidation of NR latex has been obtained using deproteinized latex.

Clonal characteristics of four clones available at Dartonfield group have been studied. Gel content of RRIC 102 has been fairly low which is useful in mastication studies.

A large number of samples from the industry has been analyzed by the FTIR. Blooming and pinking problems in shoes manufactured at a factory in the free trade zone, Katunayake, have been successfully solved.

It has been shown that synthetic enzymes give better consistency and properties than natural enzymes in the manufacture of deproteinized natural rubber.

Double centrifuged and low nitrogen centrifuged latex seem to give a low protein content which is required for the latex based products that come in contact with the skin. This would avoid possible allergic reactions in healthcare workers.

DETAILED REVIEW

Staff

Dr K G Karnika de Silva, Head, Polymer Chemistry Department; returned to the country after successful completion of a five month fellowship at MRPRA UK. The project on NR blends was financed by the CFC and INRO. The project executing agency was the IRRDB.

Dr Pushpa Goonetilleka, Rubber Chemist, was on maternity leave till March 1994.

Mr S M C E Silva, Asst Rubber Chemist, was on duty throughout the year. Mr H N K K Chandralal and Mrs Indra Denawaka, Experimental Officers, were on duty throughout the year.

Mrs Chithra Kuruppu underwent a training in Thailand for two weeks under SRRP 11 funds.

Mr S S Warnapura, Senior Technical Officer and Messers S L G Ranjith, L P Vitharana and Miss Medhavi Wijesekera, Technical Officers, were on duty throughout the year.

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

Messers S Weerasiri, P R Sigera, Laboratory Attendants and Messers L Piyasena, D S Dharmawardene and J Dayaratne were on duty throughout the year.

Research students Miss Devika Kariyawasam (Univ. of Colombo) and Mr A Gunapala (Univ. of Moratuwa) were trained in this Department under various projects.

Seminars/Meetings

Dr K G Karnika de Silva attended the following;

* Central Scientific Committee meetings.
* CARP discussion meetings.
* Discussion with IDB officials about the possible industrial extension work.
* Discussions on speciality Rubbers with visitors from Germany and Pakistan.
* Workshop on rubberwood organized by CISIR.
* Seminar on International trends on latex crepe at Planters Association.
* PRI – AGM and Institute of Chemistry – AGM

Dr K G Karnika de Silva and Dr S A Pushpa Goonetilleka participated in the following :

* 50th Annual sessions of SLAAS and Institute of Chemistry.
* IRSG technical sessions.
* Seminar on RVNR latex.
* Seminar on ISO 9000.

Dr K G Karnika de Silva served as a lecturer for NIPM Diploma course and final year undergraduate students on Industrial polymers and served as a moderator for final year examinations at Kotalawela Defence Academy. Dr Pushpa Goonetilleke served as a lecturer for NIPM Diploma course.

Institute staff held exhibitions organized by Institute of Chemistry, SLAAS and assisted students of Royal College, Sirimavo Bandaranaike and Panadura Balika Vidyalaya in organizing their school exhibitions.

Publications and Reports

De Silva, K G Karnika, Ranjith, S L G, Abeysekera, W P M, and Warnapura, S S (1993). Some aspects of rheological characteristics of NR and PP blends, Proceedings of IRTC'93 – NR current development in product manufacture and applications – p.488.

De Silva, K G Karnika, (1994). Annual Review of the Polymer Chemistry Dept., 1993.

De Silva, K G Karnika (1994). Report on the participation of CFC/IRRDB Workshop held in UK, March 1994.

De Silva, K G Karnika, Ranjith, S L G and Warnapura, S S (1994). A Study of some of the properties of blends of polypropylene and chemical incorporated granular natural rubber. *Jl. Rubb. Res. Inst. Sri Lanka*, 74, 10–23.

De Silva, K G Karnika and Hamilelec, A E (1994). `Kinetic study of the graft polymerization of unsaturated monomers with natural rubber latex and with deproteinised natural rubber latex. *Jl. Rubb. Res. Inst. Sri Lanka,* 74, 57–78.

De Silva, K G Karnika, Silva, S M C E and Vitharana, L P (1994). Depolymerized Natural Rubber as a viscosity modifier for miscellaneous applications, *Proceedings of 50th SLAAS sessions.* (1994)

De Silva, K G Karnika (1994). NR/NBR blends with compatibilizers – 4th progress report submitted by IRRDB to CFC and INRO, June 1994.

De Silva, K G Karnika and Karunaratne, S W. An introduction to rubber based adhesives – submitted to *Bull. Rubb. Res. Inst. Sri Lanka*

Goonetilleke, S A Pushpa. `Diffusion of antioxidants in rubber', paper submitted to *Jl. of Rub. Chem. and techn.* for publication.

Goonetilleka, S A Pushpa, Silva, S M C E, Vitharana, L P and Denawake, Indra (1993). Preparation and characterization of soluble Cyclised Rubber from NR – latex, Proceedings of IRTC'93, NR Current Developments in Product Manufacture and application P.429.

Goonetilleka, S A Pushpa (1994). Volatility of stabilizers – Proceedings of 50th SLAAS sessions, 1994.

FIELD AND LABORATORY INVESTIGATION

1. Natural Rubber Blends

1.1 NR/NBR blends

Blending pairs of rubber has long been a practice in the rubber industry, but it is not a straightforward process. It is difficult and sometimes impossible in practice

to achieve the actual desirable characteristics of NR and NBR through simply blending of the elastomers mainly due to the inhomogeneity of the blends arising from inherent and fundamental problems such as differences in polarity, molecular structure, interfacial energy *etc* of components in the blends.

Data on research carried out on NR/NBR blends at the Polymer Chemistry Department in the recent past were made available to the project team at the MRPRA, UK in view of its usefulness in obtaining blends with improved properties. This project was aimed at developing new and improved blends of NR with speciality elastomers. The contribution made by the RRISL has been appreciated and reported as valuable in the third progress report submitted to CFC and INRO by IRRDB.

Speciality rubbers such as MG 30 and chloroprene rubber have been used as compatibilizers for NR and NBR blends to obtain homogeneous blends with improved physical properties. Significant improvements have been obtained as expected in crosslink density, morphology and oil resistant properties. The phase size of the two components seems to get reduced efficiently as required with the introduction of a compatibilizer to the system.

Based on the results obtained, IDB has done some industrial extension work with these blends. Introduction of these findings to the local rubber industry is in progress (K G Karnika de Silva, A J Tinker (MRPRA,UK) and S S Warnapura).

Blending synthetic lattices with natural rubber latex in different proportions for special applications has also been carried out using the knowledge gained from the dry rubber blends. Compounded latex of the latex blends with compatibilizers has been used to cast films and to study the physical properties. Further work on the project is in progress (K G Karnika de Silva, Anoma Gunawardena and Champa Lokuge).

1.2 Polyurethane/PVC Blends

A novel method of making Polyurethane (PU)/PVC blends was developed. In this new method, formation of PU from diol and diisocyanate is carried out in the presence of PVC powder. A series of experiments carried out to find out a suitable temperature for kinetic studies by using KBr disc technique indicated that 45°C is suitable. A calibration curve was obtained for Methyl Dipheayl Diisocynide (MDI) concentration in PVC powder by using the same technique. This is being used for kinetic studies. Effect of the following parameters on PU formation was also studied.

a. Type of PVC
b. Stoichiometric imbalance (*ie* Presence of excess isocyanate)

(M S M Alger and Laleen Karunanayake)

2. Depolymerized Natural Rubber

A number of formulations for adhesives based on non toxic grade depolymerized rubber has been tested in `post it' pads. Several adhesive formulations based on depolymerized rubber were tried out to join thick vulcanized rubber bands. Semi commercial scale production on depolymerized natural rubber has been carried out at Associated Speciality Rubbers (Pvt) Ltd who bought over the process of manufacture from the RRISL last year. Samples have been dispatched to Europe for testing and for market promotion.

Trials have been conducted to explore the possibilities of replacing processing oils used in processing of natural rubber with depolymerized rubber. It has been found that the depolymerized rubber could part replace natural rubber in formulations and is a better processing aid for natural rubber processing with low energy consumption. In addition, it could act as a vulcanizable material thereby enhancing the physical properties of the final product. In addition, it is a non extractable material unlike the common processing oils available in the industry. Further trials are in progress (K G Karnika de Silva, S M C E Silva, L P Vitharana and A Gunapala (trainee Univ. of Moratuwa).

3. Thermoplastic Natural Rubber

Over 12 000 coagulating pans have been distributed among the RSS manufacturers since mid 1993 to December 1994. Many smallholders are encouraged by this project due to the readily availability of the pans through the Polymer Chemistry Department and the low cost of the TPNR pans compared to aluminum or any other plastic pan available in the market. A royalty payment for each pan manufactured has been made to RRISL by the manufacturer as agreed.

Many inquiries have been made for TPNR latex collecting cups. The centrifuged latex manufacturers have shown a keen interest in improving the quality of latex to meet ISO 9000 standards to compete with the international market. The importance of replacing the traditional coconut shells used for latex collection with cleaner plastic cups has been accepted by the plantation companies. A small number of TPNR cups has been distributed during the past year (K G Karnika de Silva, H N K K Chandralal, S S Warnapura and S L G Ranjith).

4. Cyclised Rubber

Cyclised rubber can be successfully prepared by the latex method developed by the Polymer Chemistry Department. The solubility of the product is somewhat inconsistent due to unknown reasons and is the main draw back of this project.

Investigations on the behavior of cyclised rubber have been carried out in different aspects.

The most possible explanation is that the depolymerized rubber is subjected to oxidation as a side reaction as well as crosslinked *via* the free chain end even though precautions were taken to block the chain ends. Further, the extent of gel in latex due to these reasons depends on the period of maturation. Therefore, the manufacture of cyclised rubber for solution application is not desirable at this stage.

The other important area for the use of CR is, as a reinforcing filler. A study has been commenced to investigate the reinforcing action of CR in applications where light colour is important. The incorporation of fine white powder of CR into latex was successful by making a dispersion using a dispersing agent.

A series of compounds was prepared with different ratios of cyclised rubber to test the hardness and compression set against the compounds with high styrene resins (Pushpa Goonetilleke, S M C E Silva, L P Vitharana and Indra Denawake).

5. Epoxidised Natural Rubber

The latex obtained after epoxidation is of very dilute viscosity and has to be concentrated for applications such as manufacture of gloves *etc*. The ultrafiltration method which was developed in Malaysia for the same purposes is not economical for use in Sri Lanka.

Attention is therefore focused on carrying out the epoxidation reaction at high DRC levels of latex to obtain epoxidised latex of high DRC. Preliminary tests carried out for latex of 50 drc at room temperature for the low levels of epoxidation were successful. The increase in temperature was not favourable to enhance the efficiency of the reaction as the latex tends to coagulate. The coagulated rubber samples were dried out and analyzed for the epoxy content and compounded and tested for the oil resistance. It was noted that the oil resistant property of ENR has been improved significantly when compared to unmodified rubber vulcanizates.

Further work is underway to perfect the reaction conditions in order to carry out the epoxidation within shorter period (Pushpa Goonetilleka, L P Vitharana and S M C E Silva).

6. Gel content studies

6.1 Effect of gel content on prevulcanization of latex during storage

Latex stored for longer periods has shown irregularities during prevulcanization in the manufacture of certain latex products. A study has therefore been commenced to explore the possibility of controlling the factors such as gel content which finally affect the viscosity of latex. Initial trials have been conducted to determine the effect of storage time on prevulcanization of latex. (Pushpa Goonetilleka, Indra Denawake and Medhavi Wijesekera).

6.2 Study of variation of gel content in latex

In the systematic investigation of the gel formation in NR latex, special attention has been given to clonal and seasonal effects. Latex samples were collected from four different clones using RRIC 121, RRIC 100, RRIC 130 and RRIC 102 and preserved with two different preservative systems. The effect of preservation on the gel content was studied by using LATZ and HACL lattices. According to the results the gel content in LATZ was found to be lower than that in HACL and decreased with time. The variation of gel content in HACL was irregular. The lowest gel content was found in the latex obtained from RRIC 102 when compared with other three clones studied.

The other physical properties of latex such as viscosity, Po and PRI are also being evaluated for the same lattices (Pushpa Goonetilleka, S L G Ranjith, S M C E Silva and L P Vitharana).

7. Compression set behavior of rubber vulcanizates

A research project on compression set behaviour of rubber vulcanizates leading to a MPhil degree was commenced at the University of North London in Oct' 1992. This work continued at the RRISL from mid 1994, to study the effect of compression set on different grades of rubber produced in Sri Lanka. It has been observed that the compression set depends on the type of rubber, initial Po and mooney viscosity *etc*. The experiments are in progress to confirm the above observations and to study the correlation between the raw rubber properties and compression set values for a given formulation (S M C E Silva, A S Farid (Univ. of North London and L P Vitharana).

8. Deproteinized natural rubber

Synthetic enzymes have been tested for their suitability in DPNR manufacture. The colour of the samples is much whiter than the samples prepared with natural enzyme, papain. The other properties are also comparable or even better than the conventional samples. Further trials are underway.

Lankem Company has shown interest on DPNR samples prepared with synthetic enzymes (K G Karnika de Silva, S S Warnapura and Chithra Kuruppu).

9. Trolley wheels

Several formulations have been prepared to improve the compression set behaviour and the hardness of trolley wheels manufactured by the DSI (Pvt) Ltd for export market. Experimental wheels were turned out at the factory using the new formulations. Higher percentage of high styrene resin (HSR) seems to increase the hardness but the compression set seems to reduce with HSR. MG 30 rubber was found to reinforce the natural rubber with low compression set. Further trials are in progress (K G Karnika de Silva, H N K K Chandralal and Chithra Kuruppu).

10. Preservative system for Hypodermic Latex Extraction (HLE) method, used for sole crepe manufacture

Since high ammonia preservation has been found to discolour sole crepe, it was necessary to find a suitable preservative system for HLE latex used for sole crepe manufacture. Several systems have been tested to preserve HLE latex that flows for 3–4 days from the tree. A preservative system based on low ammonia/boric acid/formic acid has been recommended as the most suitable system to preserve HLE latex without adversely affecting the physical properties. This work has been carried out on a request made by the Free Lanka Plantation Company and further trials are in progress

A report titled "A study of a suitable preservative system for the manufacture of sole crepe from HLE latex" has been submitted by S L G Ranjith as a partial fulfillment of the requirement for the Diploma in Rubber Technology (K G Karnika de Silva, Chithra Kuruppu and S L G Ranjith).

11. Properties and cost analysis of centrifuging latex prepared in different ways

A request has been made by the Mal Lanka (Pvt) Ltd to carry out a detailed study and a cost analysis of centrifuged latex prepared in different ways.

It is known that the use of latex with low ammonia, TMTD and low protein/nitrogen content is more suitable especially in products that are in contact with skin to avoid possible skin allergic reactions.

Double centrifuged and low nitrogen latex may be the solution for this, if the properties and the cost can meet the requirement.

Studies are underway to evaluate the properties of different types of centrifuged latex (K G Karnika de Silva, Laleen Karunanayake and Champa Lokuge).

12. Speciality grades of rubber (pilot plant)

The council for Agriculture Research Policy (CARP) has granted necessary funds to this department to construct a pilot plant at Dartonfield to manufacture speciality grades of rubber on semi commercial scale. Initial steps have been taken to fabricate the reactor and other equipment according to the requirements.

INDUSTRIAL EXTENSION

Soluble proteins in gloves	Ansell Lanka (Pvt) Ltd,
Dipped Products	Hanwella Rubber Products
TPNR	Hapangama Rubber Products
Trolley Wheels	IDB, Bata Shoe Co, DSI
Constant Viscosity Granular rubber	C W Mackie Ltd
Blooming	Plymouth Industries
NR/NBR Blends	IDB
Evaluation of latex gloves	Palma (Pvt) Ltd
Adhesives	Sinwa Holdings, Sherman Sons
Polymer Analysis (From FTIR)	Various industries
DPNR	Ceysta, Chemanex, IDB, Microcells
Bloom and stain analysis	Lankem Lanka
Purity of Chemicals	Korea Ceylon Footwear
Analysis of Polymer Content	Mal Lanka

RAW RUBBER AND CHEMICAL ANALYSIS

L M K Tillekeratne

SUMMARY

This department was engaged in the following activities during the year:

(a) Analysis, grading and issuing shipping certificates for all TSR produced in the country.
(b) Analysis and issuing quality certificates for sheet and crepe rubber.
(c) Analysis and certification of concentrated latex manufactured in the country for local industries and for exports.
(d) Analysis of chemicals and water used in the NR industry.
(e) Testing of finished products such as SPP content in rubber gloves and rubber content in vulcanized products for exports.
(f) Analysis and certification of masterbatch and reclaimed rubber for exports.
(g) Organizing demonstrations on preparation of rain guard sealant for RDOs of the Rubber Development Department and smallholders.
(h) Assistance was rendered to other departments in their research and extension work by analyzing dry rubber, latex, chemicals and water samples.
(i) Research works were carried out on following projects:

* Evaluation of properties of conventional grades of rubber which can be presented in Technically Specified Rubber (TSR) form.
* Effect of sea water on different types of rubber.
* Evaluation of protein content in dipped NR products.
* Production of Constant Viscosity (CV) rubber.

DETAILED REVIEW

Staff

Dr L M K Tillekeratne, Director, was overlooking the work of the Department. Mr L Karunanayake, Assistant Specifications Officer, was on duty throughout the year. Mrs Anoma Silva, Assistant Rubber Chemist, returned to the Island on 21st January after successfully completing a six month training programme on "Radiation Prevulcanisation of Natural Rubber" and proceeded to Loughborough University, UK for her postgraduate training on 28th November 1994.

Mrs Sriyanthi Weeraman, Experimental Officer, and Mrs L Wanigatunaga, Senior Technical Officer, were on duty throughout the year.

Technical Officers, Mrs Nanda Baduge, Mrs Vasantha Gamage, Mr R S Wijesundara, Mrs Champa Lokuge, Mrs Geethani Rajapakse, Mr G Wanigatunga and Mr P L Perera and Instrument Technician, Mr P Lelwela, were on duty throughout the year.

Specifications Assistants, Messrs B Gunasiri and K R N Karunatilake, were on duty throughout the year.

Mr W W Nandasena left for an overseas job on 30th March 1994. Laboratory Attendant, Mr Wimaladasa Vithanage and Office Peon, Mr Sarath Chandrasiri, were promoted to the specifications assistant grade with effect from 1st July 1994.

Clerk Typist, Mrs I Wijesinghe, was on duty throughout the year.

Laboratory Attendant, Mr Sirisena Gallege and Laboratory Labour, Mr G H Somasiri, were on duty throughout the year.

Visits

Dr L M K Tillekeratne, Director and Mr P L Perera, Technical Officer visited the Colombo harbour to inspect and to draw samples from waste rubber that was salvaged from a sinking ship, for the purpose of submitting a report.

Mr R S Wijesundara, Technical Officer and Mr W Wimaladasa, Specification Assistant, visited Statcon Rubber Factory, to inspect a consignment of RSS rubber ment for exporting, for issuing an inspection certificate.

Meetings and Seminars

Mr L Karunanayake, Assistant Specifications Officer, delivered lectures on manufacturing TSR for the following courses.

* Training course for planters organized by NIPM.
* Training course for Factory Officers organized by NIPM.

Mrs Anoma Silva, Assistant Rubber Chemist, delivered a lecture on "Manufacturing of RSS and ADS" for training course organized for planters by NIPM.

Training

Practical classes were conducted for the MSc students of the University of Sri Jayewardenapura.

LABORATORY INVESTIGATIONS

Effect of Sea Water on Block Rubber

Blocks of technically specified rubber, 300g in weight, were dipped in sea water. They were taken out after 10,20,30,40 and 60 days and dried in an oven heated to 70°C. These blocks were then homogenized and tested for the following properties together with the control samples:

1. Volatile matter content.
2. Po and PRI.
3. Ash content.
4. Mooney viscosity.
5. Physical properties.

(Anoma Silva and Wasantha Gamage)

Evaluation of raw rubber and the physical properties of different grades of TSR and raw materials used for TSR manufacture:

The objective of this study is to evaluate the raw rubber and physical properties of different types of rubber grades which can be presented in TSR form. There are large number of enquiries from rubber consumers about the properties of raw rubber and enquiries from manufactures about selection of raw material to meet the consumers demand.

Therefore, a detailed study on raw rubber and technological properties of different grades of natural rubber was started. A series of samples was collected and analyzed.

A. Evaluation of raw rubber properties (L Karunanayake, H S Weeraman, L Wanigatunga, W Gamage, P L Perera and B Gunasiri).

B. Evaluation of Technological properties (A Silva, G Wanigatunga and K R N Karunatilleke).

1. *Latex Proteins*

High priority was given to develop a suitable method to analyze soluble proteins in latex gloves.

The discovery in the recent years that the residual soluble proteins in the latex products can cause skin allergy problems including skin irritation, eczematic reactions *etc* to sensitized persons mainly among the health care workers, wearing gloves at the work place, led us to initiate this work.

The analysis of the proteins using Bradford Assay has been successfully developed by the RRIM. Extraction of glove cuttings from four leading companies exporting examination surgical and household gloves were analyzed using UV spectrophotometer.

Chlorination and leaching in water at different conditions have given lower percentage of soluble proteins in the gloves.

Further, tests and analysis of gloves are in progress (K G Karnika de Silva, H N K K Chandralal, Anoma Silva, Lalin Karunanayake and S L G Ranjith).

2. *Preparation of CV Rubber*

i. Non-toxic grade CV rubber:

A few samples of non-toxic grade constant viscosity rubber were prepared for commercial scale trials. The toxic fumes of hydroxyl amine neutral sulphate usually experienced in drying stage of conventional CV rubber were not experienced with the new batches.

Analysis of raw CV rubber and the evaluation of their technological properties are under investigation (K G Karnika de Silva, S M C E Silva and L P Vitharana).

Constant Viscosity Rubber - Latex method

The natural rubber is subjected to storage hardening unless it is treated to prevent crosslinking during storage. Constant Viscosity rubbers do not have consistent properties due to some factors. Therefore this study was commenced to develop a method for the manufacture of CV rubbers, from field latex to obtain constant quality

rubbers. Preliminary trials conducted show that the P can be reduced to a lower value (*ie* 2) by our method. Further trials are underway to prepare samples having viscosity of 60 (Pushpa Goonetilleke, Chitra Kuruppu and S L G Ranjith).

MISCELLANEOUS

Table 1. *Number of the samples tested from each TSR factory during 1994*

Code	Producer	No. of samples
AD	Statcon Block Rubber Factory, Getahetta.	879
AE	Sherman Block Rubber Factory, Ingiriya.	1305
AF	Ceymac Block Rubber Factory,	1484
	Total	3668

Table No 2. *Miscellaneous samples tested during the year 1994.*

Samples	No. tested
Rubber samples	597
Water samples	08
Latex samples	223
Chemicals	89
Masterbatch	213
Gloves	64
Reclaim rubber	204
Polythene	15
Total	1413

RAW RUBBER PROCESS DEVELOPMENT AND CHEMICAL ENGINEERING

W M G Seneviratne

SUMMARY

Investigations on the Mooney viscosity of rubber revealed that it depends very much on different processing conditions such as the dosage of peptisers, processing and drying temperature *etc*. However, dilution of latex was found to have a lesser effect on viscosity reduction of rubber. Much emphasis was placed on the manufacture of CV 60 grade which is in high demand among the rubber industrialists here and abroad. A batch of CV 60 crepe rubber prepared at the Dartonfield rubber factory was sent to Germany through M/s Associated Traders.

The evaluation of physical properties of raw crepe rubber prepared under various conditions showed that they possess different levels of properties and hence could be presented to the market with technical specifications to enable the end user to select the most suitable grade of crepe rubber required for his purpose. Evaluation of physical properties of different compositions of the blends of skim rubber/Natural rubber shows that certain important properties are comparable to those of average NR compounds and therefore these blends could be used for some special applications.

Council of Agricultural Research Policy (CARP) has awarded a grant to set up a demonstration treatment plant and to organize an effluent testing laboratory at the RRI.

Associate Agreement between the BKH environmental consultants from Netherlands and the RRI has been signed for the complete execution of the effluent treatment plants that have been proposed for three rubber factories.

Effluent treatment plant to treat effluent discharged from Nakiadeniya oil palm factory is now in operation and rubber factory effluent treatment plant too is nearing completion and would be able to commence operation soon. Both treatment plants are designed, based on anaerobic/aerobic treatment principle developed by the RRI, recently.

Treatment plants were also designed for various other industries such as ceramics and pesticide plants to treat the waste water prior to their disposal to comply

with the CEA standards. Preparation of draft Quality Manuals and Procedure Manuals of the ISO 9000 Quality Assurance Scheme for six rubber processing factories is now completed. A few of these factories have already begun reorganization of the premises and of the processes of manufacture to suit the ISO guidelines according to the manuals, aiming to obtain ISO 9000 accreditation, subsequently.

A large number of Rubber estates/factories was visited during the year in order to help them in improving the quality of their raw rubber manufactured as this is one of the main functions of this department.

DETAILED REVIEW

Staff

Dr W M G Seneviratne was appointed as the Head of the Department with effect from 26th April.

Mr Susantha Siriwardena, Assistant Rubber Chemist, left for Australia on 26th February to pursue his Post graduate studies at the University of Melbourne.

Mr P P Jayasinghe, Development Officer, was transferred to the department in July and was on duty since then.

Mr P H Sarath Kumara, Experimental Officer, visited Indonesia in July for a two weeks' training on Raw Rubber Processing.

Messrs C D Senanayake, T A S Siriwardena and Mrs W K C Nalini; Technical Officers were on duty throughout the year.

Miss Malkanthi Thenabadu joined as a temporary Technical Officer on 01st of November to work in the project on Effluent Treatment Technology funded by CARP.

Mr R M U N Ratnayake, Trainee Development Programme Assistant from the Ministry of Policy Planning, was undergoing training since 10th October, under the graduate training programme.

Mrs Anusha Paranavitane, Clerk/Typist and Mrs L Rukmani, Stores Assistant, were on duty throughout the year.

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

Research Students

NDT students, Miss M A Priyanthi Marasinghe and Mr J A Sujith Pushpakumara, were trained under the National Apprenticeship Board Scheme.

Meetings, Seminars and Lectures

The head of the Department was engaged in the following;

* Attended a seminar held at Central Environmental Authority on "Anaerobic Digestion of Distillery wastes' by Mr Andrew Milstead, UNIDO Technical Expert, on waste water management.[1]

* Attended a seminar on `waste management and control' organized by IWEM at Sausiripaya.

* Served as a member of the Panned of Examiners at the Examination on Rubber Manufacture for Planters' conducted by NIPM.

* Participated at a discussion with Mr P Logat of United Nations on `Maximization of the use of energy in waste management' held at the Central Environmental Authority.

* Attended a seminar on `ISO 9000 Quality Assurance Scheme' held at the World Trade Centre Organized by the Export Development Board.

* Attended the IRSG Conference held during the period between 23rd May and 27th May.

* Attended the ANRPC Meeting held in Colombo on 30th and 31st May.

* Attended all PRI Committee meetings and two education sub committee meetings.

* Served as the Course-coordinator for the rubber module of the 7th Diploma Course for Planters conducted by NIPM at RRI.

* Conducted lectures at Colombo and Jayawardenepura Universities.

* Served as the Chief Examiner for the 7th Diploma Examination on Rubber Module conducted by NIPM at Athurugiriya.

* Attended two NIPM technical committee meetings.

* Attended a workshop and seminar conducted by Sri Lanka Energy Management Association.

* Attended a workshop on ISO 9000 at Colombo Marriot Hotel.

* Attended four scientific committee meetings.

* Supervised the NIPM 7th Diploma examination on Plantation Management conducted at NIPM, Athurugiriya, in October.

* Delivered a lecture on ISO 9000 implementation for Tea industry at the Professional course for Tea manufacturers at NIPM auditorium at Bogowantalawa in November organized by NIPM.

Dr W M G Seneviratne[1], P H Sarath Kumara[2] and T A S Siriwardane[3] participated at the following ;

* `Delivered an introductory talk on' Latex based products manufacture' for the youth at the Gatamanne Youth Training Centre at Beliatte.[2]

* Discussions on `Pale crepe manufacture' specially intended for factory officers organized by the SRMC at its Head Office, on two occasions. [1,2]

* Addressed the Managers, Asst. Managers and Factory Officers on `Pale crepe rubber processing and manufacture' at a seminar organized by BC Plantations Limited held at Yatadola Estate.[1,2]

* Delivered five lectures for medium scale raw rubber manufacturers at Nivithigalakele Training Centre. All aspects of processing and drying of raw rubber were covered.[2]

* Attended the IRSG Conference held on 26th and 27th of May.[2]

* Attended a training programme on `Raw Rubber Processing' at Sembawa Research Station in South Sumatra belonging to Rubber Research Institute of Indonesia during the period between 6th July and 19th July.[2]

* Visited Pallegoda, Eladuwa and Yatadola estates to advise the Estate Managers and Assistant Managers of Bartleat Company Limited on the manufacture of crepe rubber. This was followed by a workshop held at Pallegoda estate where a demonstration was also carried out on fractionation of latex by the aeration technique.[1,3]

* Conducted lectures for part – time course in Polymer Technology at the University of Moratuwa.[2]

Publications

Seneviratne, W M G and Siriwardena, T A S, (1994). Influence of non rubber constituents on physical properties of crepe. *Annual Sessions SLAAS December 1994.*

Visits

Advisory visits for development work on crepe, RSS and Block rubber processing and manufacture

The following estates and rubber factories were visited during the year:

Wellandura Fstate

Discolouration of the crepe rubber produced at their factory was due to heating of the mills. The delay in drying was due to the excessive number of ducts in the drying tower and the slightly higher thickness of the laces and also due to insufficient washing of the laces. The Factory Officer was given instructions accordingly, to take remedial measures.

Hapugastenna Estate

Discolouration of crepe rubber was reported. Inspection of the factory revealed that there were several reasons for the discolouration and a comprehensive report was sent with a set of leaflets.

Kiriporuwa Estate

Discolouration of their sole crepe was reported. This discolouration was found to be mainly due to the delay in the transport of latex to the factory and inadequate capacity of the bulking tank and coagulation tanks. A report was sent with remedial measures that should be adopted.

Palmgarden Estate

Assistance was sought from the RRI, to prepare the ground plan for installation of machinery *etc* in the factory building to recommission this factory in order to process about 2 000 kg of the estate crop as well as 1 000 kg from Mahawela estate. Inspection of the building was made and a ground plan was subsequently sent. A discussion was held later to discuss the final plan of machinery layout prepared by Colombo Commercial Company according to RRI recommendations.

Eduragala Estate

This estate was visited to obtain information for the purpose of proposing a suitable drying chamber for drying of ADS. A sketch of a plan of the drying chamber was forwarded later.

Vincit Estate

A visit was made to the centrifuge factory at Vincit estate following a complaint and a request made by the management of the Malwatte Valley Plantation Company to look into the recorded loss of 6.5% of centrifuged latex from the Vincit factory. An experiment was carried out at their request and the results of this experiment indicated that there was no possibility for such a loss and that the percentages of dry rubber which go into cream, skim latex and washings calculated on the total throughput could be taken as follows;

Cream	= 88%
Skim latex	= 10.0 – 10.5%
Washings	= 1.5 – 2.0%

RRI officials visited this factory several times later to investigate into the loss of 36 132 kg (DRC) of centrifuged latex that occurred at the factory during the period February to June.

Investigations were focused on the following and appropriate recommendations were made accordingly, to prevent further losses, after a few experiments:

* Thorough study and evaluation of the factory crop book records.

* Determination of the latex concentrating efficiencies of each centrifuging machine separately.

* Establishment of an average recovery percentage.

* Mathematical calibration of dipsticks for reception and storage tanks for very accurate measurements of the quantity of latex *etc* was done.

Calibration charts were computed for new dipsticks for reception and storage tanks with the aid of the computer and sent to the factory for calibration of the dipsticks.

A comprehensive report was later sent to the management of the estate detailing all the reasons, comments and observations in respect of these losses. Subsequent to implementation of these recommendations, management of the company informed the RRI that no losses have been observed and that they would continue to adhere to the same practices in the future too.

Yatideriya Rubber Factory

A visit was made to the factory at their request with a view to set up an effluent treatment unit. This company has shown interest in going for a treatment unit recommended by the RRI. In the first stage, a 1500 gallon capacity effluent treatment unit was proposed to be set up at the site making due allowance for extending it further to cater to the entire amount of effluent discharged by the factory.

A comprehensive report to set up a full scale treatment plant was submitted.

Eheliyagoda estate

After a preliminary discussion the company officials had with BKH Consulting Engineers of Netherlands, both parties mutually agreed to set up an effluent treatment plant on the estate with BKH assistance. RRI played an important role in bringing these two parties together and a substantial amount of the cost that will be incurred in the project will be borne by the government of Netherlands. As a follow up of this, a visit was made to the estate by Mr Hans Bruins, Environmental

Technologist of BKH Engineers, and the design of the treatment plant was completed with the help of the RRI.

Paiyagala factory

Visited the Paiyagala skim processing factory on a request made by the General Manager of the Kotagala Plantations Limited in order to advise on the present effluent discharging system adopted by the factory of Ansell Lanka Limited which sends the skim latex to be processed at the Paiyagala factory. Kotagala Plantations Limited agreed to set up a treatment plant jointly with Ansell, in consultation with the RRI. A comprehensive report was sent along with sketches of plans for a cost effective treatment method.

The factory was later visited occasionally and was advised repeatedly until the work was completed at the end of the year to partial satisfaction of the RRI. The anaerobic digester with stainless steel partitions is now completed and ready for operation.

Sorana Rubber factory

The factory was visited in view of making recommendations for refurbishing of the same to improve the condition of the factory.
A report was sent to this effect.

D. Samson Industries – Reclaiming factory, Galle

It was observed that a notable quantity of effluent was being discharged from the reclaiming process. The effluent which is directly generated from autoclave blowdowns had a very strong bad ordour. This was mainly due to the use of strong peptizing agent in the reclaiming process.

Several methods were attempted to treat this effluent and finally activated sludge aeration process yielded successful results. Complete design of the treatment plant was submitted subsequently.

Gunaseela Rubber Mills

This factory was visited to inspect the partly constructed building to be converted into a smoke house. Sketches of plan for a 2000 kg capacity smoke house with other relevant details of the construction of smoke house were sent subsequently.

Sunderland Estate

Sketches of plan for a smoke house of 5000 kg capacity were sent on a request made by the Manager of the estate.

Statcon Block Rubber factory

Assisted in the preparation of creamed latex.

Mal Lanka Rubberized Coir and Foam Rubber Factories - Ranala

Design of an effluent treatment plant was submitted to the proposed factories at Ranala, based on anaerobic/aerobic digestion process.

Glenross Centrifuging factory - Matugama

This factory was visited to advise on the construction of the effluent treatment plant proposed by the RRI.

Werellamandiya and Nothamberland Rubber factories - Kosgama and Puwakpitiya

These two factories were visited for inspection and obtaining information to make recommendations for infrastructure developments and to improve the existing processing facilities available on the two sites. Werellamandiya was proposed to be developed as a good crepe rubber processing factory and Nothamberland as a good RSS and scrap rubber processing centre. A report with recommendations and a plan for a smoke house was sent for these development work.

Dewalakande Crepe Rubber Factory

This factory was inspected at the request of the Estate Manager to explore the possibility of modifying the existing conventional drying tower into a forced air drying system. It was proposed to install a fan having longer blades in the radiator room to distribute and forcibly convect up the heated air inside the drying tower, to accelerate the rate of drying. Consequently, the estate was visited again with M/s Industrial Engineers for designing a technique for one of the drying towers on an experimental basis. A report and the estimate for these modifications were subsequently forwarded and the technique is yet be implemented.

Nakiadeniya Rubber factory

The existing buildings were inspected to design a plan for a smoke house, and the report was sent with sketches of the plan.

Sherman Sons Block Rubber Factory - Ingiriya

A trial was carried out employing a novel method to manufacture CV rubber from scrap materials.

Sirikandura Estate

An inspection was made to the abandoned drying tower building at Mukalana Upper Division and a modified plan for a smoke house for this existing building was sent along with additional handouts on 'manufacture of RSS'.

An alternate plan also was sent for modifications of the same for air drying of sheets.

Pallegama and Atale Rubber Factories

Visited these two factories to collect information to prepare an evaluation report on effluent treatment employed at these two factories. The report was submitted to the scientific committee.

Udapola estate - proposed effluent treatment plant

Dr W M G Seneviratne served in the technical Committee in the evaluation of the tender bids submitted by various contractors to set up a treatment plant to treat centrifuged latex effluent discharge at Udapola factory, Polgahawela. A technical report was submitted to Kegalle Plantations for final approval.

Mackwoods factory - Ekala

An effluent treatment plant was designed for the waste water generated from pesticide and weedicide plants of M/s Mackwoods factory, after a series of trial experiments at the RRI laboratories. Treatment technique based on anaerobic/aerobic process was found to be highly satisfactory with final Alum mixed sedimentation and ordinary sand bed filtration. A complete design was sent.

Pussella rubber factory

A comprehensive report with detailed sketches of plans was sent to Pussella SP to set up a treatment plant to treat factory effluent which is causing a significant environmental threat to the neighbourhood.

Peedamo Ceramic (Pvt) Limited

A visit was made to the proposed BOD approved ceramic factory site at Panadura Industrial Zone with a view to propose a possible waste water treatment plant to treat factory discharge generating from production of ceramicware. After experimenting with the effluent discharged from their existing factory, a treatment plant was designed based on only sedimentation and sand bed filtration technique.

LABORATORY AND FIELD INVESTIGATIONS

Manufacture of CV RSS and CV crepe rubber

This project was started in the previous year and was continued this year too. Investigations were extended to study the effect of the dilution of latex, the dosage of peptizer, dripping the sheets under the sun and heating at elevated temperature on the reduction of Mooney viscosity of RSS. The results have shown that all the above factors have a clear bearing on the final Mooney viscosity of RSS.

Results of the trials carried out on manufacture of CV crepe indicate that dilution of field latex has only a minor effect on viscosity reduction. Exposure of laces to sun for 2 hours or doubling the recommended number of mill passes with 50 g peptizer added on 100kg of dry rubber can bring down the Mooney viscosity of rubber to 50 units.

At the request made by a German delegation a batch of 25 kg of crepe rubber Cv 60 produced at Dartonfield Rubber Factory was despatched to Germany through Messrs Associated Traders (W M G Seneviratne, P H Sarath Kumara and T A S Siriwardane).

Effluent Treatment and disposal

Laboratory and Pilot Plant experiments on the treatment technique based on enclosed anaerobic coupled with aerobic process have now been completed. The

treatment technique has been found to be highly cost effective when compared with the other conventional treatment techniques available to treat industrial waste waters. The treatment principle can be summarized as follows:-

(1). Rubberized coir carrier matrix filled Anaerobic septic tank digester.

(2). Aerobic process:- Cylindrical with slightly conical bottom tank.

One day retention period. Fine bubble aerator is preferred to maintain 2 ppm oxygen level right throughout the digestion period.

(3). Sedimentation/clarifying stage:-

Cylindrical with conical bottom tank. Half day's retention period is adequate.

(4). Sand bed filtering unit:-

Ordinary sand bed filter is required for final polishing of the treatment for effluent after sedimentation process.

Central Agricultural Research Policy (CARP) has awarded a grant of Rs.1.9 millon to set up a demonstration treatment plant near the rubber factory at RRI, Dartonfield and to organize an effluent testing laboratory at the Ratmalana premises. Implementation of both these activities commenced in November 1994.

Associate Agreement between the environmental Consultants, BKH from Netherlands and the RRI has been signed in respect of the effluent treatment plants proposed for Ellakanda, Eheliyagoda and Hanwella Rubber factories. These three projects are sponsored by the Government of Netherlands. BKH Consultants have included the Aerobic digester unit in their design as one of the treatment stages to be coupled to the other processes proposed by them. According to the agreement, RRI should be involved in the complete execution of the project and in testing the quality of the treated effluent in RRI laboratories. The plant at Ellakanda factory is now nearing completion.

A 25 000 gallon capacity oil palm effluent treatment plant is now in operation at Nakiadeniya oil palm factory.

The rubber factory waste treatment plant in the same plantation is due to be commissioned shortly. Both processes are based on Anaerobic/Aerobic technique (W M G Seneviratne, T A S Siriwardena and W K C Nalini).

ISO 9000 Quality Assurance Scheme

Assistance required by Plantation Management Companies to prepare ISO Quality manuals for their rubber factories was extended.

The following estates were visited to gather information for the preparation of the manuals and considerable time was spent with the staff of the factories to explain the concept of the ISO quality management system.

(1).	Padukka Estate	–	Padukka.
(2).	Elston Estate	–	Puwakpitiya.
(3).	Madampe Estate	–	Kahawatte.
(4).	Rambukkanda Estate	–	Ratnapura.
(5).	Elpitiya Estate	–	Elpitiya.
(6).	Peenkande Estate	–	Nivithigala.
(7).	Vincit Estate	–	Waharaka.

Draft quality manuals and procedure manuals for the factories of the above estates, except for Vincit, were prepared and sent to the respective estates for their comments and return. The manuals and all the supporting documents for Dartonfield factory are completed.

Nakiadeniya and Frocester estates have to be visited for gathering information to prepare the manuals (S W Karunaratne, W M G Seneviratne, P P Jayasinghe and P H Sarath Kumara).

Evaluation of physical and raw rubber properties of skim rubber/NR blends

Various types of skim rubber (sorted and unsorted) blended with natural rubber and Deprotenized natural rubber (DPNR) in different compositions were tested. Physical properties of some of the blends revealed that some of the properties were comparable to pure NR compounds and hence they could be used in certain applications of the rubber industry. These have yet to be tried out in industrial scale (W M G Seneviratne, P P Jayasinghe, T A S Siriwardane and C Senanayake).

Raw Rubber and physical property evaluation of different types of NR

Following types of crepe rubbers prepared from the same batch were subjected for analysis.

UFUB – Unfractionated unbleached rubber.
UFB – Unfractionated bleached rubber.
FUB – Fractionated unbleached rubber.
FB – Fractionated bleached rubber.
UF – Yellow fractionated rubber.
LNNR – Low Nitrogen Natural Rubber.
RSS – Ribbed smoked sheets.

Physical properties were studied with a standard tyre tread formula. Each type of rubber showed the properties expected from its their raw rubber properties. Dynamic properties were found to be superior in LNNR and to a lesser extent in rubbers whose nitrogen content is lower than other grades of rubbers as revealed by tan δ value. Hence the customary visual gradings adopted for marketing of rubber should now be eliminated and should cater the rubber to the end users according to their technical requirements (W M G Seneviratne and T A S Siriwardane).

ADAPTIVE RESEARCH UNIT

N Yogaratnam

SUMMARY

New Programmes were started on, organic manures such as poultry litter and dead mulch of rice straw, Eppawela rock phosphate as a source of phosphorous for immature rubber, young budding and multicropping of rubber with tea. Girth of rubber plants did not show any significant difference between treatments in the experiment on multicropping of rubber with tea. A newly developed collar protectant has given promising results in the management of white root disease in smallholdings. Results of the rainguard programmes indicate that the number of extra tapping days possible with the use of rainguards would be as high as 52 days in some areas.

DETAILED REVIEW

Staff

The Deputy Director (Research), Dr N Yogaratnam coordinated the activities of this unit. Following officers were on duty throughout the year:.

Research Assistant in Agronomy	:	Mr S M M Iqbal
Development Officers	:	Mr F P W Silva
		Mr W C Dayaratne
Senior Technical Officer	:	Mr E A T Senadeera (Kegalle Region)
Senior Testing Officer	:	Mr S Wijesekera (Galle Region)

Mr P P Jayasinghe, Development Officer was transferred to the Raw Rubber Processing Development and Chemical Engineering Department with effect from 1st July 1994.

Other Scientists and Extension personnel involved in this programme are :

(A) SCIENTISTS :

Dr N E M Jayasekera	:	Head, Genetics and Plant Breeding
Dr A Nugawela	:	Head, Plant Science
Dr (Mrs) L Samarappuli	:	Head, Soils and Plant Nutrition
Mr C K Jayasinghe	:	Head, Plant Pathology and Microbiology
Dr (Mrs) K de Silva	:	Head, Polymer Chemistry
Mr V H L Rodrigo	:	Research Officer in Intercropping
Mr P H M U Herath	:	Asst. Agricultural Economist

(B) EXTENSION PERSONNEL :

Mr K Meegahawatta	:	Deputy Director Extension, Rubber Development Dept. (RDD)
Mr P Samaranayake	:	Asst. Director Extension, Kalutara, (RDD)
Mr D D Dasanayake	:	Asst. Director Extension, Kegalle, (RDD)
Mr A H Kularatne	:	Asst. Director Extension, Ratnapura, (RDD)
Mr G Gunawardena	:	Asst. Director Extension, Colombo, (RDD)
Mr A Kalubowila	:	Asst. Director Extension, Galle/Matara, (RDD)

Temporary worker

Miss Rupani Ratnasinghe, Temporary Technical Assistant (CARP) resigned on 1st April 1994.

Visits

The World Bank Mission of the SRRP II made inspection tours to the Adaptive Research Experimental areas in the Kalutara region.

Meetings

Mr S M M Iqbal, delivered a lecture on "Objectives and Role of Extension Supervisors on the Implementation of Adaptive Research Programme" at the work shop for Senior Rubber Development Officers organized by RDD at Nivitigalakele and

"Multicropping of Rubber with Tea" at the meetings with smallholder and Rubber Development Officers – Galle region, organized by RDD.

The Adaptive Research Unit staff attended the following:

(1) Review Meetings of the ARU and RDD.
(2) Monthly conferences in all regions.

Mr S Wijesekera attended the smallholder meetings in the Galle/Matara region and discussed the Adaptive Research Programmes.

Publications

Yogaratnam, N and Iqbal, S M M (1994). Multicropping of Rubber lands with Tea. *Jl. of National Institute of Plantation Management* (in press).

Iqbal, S M M and Yogaratnam, N (1994). The Effect of Potassium and Magnesium Nutrition of Growth and Mineral Composition of Young *Hevea brasiliensis*. *Jl. Rubb. Res. Inst. of Sri Lanka*. (in press)

FIELD INVESTIGATIONS

1989 Integrated Programme

(1) Field establishment practices : Young Budding/bare root/poly bag.
(2) Clones : PB 86/RRIC 100/RRIC 102/RRIC 121.
(3) Planting distances : 12'x18'/9'x27'/14'x14'/8'x27' (4) Intercropping

Number of plots and locations are as follows:

Regions	Number of Plots
Ratnapura	16
Kegalle	22
Kalutara	59
Colombo	22
Galle	20

Girth of rubber plants in each plot was recorded in 1993. Analyses of growth were done using Nested Factor design. Average girth in each region irrespective of the treatments is given in Table 1. Galle region showed significantly lower girth in comparison with the other regions.

Table 1. *Comparison of mean girth between the regions*

Region	No. of Plots	Mean girth (m)
Kegalle	22	34.57A
Ratnapura	16	32.24A
Colombo	22	32.20A
Kalutara	59	31.34A
Galle	20	26.12B

Means with same letters are not significantly different. Further, analysis, *ie* discriminant analysis based on scoring and categorical statistical methods are in progress (A Nugawela, S M M Iqbal, F P W Silva, and W C Dayaratne).

1990 – 1994 Programme

Clone Evaluation (1990 Programme)

Details of these programmes were reported in the Annual Review of 1990. Girth of rubber plants in each site measured at a height of 3 feet from the union are given in Table 2.

Table 2. *Mean girth of the rubber plants after 3 years of growth in Kegalle and Kalutara regions.*

Region	Site	Treatments	Mean girth (cm)	Cov.
Kegalle	1	RRIC 100; SHP	16.28	24.53
	2	RRIC 100; RRI	25.62	20.74
	3	RRIC 102; SHP	19.67	15.09
	4	RRIC 102; RRI	33.41	15.18
	5	RRIC 110; SHP	22.05	25.60
	6	RRIC 110; RRI	28.54	14.61
	7	RRIC 121; SHP	23.43	14.42
	8	RRIC 121; RRI	27.40	17.15
	9	RRIC 110; SHP	17.90	30.31
		RRI	19.50	27.50
	10	RRIC 121; SHP	22.28	17.70
		RRI	23.88	18.60
Kalutara	1	RRIC 100; RRI	24.49	14.90
	2	RRIC 102; SMP	27.64	19.50
	3	RRIC 102; RRI	17.90	29.60
	4	RRIC 110; SMP	27.16	24.50
	5	RRIC 110; RRI	22.99	18.40
	6	RRIC 121; SHP	27.90	16.60
	7	RRIC 121; RRI	29.44	10.76
	8	RRIC 100; SHP	28.43	19.30
		RRI	27.76	21.50
	9	RRIC 110; SHP	30.43	12.30
		RRI	29.67	19.00
	10	RRIC 121; SHP	20.43	18.84
		RRI	20.43	22.60

(N E M Jayasekera, S M M Iqbal, F P W Silva and W C Dayaratne).

Intercropping

Kegalle Region (1992)

Programmes on Rubber with Pineapple and Rubber with Coffee were in progress. Girth of rubber in Rubber/Coffee trial was recorded (Table 3).

Galle Region (1993)

Trials on Rubber with Cinnamon was continued.

Ratnapura Region (1993)

Girth of the rubber plants was recorded in the Rubber with Banana trial (Table 3).

Table 3. *Mean girth of rubber plants in the plots intercropped and not intercropped in the Kegalle and Ratnapura regions.*

Treatment	Mean girth (cm) Rubber	
	Kegalle	Ratnapura
With intercropping	42.47	34.00
Without intercropping	40.66	32.06

Colombo/Kalutara Region

Trials started in 1990 were in progress. Recording of girth was continued. (L Rodrigo, S M M Iqbal, W C Dayaratna and F P W Silva).

Use of Rainguards

Sites where rainguards were fixed by the smallholders are given in Table 4. Materials were provided by this unit.

Table 4. *Details of the rainguard programme*

	Smallholder & Address	Extent	Treatments	Remarks
Location :	Kalutara Region			
1.	Mrs Simon Nona, Amaragedara, Bulathsinhala.	Two tapping blocks.	With rain-guard/without rainguards	In progress.
2.	Mr D J Jayatunga, Dodangoda.	– do –	– do –	– do –
3.	Mr R Jayasinghe, Uragala, Ingiriya.	– do –	– do –	– do –
Location :	Ratnapura Region			
1.	Mr H A Gunawardena, Hedellana, Ratnapura.	– do –	– do –	– do –
2.	Mr D D Gunaratne, Ekneligoda, Kuruwita.	– do –	– do –	– do –
3.	Sri Visuddaramaya, Arapola, Hitipola, Ehaliyagoda.	– do –	– do –	– do –
Location :	Kegalle Region			
1.	Mr S B Ekanayake, Atale.	– do –	– do –	– do –
2.	Denaviour Estate, Mawathagama.	– do –	– do –	Discontinued due to damage to the rainguard caused by the tapper
3.	Mr Abilinu, Kegalle.	– do –	– do –	In progress.
Location :	Colombo Region			
1.	Mr M K Wickramaratne, Udagalla Rd., Avissawella.	– do –	– do –	– do –

	Smallholder & Address	Extent	Treatments	Remarks
Location :	Galle/Matara Region			
1.	Mr E Wijekoon, Haburugoda, Kamburupitiya.	- do -	- do -	- do -
2.	Mr A E Haroon, Gonagala, Maha Induruwa.	- do -	- do -	- do -
3.	Mr K E de Silva, Gonapinawala, Elpitiya.	- do -	- do -	- do -

Results obtained from these sites are given in Table 5. Insect attack on rainguarded polythene was minimized as the smallholders has adopted the recommended practices.

Table 5. *No. of extra tapping days*

Region	Site No.	Periods	No. of extra tapping days
Kalutara	1	May - Nov.	10
	2	April- Sept.	20
Ratnapura	1	July - Sept.	05
	2	March - Aug.	29
	3	April - Sept.	42
Kegalle	1	May - Sept.	18
	3	June - Oct.	29
Colombo	1	June - Sept.	18
Galle	1	July - Nov.	52
	3	June - Nov.	10

(A Nugawela, L M K Tillekeratne, S M M Iqbal, F P W Silva and W C Dayaratne).

Soil Moisture Conservation/Organic Fertilizer

A new set of trials were started the details of which are given in Table 6.

Table 6. *Details of soil moisture conservation/organic fertilizer programme.*

Yr. of commencement	Smallholder & Address	Extent	Treatments
Location	: Kegalle Region		
1994	Mr R P G Ratnayake Kotiyakumbura.	2Ac	Immature rubber bush legumes/paddy straw.
	Mr L R Sirisena Aunagalla, Hettimulla.	1Ac	– do –
	Mr H R Podiralahamy Pahalawalawa, Kotiyakumbura	1Ac	Immature rubber, poultry litter.
	Mr N Wijetunga, Garagoda, Yatiyantota.	1Ac	– do –
Location	: Ratnapura Region		
1994	Mr B D Abeynayake, Gonapitiya Estate, Kuruwita.	1Ac	Mature rubber, paddy straw.
	Mr P S Wijenayake, Paradise Estate(Pvt) Kuruwita	1Ac	Immature rubber, poultry litter
Location	: Galle Region		
1994	Mr U Y U Haroon, Kalahena, Walakamada, Puhulwela.	1Ac	Immature rubber, poultry litter.
	Mr H S K Fernando, Heenkelewatta, Pitigala	1Ac	– do –

Yr. of commencement	Smallholder & Address	Extent	Treatments
Location	: Kegalle Region		
	Mr Samaratunga, "Siriyani", Matara Road, Kamburupitiya.	1Ac	– do –
	Mr W K N Abeyratne, 6, Mahagoda, Haburugala, Bentota	1Ac	Immature rubber, paddy straw
	Mr C Gajanayake, Sundaraveneyge Watta, Warakapitiya, Denipitiya.	1Ac	– do –
Location	: Kalutara Region		
1994	Mr D Edirimanne, Weherawatta, Anguruwatota.	1Ac	Immature rubber poultry litter.
	Mr K S Nandasiri, Akuralawita, Anguruwatota.	1Ac	Mature rubber, paddy straw.
	Mr E A Siripala, Uragoda, Welipenna.	1Ac	Immature rubber, poultry litter.
	Mr D Kularatne, Uragoda, Welipenna.	1Ac	Mature rubber, paddy straw.
	Mr M L A Faiz, Galassahena, Kalutara.	1Ac.	Immature rubber, poultry litter.
Location	: Colombo Region		
1994	Mr W Siriwardena, Oruwala, Aturugiriya.	1Ac	Immature rubber, poultry litter.

Poultry litter was applied in a circle at 30 – 60 cm from the base of the rubber plants with light forking.

Schedule for applying poultry litter is as follows:

Rubber – Year of Planting	**Rate**
During the 1st year	2kg/plant in 2 application
2nd year	4kg/plant in 2 application
3rd year	6kg/plant in 2 application
5th year until tapping	8kg/plant in 2 application
Mature	8kg/plant in 2 application

Application of rice straw was done in a circle of about 2 – 3 ft. radius around each rubber plant. 5kg of rice straw was applied. 2 applications are recommended per year.

Poultry litter and rice straw were applied in addition to the inorganic fertilizers that were distributed by the Rubber Development Department (L Samarappuli, S M M Iqbal, F P W Silva and W C Dayaratne).

Disease Control

The following sites were treated against white root disease with "Masons Mixture". Observation showed that 80% of the treated plants recovered.

LOCATION : GALLE REGION.

Mr K Palihawadana – 10 trees treated.
Akuressa.

LOCATION : KALUTARA REGION.

Mr S Rupasinghe, Anguruwathota.	– 10 trees treated.
Mr R Withana, Anguruwathota.	– 10 trees treated.

(C K Jayasinghe, F P W Silva and W C Dayaratne).

Planting Techniques

The objective of these trials is to compare the performance of young budding with bare root in the following sites. Planting of these materials were completed (Table 7).

Table 7. *Details of planting technique programme*

Yr. of commence–ment	Smallholder name & Address	Extent	Treatments
Location	: **Kalutara Region**		
1994	Mr D M Amarasena, Badugama, Matugama.	2.2Ac	Young budding/ bare root, RRIC 100
	Mr W D D Thilakeratne Ukgalboda, Kalutara	– do –	– do –
Location	: **Galle Region**		
1994	Mr E Wijekoon, Akurugoda, Kamburupitiya.	1Ac	– do –
	Mr K W Gunathilake, Eladatha, Haburugala.	1Ac	– do –
Location	: **Ratnapura Region**		
1994	Mr Dharmawardana, Elapatha.	1Ac	– do –

Yr. of commence-ment	Smallholder name & Address	Extent	Treatments
Location	: **Kegalle Region**		
1994	Mr M Singho, Dehiowita.	1Ac	- do -
Location	: **Colombo Region**		
1994	Mr A W Abeywickrama, Galagedera, Padukka.	1Ac	- do -

(A Nugawela, S M M Iqbal, F P W Silva and W C Dayaratne).

Inorganic Fertilizer

Four sites selected for the programme on Eppawala rock phosphate as a source of phosphorous for immature rubber. Details of this programmes are given in Table 8.

Table 8. *Detail of the Eppawela rock phosphate programme*

Yr. of commencement	Smallholder Name and Address	Extent	Treatment
1994	Mr I D S Tillekeratne, Remunegoda, Kalutara.	1Ac	Eppawala rock phosphate for immature rubber.
	Mr S Dharmasena, Kiulawatta, Bombuwela.	- do -	- do -
	Mrs C Karunaratne, Menikgoda, Katugahahena.	1.2Ac	- do -
	Mrs P D Wimalawathi Athura, Bulathsinhala.	2Ac	- do -

(D M A P Dissanayake, S M M Iqbal and F P W Silva)

Rubber Processing

Introduction of varnish coated coconut shells for collection of latex.

Experiments on five sites in Galle/Matara region were continued. The scrap content are presented in Table 9.

Table 9. *Dry weight of scrap in coated coconut shell plots and uncoated coconut shell plots on 10 tapping days in 1994.*

Site	Weight of scrap in g/100 trees/10 tapping days	
	Varnish coated coconut shell (g)	Uncoated coconut shell (g)
1	143	286
2	197	243
3	156	329
4	186	257
5	181	330

(K G Karnika de Silva, S M M Iqbal F P W Silva and S Wijesekera).

Multicropping of Rubber with Tea

State Sector I

The Rubber Research Institute of Sri Lanka commenced pilot studies on this subject in 1985 in collaboration with Tea Research Institute in some commercial estates. Details of these experiments were reported in the earlier Annual Reviews. Annual yield figures of rubber and tea and girth of the rubber plants were collected. Statistical analysis of these results are in progress.

State Sector II

Two experiments were in progress in Dartonfield, Agalawatta and RRISL substation, Kuruwita.

EXPERIMENT 1 (RRISL Sub Station, Kuruwita).

Pruning of tea in the unrehabilitated plot was done. All the fertilizers were applied according to the recommendations of the RRI and the TRI. Plucking of tea in the rehabilitated area was started in January 1994. Rubber and tea leaf samples and soil samples were collected. Girth of the rubber plants and yield of tea in rehabilitated and unrehabilitated plots were recorded. Statistical analysis of data on girthing of rubber after the 4th year of planting is presented in Table 10.

Table 10. *The effect of multicropping of rubber lands with tea on growth of rubber.*

Treatments	Mean girth (cm)
Rubber only	39.27A
Tea(Rehab)+Rubber 8'x27'	39.67A
Tea(Unrehab)+Rubber 8'x27'	40.73A
Tea(Rehab)+Rubber 8'x40'	40.55A
Tea(Unrehab)+Rubber 8'x40'	41.10A

Means followed by a common letter are not significantly different.

Monthly tea yield data in unrehabilitated plots were also analyzed (Table 11).

Table 11. *The effect of multicropping of rubber lands with tea on yield of tea.*

Treatments	Mean fresh tea yield monthly (kg/ha) (Average of six months)		
	1992	**1993**	**1994**
Tea (Unrehab)+Rubber 8'x27'	515.17A	1030.06A	845.70A
Tea (Unrehab)+Rubber 8'x40'	541.15A	1086.60A	980.49A

Means with the same letter are not significantly different.

EXPERIMENT II (RRISL – Agalawatta)

Details of this experiment were reported in the earlier Annual Reviews. The following were done :

* Uprooting of mana grass.
* Lining and holing
* Planting of tea
* Application of fertilizer to tea and rubber
* Soil suitability study was done in the area with the assistance of TRI, Ratnapura.
* Girth assessment of rubber

Girth of the rubber plants after the 3rd year of growth is given in Table 12.

Table 12. *The effect of multicropping of rubber lands with tea on girth of rubber*

Treatments	Mean girth (cm) 1994
Rubber only	24.49A
Rubber 8'x27' + Tea	26.10A
Rubber 8'x32' + Tea	25.44A
Rubber 8'x36' + Tea	24.61A
Rubber 8'x40' + Tea	24.99A
Rubber 8'x44' + Tea	25.31A

Means with the same letter are not significantly different (N Yogaratnam, S M M Iqbal and in collaboration with TRI).

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Means with the same letter are not significantly different (N Yogaratnam, S M M Iqbal and in collaboration with TRI).

AGRICULTURAL ECONOMICS

P H M U Herath

SUMMARY

A review study conducted on privatization of the plantation sector indicates the possible ill effects on long term direct and indirect economic benefits as it appears that the present crisis is not merely a management problem.

More than sixty models were developed to forecast the world rubber economic growth as well as to project the growth rates per individual country/region.

Importance of rubber based model farms to intensify the diffusability of different technologies was revealed by a analyzed survey results.

A commissioned paper was prepared and submitted for publication on impact of physical environment and agro-management on land degradation and on the performance of rubber.

DETAILED REVIEW

Staff

Mr A K B Naranpanawa, assumed duties as Assistant Agricultural Economist with effect from 01st of August 1994. Mrs S Amarathunge resigned from the post of Assistant Agricultural Economist with effect from 01st of February 1994. Mr I N Samarappuli continued his PhD programme at the PGIA while attending to the work of the unit. Mr H Thalgaswatta, Assistant Agricultural Economist who was doing his postgraduate studies at the Lincon University, New Zealand vacated the post. Mr P H M U Herath, Assistant Agricultural Economist was on duty throughout the year and is coordinating the activities of this Unit.

Meetings, Seminars and Workshops

P H M U Herath and I N Samarappuli attended the following meetings, seminars and workshops.

* Scientific committee meetings.

* I N Samarappuli made a presentation to the Scientific Committee Meeting of the Rubber Research Board on "The world rubber economy: Past, present and future" held at the SLAAS, Colombo on 21st July, 1994.

* Workshop on economic wide modelling conducted by the EDB from 11th to 21st July 1994.

* Seminar on GATT Uruguay round held on 3rd March 1994.

* Adaptive research review committee meetings

* Technical session of the 35th Assembly of the IRSG held on 27th and 28th May 1994.

* The Fourth meeting of the Committee on processing, quality and marketing, ANRPC, Colombo, Sri Lanka.

* I N Samarappuli attended the International workshop on Computer simulations on world NR market. Songhla, Thailand.

Research Students

Mr D G S B Dias, an undergraduate student from Ruhuna University, completed the final year research project on "An economic study of regional variations on conventional and soil and foliar based fertilizer applications in rubber plantations" under the supervision of I N Samarappuli.

Miss C S Wickramaratne, an undergraduate student from Ruhuna University, completed the final year research project on "Economic assessment of discriminatory fertilizer application for mature rubber plantations in Kegalle district" under the supervision of I N Samarappuli.

Publications

Rodrigo, V H L, Herath, P H M U and Nugawela, A (1993). An economic evaluation of the use of rainguards *Jl. Rubb. Res. Inst. Sri Lanka,* **73**, 1–19

Herath, P H M U (1994). Privatization of Plantation sector: An economic view. *Jl. of Mgt. Review. Fac. of Mgt. Studies Univ. of Jayawardenapura.* (in press)

Herath, P H M U (1994). Simulation model: A useful technique to be developed for rubber sector. *Bull. Rubb. Res. Inst. Sri Lanka*, **31**, 45–48.

Herath, P H M U (1994). Smallholder and Estate level rubber growers: An economic definition. *Bull. Rubb. Res. Inst. Sri Lanka,* **31**, 40–45.

Samarappuli, I N. A cross sectional analysis of Sri Lankan rubber industry and investigation of opportunities for market access. *Ann. J. of NIPM.* (in press).

Samarappuli, L, Yogaratnam, N, Samarappuli, I N, Karunadasa, P and Mithrasena, U (1993). Towards shorter immaturity and higher yields by mulching with rice straw. *Jl. Rub. Res. Inst. Sri Lanka*. **72**, 27–38.

Samarappuli, I N (1994). Guaranteed work for estate labour force: Implications on rubber economy. *Bull. Rubb. Res. Inst. Sri Lanka*. **31**, 6–20.

Samarappuli, I N (1994). Guide to communication campaign planning: A lesson from rubber sector. *Bull. Rubb. Res. Inst. Sri Lanka*. **31**, 21–35.

Samarappuli, I N. The need to supplement the research cess on raw rubber exports and investigation of alternative policies. *Bull. Rubb. Res. Inst. Sri Lanka*. **32** (in press).

Samarappuli, I N and Jayasekara, D (1994). International competitiveness of Sri Lanka's rubber industry. A paper presented at the seminar on Rubber and Global Trade Developments held at World Trade Centre. Colombo.

Samarappuli, I N, Deshapriya, K W, and Silva, A de (1994). Planting and production policies of Sri Lanka: Past, present and future. A paper presented at International workshop on Computer simulations on world NR market. Songhla, Thailand.

Samarappuli, I N, Deshapriya, K W, and Silva, A de (1994). Smallholder marketing and management in Sri Lanka: Systems and policies. A paper presented at International workshop on Computer simulations on world NR market. Songhla, Thailand.

Reports

Herath, P H M U (1994). Annual Review of the Agricultural Economic Unit, 1993.

RESEARCH

Comparative study of Sri Lankan NR auction and FOB prices with other major producing countries

The main objective of the study is to identify the difference between auction and F.O.B. prices of rubber among different NR producing countries and to analyze the different components of the gap. This would enable the recommendation of necessary policy measures according to local conditions. Also, this study would be extended further to estimate the margins at different points in the marketing channel inorder to recommend necessary adjustments to improve the producer share particularly at smallholder level (A K B Naranpanawa).

An economic study on privatization of plantation sector

A review study was conducted on this aspect. This study indicates the benefits of privatization in increasing the efficiency of the system in accordance with free functioning of the market forces. Also, the study indicated the possible ill effects of privatization such as development of private monopoly, less attention to environmental conservation aspects, cronyism and corruption and poor financial and labour strategies. Hence, this study recommends a close monitoring of the present activities of the plantation sector because in profit making process there is a strong possibility of making negative effects on long term direct and indirect economic benefits as it appears that the present crisis in plantations is not merely a problem of management. Further studies have been planned to quantify the effect of recent structural changes on key economic aspects of the plantation sector (P H M U Herath).

A simulation model of the rubber economy

The specific objectives of this study are as follows:

1. Analysis and forecast of total demand for rubber in both tyre sector and non-tyre sector.
2. Analysis and forecast of NR production at normal (average) prices based on acceptable planting, replanting and uprooting policy projections.
3. Assessment of the share of NR by end-use in relation to
   a) economic aspects
   b) technical aspects
   c) availability of NR
4. Simulation of future developments and to assess the effects of production policies for NR.
5. To make recommendations concerning an optimal policy for NR production in view of future developments in rubber demand.

More than sixty models were developed to forecast the world economic growth as well as to project the growth rates per individual country/region. Some alternative scenarios for the future economic growth were also designed as a preliminary prerequisite in developing the simulation model of the rubber economy (I N Samarappuli).

Time series analysis on Natural rubber prices

The behaviour of quarterly Natural rubber (NR) prices in the Colombo market were studied for three different NR grades *viz* RSS-1, Latex Crepe and Sole Crepe for the period of 1979-93. Preliminary results are reported under the review of the Biometry Section (I N Samarappuli and B W Wijesuriya).

A computer model to assess agro-climatic feasibility for rubber cultivation in Sri Lanka

Preliminary data were collected to compile the parameter files in order to develop a user friendly computer model which will enable to assess the agro-climatic suitability for commercial scale cultivation of rubber. The model intends to cover all the rubber growing agro-climatic regions and also the changes in suitability indices (I N Samarappuli, W Wijesuriya, N Yogaratnam and L Samarappuli).

Statistical modelling on Run-off Studies

Further analyses were done to estimate a run-off model using the Principal Component Analysis procedure on data available in the soils and Plant Nutrition Department (I N Samarappuli, W Wijesuriya, L Samarappuli and N Yogaratnam).

An economic evaluation of the adaptive research programme.

It has been planned to do an economic evaluation of the different activities involved in the adaptive research programmes. The data gathered from the innovators and analyzed indicated the importance of establishing the rubber based model farms at different RDO ranges. A questionnaire was prepared and pre tested to analyze the smallholder aspects (P H M U Herath).

Collaborative research project on land degradation

A commissioned paper was prepared and submitted for publication on "Impact of physical environment and agro-management on land degradation and on the performance of *Hevea* (rubber) *brasiliensis*". The work is in progress in collecting field data on some key variables in order to construct a time series model and thereby to estimate the required parameters which can be used to explain the land degradation on rubber soils under different scenarios (Agric. Economics Unit and Soils and Plant nutrition Dept. in collaboration with the La Trobe University and Ministry of Plantation Industries).

Developing commercially viable livestock based farming systems for sustainable agriculture in the rubber growing districts of Sri Lanka

A detailed field survey was conducted in major rubber growing districts using a pre-tested questionnaire to collect the primary data. Presently, the data are being entered into a computer spread sheet for analysis (I N Samarappuli and C Bogahawatte).

An economic study on intercropping

Survey conducted in 1993 showed that the practise of intercropping in the smallholder as well as the estate, sectors is not at the expected levels. This suggests the importance of studying by quantifying the different factors that affect intercropping decision. In this regard, a questionnaire was developed to obtain data on the different socioeconomic factors that affect intercropping at smallholder and estate levels. Financial analysis of intercropping is planned in collaboration with the

plant science department. Further, a macro level study was planned to evaluate the marginal benefits gained by intercropping in rubber sector in comparison with marginal increment in research cost (P H M U Herath and A K B Naranpanawa).

Feasibility study on the rubber wood industry in Sri Lanka

A comprehensive literature survey was carried out to gather all possible information on the rubber wood industry. Steps will now be taken to feed the available data into a matrix form. A survey will then be conducted to check the validity of the matrix and to adjust the values accordingly before embarking on economic analysis (I N Samarappuli, L M K Tillekeratne and K G K de Silva).

Economic analysis of soil and foliar based fertilizer programme

A study was done to investigate the economics of conventional and soil and foliar based fertilizer applications using secondary data available at the Soils and Plant Nutrition Department. The results of this study are described under the review of the Soils and Plant Nutrition Department (I N Samarappuli, L Samarappuli, N Yogaratnam, W Wijesuriya, D G S B Dias and C S Wickramaratne).

Developing a simulation model for rubber sector in Sri Lanka.

In this study, the explanatory model developed to count different biological aspects on production was further strengthened in its explanatory power by introducing different relationships in mathematical form. A explanatory model was also developed to explain the effect of different aspects of local and foreign market trends on production pattern. Converting these relations to mathematical form was continued (P H M U Herath).

Database on global rubber economy

Time series data on different aspects of the global rubber economy are being collected with a view of updating all such information periodically (I N Samarappuli).

Evaluation of research projects

Economic evaluation of applied research projects of the Rubber Chemistry Departments is being planned. An analytical model is being developed in order to conduct the evaluation (A K B Naranpanawa).

BIOMETRY

Wasana Wijesuriya

SUMMARY

The primary concern of the Biometry Section is to assist the Research Departments in designing of experiments, analyses and interpretation of results. Statistical and other mathematical problems that arise frequently are also referred to this section which includes fitting curves and dealing with much more complex models for experimental data to obtain estimates and predictions of quantities of biological interest. Development of computer programs for routine work of Research Departments, devising graphical methods for presenting complex results in an assimilable manner, effective usage of word processing software in preparation of audio visuals and various kinds of reports are among the services rendered to other departments. Assistance is also given to the scientists who attempt to perform their own statistical computing by providing sample programs for statistical analyses.

The ways and means of increasing precision of experiments was the main theme for biometrical research during this year. In this regard, an effective sampling procedure was developed to estimate annual yield of rubber and an evaluation was made using available secondary data to assess the effectiveness of pretreatment records in improving precision of experiments.

An attempt was made to identify trends, seasonals and cycles in Natural Rubber (NR) prices as a preliminary approach towards a detail study of time series analyses of NR prices.

The databases on meteorological factors at Dartonfield and management information; *viz* personal and project information have been successfully maintained during the year under review.

DETAILED REVIEW

Staff

Ms Wasana Wijesuriya, Assistant Biometrician was coordinating the work of this section while continuing her postgraduate studies at the PGIA. The technical staff consisting of the Senior Technical Officer, Ms Nandani Wanigatunga and Technical Officers; Ms Chintha Munasinghe, Mr M A Bodiwansa and Ms Sagari Kudaligama were on duty throughout the year.

Services

Statistical

Assistance was given in designing of experiments and analysis of results to the Institute's research staff in their routine research and to the University students in their specialization projects. The areas of statistical analyses include; linear and non linear modelling, analysis of variance and covariance, multivariate methods, categorical and non parametric methods.

Computer Programming

A computer program was written in GWBASIC for the recent fertilizer recommendations of the Soils and Plant Nutrition Department with several new features including storage of nutrient data for secondary use.

Database Management

Daily meteorological observations of the Dartonfield station were recorded and maintained successfully. Being a regional meteorological station in the agroecological zone; WL_1, these records in the Dartonfield station serve two purposes, *viz* to maintain a database to be employed in research activities, onfarm and its surrounding vicinity and to provide daily data to the Central Meteorological Station for various purposes of national interest.

The personnel and project information of the Institute were updated for the program year 1995 during last year.

Word Processing and Graphics

Technical support was provided to the research staff in preparation of reports and audio visuals by effective use of word processing and graphic packages.

RESEARCH

An Effective Sampling Procedure for Estimating the Annual Yield of Rubber

Recording of yields is generally a costly activity and therefore occupy a considerable portion of the experimental budget: As a consequence, to work within the budgetary constraint, the researchers tend to restrict their sampling frequency to one test tapping per month. It is believed that 24 test tappings would estimate the annual yield of rubber with sufficient accuracy, as the sampling points are distributed evenly along the yield cycle.

However, adopting a less frequent evenly distributed sampling procedure is not advisable for perennial crop species showing seasonal variation in yield as it may lead to biased estimations of annual yield. Hence, this study was undertaken to identify the possible sampling alternatives for some *Hevea* clones, by taking into account the variability and the seasonal variation in yield.

Yield data collected from several long term field experiments conducted by the Rubber Research Institute and estate tapping records available at the Dartonfield Group were used in this study.

Investigation of seasonal variation is a prerequisite for establishing a sampling system to estimate annual yields in perennial crops. This study revealed 4 seasonal quarters in annual yield of rubber, which were in reasonable agreement with those observed in other countries, and were used as strata for the stratified sampling method used.

The relationships established between coefficients of variation (CV) and sample size confirmed that a sample size of 8 test tappings was sufficient to estimate annual yields in terms of variability. Moreover, the variability within each strata were similar, suggesting an equal allocation in each strata. This allocation resulted in 15 combinations of 2 test tapping in one stratum; with a total of 625, 8 sample combinations.

The difficulty encountered with stratified or systematic sampling is the risk of bias. Therefore, all possible combinations were evaluated by the maximum difference (D_{max}) *i.e.*

$$D_{max} = \max. \ |X_1 - X_{2i}|$$

where, X_1 and X_2 are the averages obtained by 24 test tapping and 8 sample combinations respectively. The combinations giving the minimum D_{max} values were chosen as the 'best' 8 sample combinations. Consequently, seven combinations which had maximum differences less than 0.4 grams per tree per tapping were recommended to estimate annual yield of rubber, which is one third of the total sampling cost compared to the previous system where 24 test tappings were used.

The sampling schedule given in figure 01 enables the experimenters to use any system according to their convenience (B W Wijesuriya and R O Thattil).

Time Series Analysis on Natural Rubber Prices

The behaviour of quarterly Natural Rubber (NR) prices in the Colombo market were studied for three different NR grades; *viz* RSS - 1, Latex Crepe and Sole crepe for the period of 1979–93 (after the introduction of open market policies). The components of the series were decomposed into seasonal, trend and cycles as a preliminary approach.

An increasing trend was observed in NR prices since nominal prices were used in the analysis (Fig. 02). The seasonal effect in RSS and latex crepe grades followed a similar sequence; while a different behavior was observed for sole crepe, as shown in figure 03.

The cycles were very much similar for RSS and Sole Crepe grades throughout the period studied (1979 –1993). All three types followed the same sequence after 1988, with larger amplitudes in cycles of latex crepe grade, which is mainly produced for the Eastern European Market. This scenario signifies larger fluctuations in prices of latex crepe, coincided with the fall of Eastern European Economy in late 1980s (Fig. 04) This study will be continued in order to analyze the likely behaviour of rubber prices. For instance, to compare autocorrelation and cross correlations in prices of different NR grades at different terminal markets around the world (B W Wijesuriya and I N Samarappuli).

Schedule	Test Tapping Days																					
	Strata 01 (Peak Yielding)						Strata 02 (Wintering)						Strata 03 (Post Wintering)						Strata 04 (High Yielding)					
	Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
01	x				x		x	x								x		x	x				x	
02	x					x	x		x							x		x	x				x	
03					x	x	x		x							x		x	x				x	
04	x					x	x	x									x	x	x				x	
05	x					x	x	x									x	x	x				x	
06	x					x		x	x								x	x	x		x			
07	x				x		x		x							x		x	x				x	

Figure 01. Sampling Schedule for Estimation of Annual Yield of Rubber

Meteorological Summary - 1994

A fairly distributed rainfall pattern was observed in 1994 with a total of 3811.7 mm, a comparatively low value when the last year is considered. However, the usual dry spell during the early part of the year was not observed in 1994, when compared to previous years. The highest rainfall experienced in May followed by another heavy fall in October, coincided with the first intermonsoon/South-West season and the second inter monsoon prior to the commencement of North-East rains respectively. The variation in rainfall in 1993, 1994 and 75% expected values on monthly basis and rainfall distribution in 1994 on standard week basis are given in figures 05 and 06. Figure 07 depicts the seasonal distribution in rainfall during 1993 and 1994. Number of rainy days in each month under respective category are listed in Table 01 and the monthly variations of other important meteorological factors at Dartonfield are presented in figure 08 (W Wijesuriya, N Wanigatunga, C Munasinghe and M A Bodiwansa).

Table 1. *Monthly variation of rainy days in 1994*

Month	0.3-2.5mm	2.5-50mm	> 50mm	1993 Total	1994 Total
January	-	12	01	04	13
February	02	09	-	02	11
March	02	13	-	13	15
April	01	14	01	16	16
May	02	18	06	25	26
June	03	15	-	23	18
July	04	19	-	24	23
August	02	15	-	22	17
September	01	17	02	19	20
October	02	20	04	24	26
November	05	14	-	21	19
December	06	11	01	19	18
Total	30	177	15	212	222

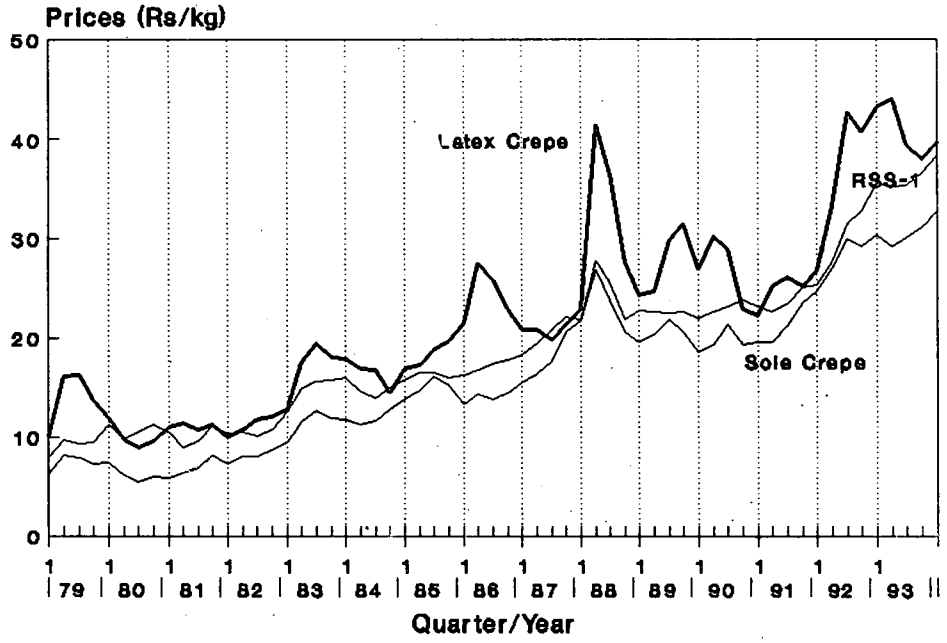


Fig. 2 Variation in quartering NR prices (1979 – 1993)

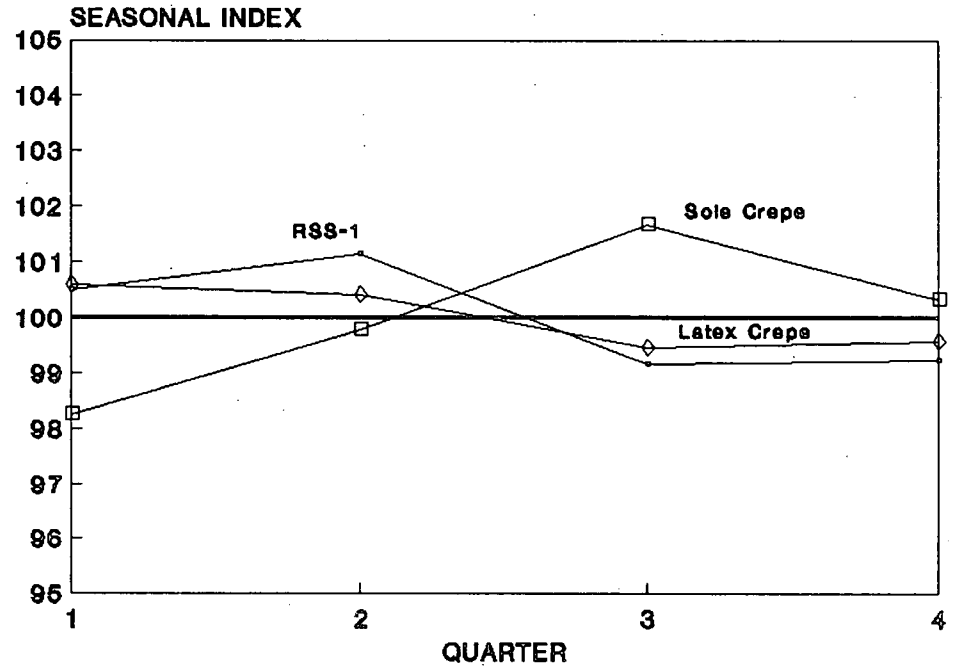


Fig. 3 Average seasonal variation of NR prices (1979 – 1993)

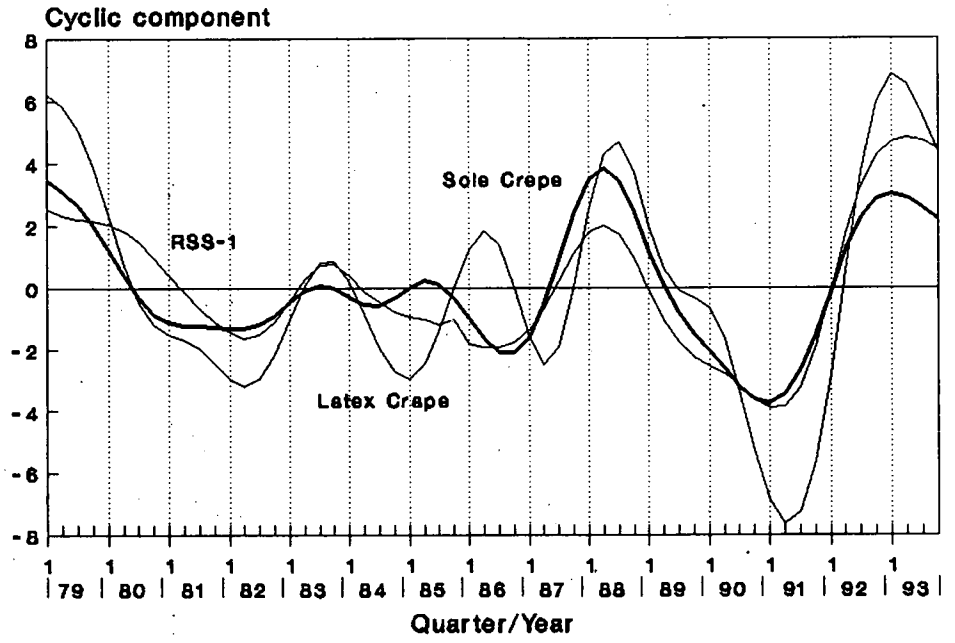


Fig. 4 Cyclic variation in NR prices (1979 – 1993)

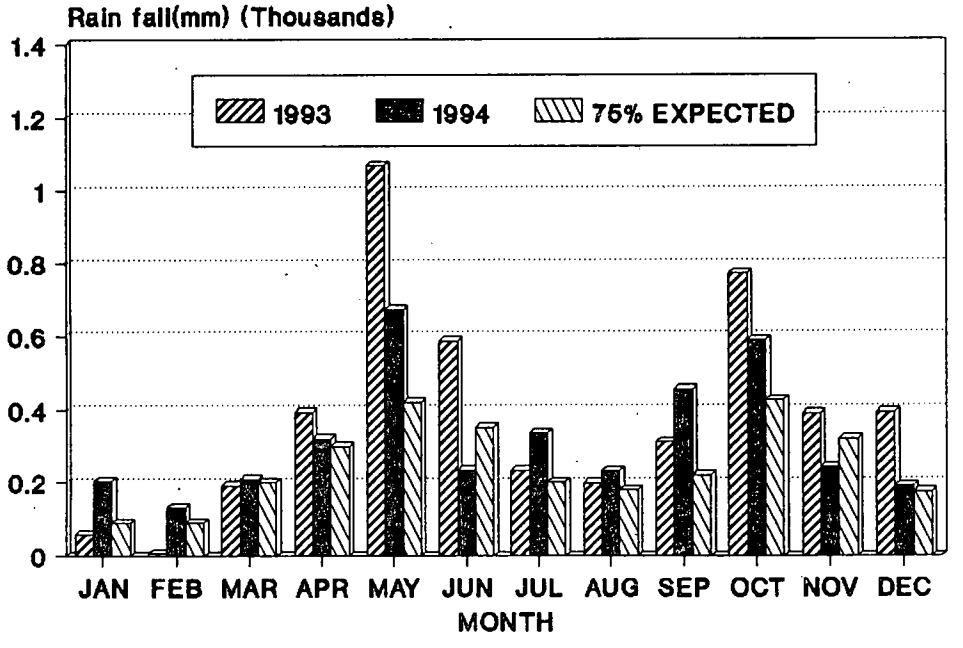


Fig. 5 Rainfall distribution on monthly basis at Dartonfield

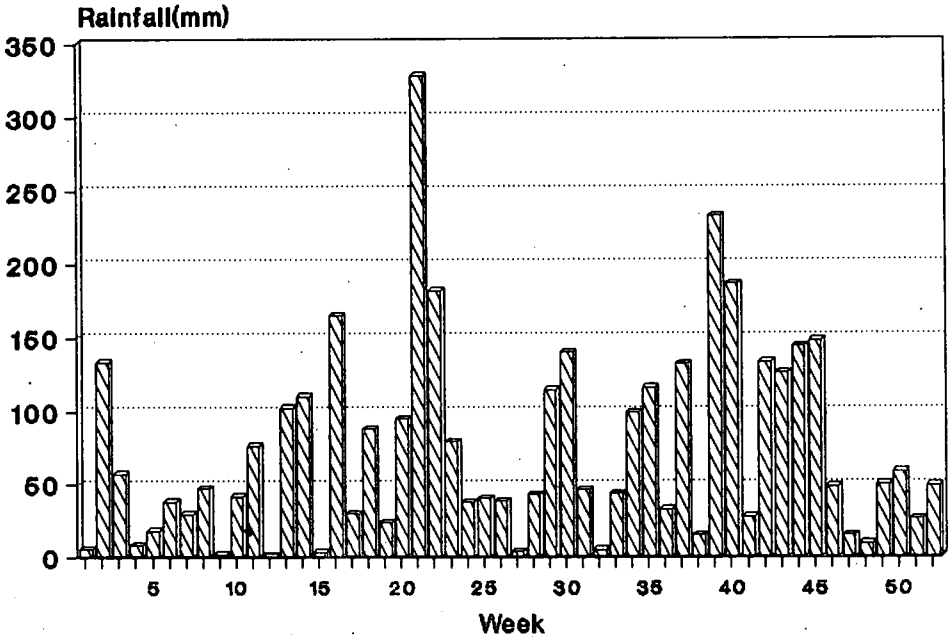
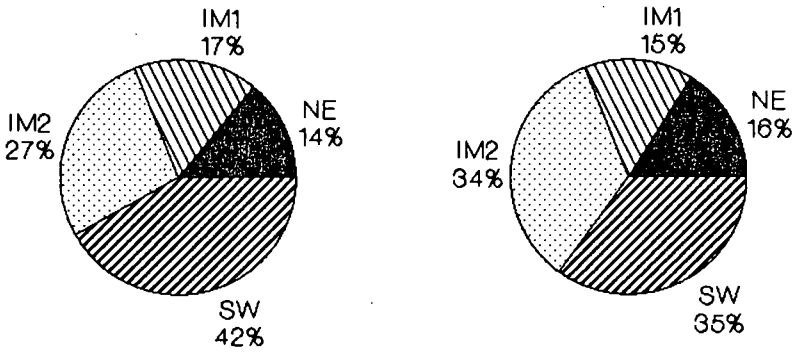


Fig. 6 Rainfall distribution on standard week basis



1993 1994

SW = South West
IM1 = Mid March to Mid May
NE = North East
IM2 = Sept. to Mid Nov.

Fig. 7 Seasonal distribution of rainfall

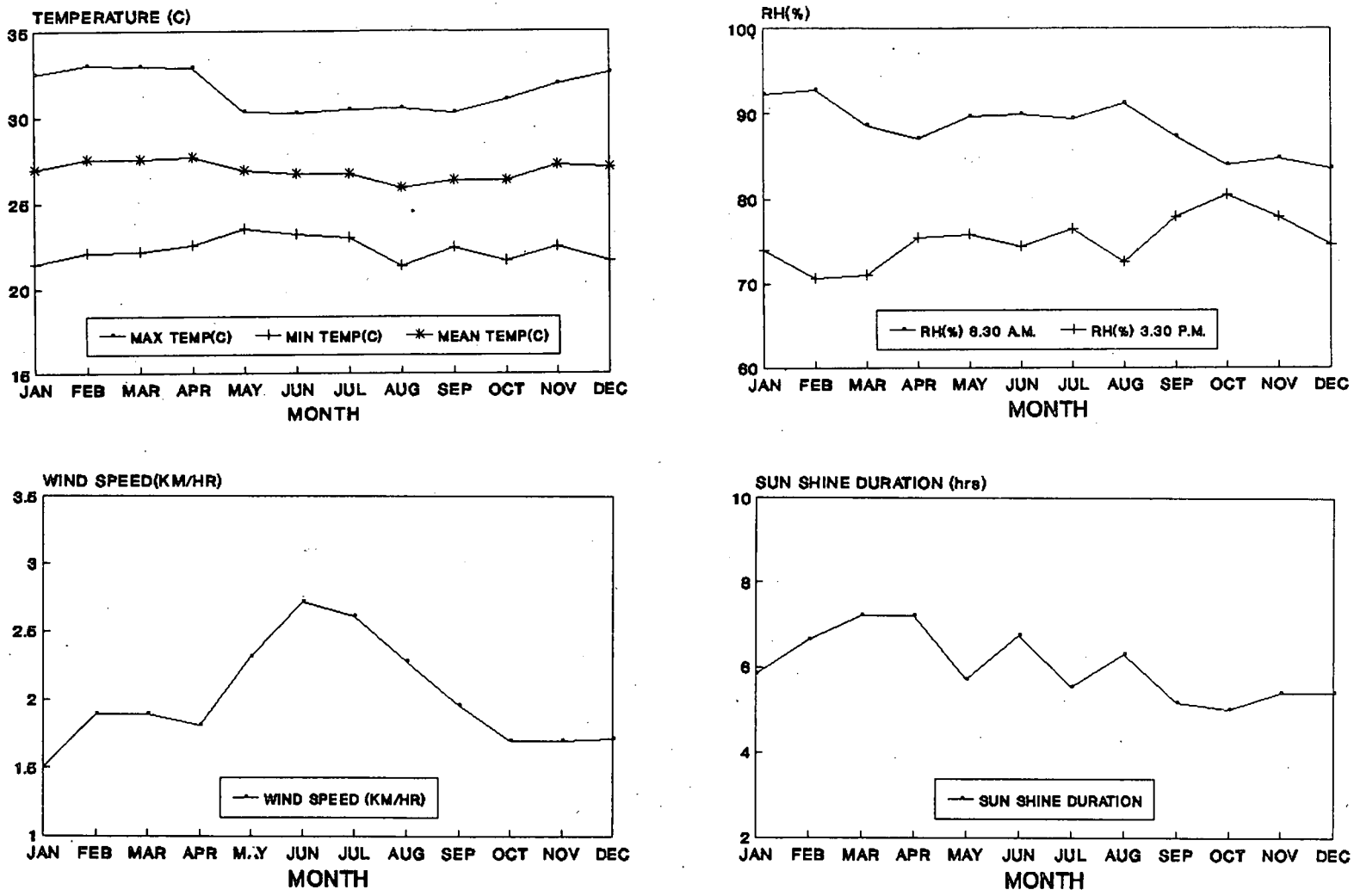


Fig. 8 Monthly variation in observed meteorogical factors at Dartonfield

LIBRARY AND PUBLICATIONS

Kamani Perera

SUMMARY

The Library and Publications Unit was engaged in the following activities during the year:

Maintaining, processing and publishing of Institute's regular publications.

Collecting and disseminating of information on NR and related areas.

Participation in AGRINET (Agricultural Information Network) activities.

DETAILED REVIEW

Staff

Mrs Kamani Perera, Librarian and Publications Officer, Mrs Tilaka Dantanarayana, Library Assistant and Assistant Publications Officer, (Colombo Office), Mrs Ramani Amaratunga, Clerk/Typist and two Library Attendants were on duty throughout the year.

Automation of Library

The Library, with the co-operation and assistance of AGRINET installed a common database of Agricultural Libraries using CDS/ISIS package.

Resource development activities

Book/Serial acquisition

The Library stock increased to 4595 books and the bound volumes to 2918 by the end of the year.

The Library subscribed to 18 Journals only, out of 54, due to financial constraints and about 43 other Journals were also received as gift/exchange.

Meetings/Workshops

Librarian and Publications Officer attended the AGRINET Librarian's meetings held on 04.03.94 at CARP Office, Colombo.

Overseas/Local Trainings

Mrs Kamani Perera, Librarian and Publications Officer attended the 11th course on New Information Technologies and Computerized Library Services from 4th July – 23rd September at the Asian Institute of Technology, Bangkok, Thailand. Her training was funded by International Federation of Libraries Associations and Institutions (IFLA), Bangkok, Thailand.

Mrs Ramani Amaratunga, Clerk/Typist attended the training course on Development of Agricultural Information Systems based on micro CDS/ISIS from 15–19 December, at NIBM, Colombo.

Reports

Perera, Kamani (1994). Review of the Library and Publications Section. Annual Review, RRISL, 1993.

Publications

Processing and publishing of RRISL publications were continued. The following publications were published during the year.

RRISL Journal Vol.71, 1991
RRISL Journal Vol.72, 1992
RRISL Journal Vol.73, 1993
RRISL Journal Vol.74, 1994
RRISL Bulletin Vol.30, 1993
RRISL Bulletin Vol.31, 1994
Rubber Puwath Vol.16, 1993
RRISL Annual Review 1993

Advisory Leaflets

Polybag plants (Sinhala/English)
Young budding (Sinhala/English)
Tapping (Sinhala/English)
Rainguards (Sinhala/English)
Rootstock Nurseries (English)
Budwood Nurseries (English)
Intercropping (Sinhala/English)
Ethrel Stimulation (English)

Information Services

Journals, text books and photocopies of articles etc were received from other Libraries when requested by our users and we did same for them.

DARTONFIELD GROUP

A Nugawela

SUMMARY

A crop of 146 156 kg were harvested during the year which is an increase of 6.3% above the estimated crop for the same period and an increase of 15% over the crop of previous year.

The relative tapping intensity during the year in 100% tapped areas was 77.7%. At this relative intensity of tapping an actual yield per hectare (YPH) of 1012 kg have been achieved during the year.

The average intake per tapper during the year is 6.21 kg from 250 tree tapping tasks. This is an increase of 10% over the previous year. The highest intake per tapper recorded during the year was 17 kg from 250 trees in the 1986, RRIC 100 clearing at the Galewatta Division.

The average number of normal, late, double and no tapping plus rain interference days were 214, 57, 9 and 91 days respectively. The relative tapping intensity for the year, *ie* 77.7% is higher than in previous year.

A total rainfall of 3884.2 mm was recorded over 185 wet days. The total rainfall is less than in the previous year.

The cost of production and the net sale average for the year were Rs.32.00 and Rs.55.00 respectively. This enabled to record a profit of Rs.23.00 on a kilo and nearly Rs.3.4 million from the revenue area. Sundry income during the year was around Rs.1.0 million. The total expenditure on the immature extent, *ie* capital expenditure was Rs.1.1 million. Therefore, the estate has made a net gain of around Rs.3.3 million during the year.

The manufacture records during the year reveal that the latex grade 1 percentage is around 93. This high percentage of grade 1 is attributed to the manufacture of unfractioned unbleached rubber from May 1994.

The extents replanted were 2.00 ha and 6.00 ha. at Dartonfield and Galewatta Divisions respectively. Banana intercropped in a 1 ha block in the 1.30 ha mixed 1993 clearing at the Dartonfield Division is in bearing. Around 650 kg of Banana were harvested during the year. A further 1 ha in a 1994 clearing at the Dartonfield Division was intercropped with Banana during the year. Uprooting of around 21.87 ha of old rubber in the Dartonfield Group is in progress. 475 and 1075 yards of budwood of clones RRIC 100 and RRIC 121 respectively, were issued to smallholders of the area.

DETAILED REVIEW

Staff

Dr A Nugawela, Acting Superintendent, Mr K K P Gunawardena, Senior Assistant Clerk, Mrs C Dissanayake, Junior Assistant Clerk, Mr H M J Premalal and Mr S K S de Silva, Field Officers, Mr J A Wimalasena, Assistant Field Officer, Mr S R Vadivel, Mr T Somaratne and Mr N L D Reggie, Field Supervisors, Mr D S K Ranaweera, Rubber Factory Supervisor, Mr A K D I Rukmal, Mr J K Nakandala, Mr K A Sarath Kumara and Mr B M Siriwardena Assistant KPP, Mrs C S Hettiarachchi, Creche Attendant and Mr K Piyasena Office Peon were on duty throughout the duty.

Mr S A L Chandrawansa, acted for the Chief Clerk post upto 15th July. Mr P Kannangara joined as Chief Clerk on 15th July.

Mr Asoka Wickramasinghe, Junior Assistant Clerk was on no pay leave from 1st January to 1st December.

Mr J A Wimalasena, Assistant Field Officer and Mr T Somaratne, Field Supervisor were promoted to Field Officer with effect from 1st January.

Designation of Mr W D D Senanayake, Factory Supervisor was changed to Assistant Factory Officer with effect from 1st January.

The Group cadre stood at 19 at the end of the year, is made as follows;

Senior Staff	01
Assistant Staff	17
Minor Staff	01
Total	19

Hectarage

A Summary of the Hectarage is given in Table 1.

Table 1. *Land distribution in Dartonfield Group*

	Dartonfield	Galewatta	Nivitigalakele	Total
Mature area	9.9	100.85	44.84	155.59
Immature area	26.65	44.40	–	71.05
Uprooting area	5.33	21.87	–	27.20
Nurseries	7.27	–	7.69	14.96
Paddy field/deniya	–	1.22	–	1.22
Earth slip area	1.65	1.26	2.62	5.53
Rocks	0.29	1.80	1.21	3.30
Waste land	0.19	0.18	–	0.37
Jungle	0.80	–	0.71	1.51
Roads	3.27	6.86	0.32	10.45
Building	16.14	5.07	7.79	29.00
Abandoned	–	–	8.06	8.06
Reserved for buildings	2.53	–	–	2.53
Streams	–	0.84	–	0.84
State land taken–in	0.27	–	–	0.27
Total	74.29	184.35	73.24	331.88

Crop

A total crop of 146 156 kg were harvested from an extent of 155.59 ha during the year. This is 8656 kg or 6.3% above the estimated crop *ie* 137 500 kg for the season.

The yield per hectare (YPH) for the last five years is given in Table 2.

Table 2. *The yield per hectare (YPH,kg) at Dartonfield Group, from 1990 to 1994*

Division	1990	1991	1992	1993	1994
Dartonfield	696	709	605	943	1037
Galewatta	805	636	740	958	958*
Nivitigalakele	929	632	771	841	876
Average	865	640	740	918	939**
Estimate	740	715	883	883	884

* 1077 – based on actual hectarage tapped
** 1012 – based on actual hectarage tapped

In the Galewatta Division, though the estimated revenue extent is 100.85 ha only 89.68 ha were tapped. Therefore the actual hectarage tapped during the year is 144.42 ha which is 11.17 ha less than the estimated extent of 155.59 ha. The actual YPH recorded in the Galewatta Division and in the Dartonfield Group is 1077 and 1012 kg respectively.

A monthly breakdown of the yield per hectare, based on estimated revenue extent is given in Table 3.

Table 3. *The yield per hectare (YPH, kg) recorded during each month in 1994 in the different Divisions*

Month	Dartonfield	Galewatta	Nivitigalakele
January	105	117	113
February	104	78	77
March	78	73	80
April	57	59	61
May	25	31	21
June	53	71	50
July	81	60	66
August	88	69	55
September	66	62	59
October	79	84	75
November	103	107	98
December	198	149	124

Highest yields are recorded in the months of January, November and December. The crop harvested during these three months is around 39% of the total annual crop.

Tapper productivity

The average intake per tapper (kg) during the past three years is given in Table 4.

Table 4. *The average intake per tapper (kg) division wise for years 1992, 1993 and 1994*

Division	1992	1993	1994
Dartonfield	5.15	6.96	6.96
Galewatta	4.78	6.06	6.35
Nivitigalakele	5.06	5.67	5.78
Group Average	4.90(100)	5.97(122)	6.21(127)

The average intake per tapper for the Group (250 tree blocks) has increased steadily since 1992 indicating an improvement made in tapper productivity.

Manufacture

A summary of the manufacture records during the year is given in Table 5.

Table 5. *Details of the crop manufactured in Dartonfield Group (aggregate of Latex and Scrap percentage)*

	Total (kg)	Latex %	Scrap %	Group %
Crepe No.1	121 401	93	–	83.1
Crepe No.3	9 657	7	–	6.6
Scrap Crepe No.1	10 899	–	72	7.5
Scrape Crepe No.2	3 812	–	25	2.6
Scrape Crepe No.3	387	–	3	0.2

The grade 1 percentage of latex and scrap were 93 and 72 per cent respectively. The high grade 1 percentage of latex can be attributed to manufacturing of unfractioned unbleached rubber from May 1994. The grade 1 percentage would have been even higher if this grade was manufactured from January. Manufacturing

of unfractioned unbleached rubber has the advantages of a high grade 1 percentage, less off-grades, low labour and chemical costs.

Weather

The rainfall figures (mm) for the last 3 years are given in Table 6.

Table 6. *Rainfall distribution in years 1992, 1993 and 1994*

	Year and Rainfall (mm)		
Month	1992	1993	1994
January	70.2	39.4	211.3
February	46.2	13.0	149.8
March	2.6	126.7	199.7
April	306.3	338.5	271.8
May	572.1	926.9	658.8
June	417.3	508.3	229.9
July	526.8	205.3	325.3
August	232.7	186.9	326.9
September	593.0	401.2	457.7
October	512.2	724.6	581.2
November	473.4	417.0	316.1
December	221.6	487.7	156.2
Total	3 974.4	4 391.9	3 884.7
Wet days	163	192	185

The total rainfall and number of wet days for the year are 3884.7 mm and 185 days respectively. They are marginally less than in 1993 (Table 6).

Monthly breakdown of the average number of normal tapping (NT), late tapping (LT), double tapping (DT) and no tapping, rain interference, holidays (No.T,RI,H) of the Group are given in Table 7.

Table 6. *A monthly brake down of the average number of normal tapping (NT), late tapping (LT), double tapping (DT) and no tapping, rain interference, holidays (No.T,RI,H) in Dartonfield Group.*

	Number of days			
Month	NT	DT	LT	No.T,RI,H
January	22	–	9	–
February	21	–	6	1
March	25	–	3	3
April	20	–	5	5
May	9	–	2	20
June	16	2	2	10
July	15	1	2	13
August	15	–	5	11
September	14	–	4	12
October	13	–	8	10
November	17	2	7	6
December	27	4	4	0
Total (1994)	214	9	57	91
Total (1983)	198	16	52	115

The number of normal and late tapping days during 1994 are relatively higher than in 1993. Nevertheless, inclusive of normal, double and late tapping days the relative tapping intensity during the year is 78%. This is marginally higher than the figure for 1993 which was 74%.

Cost of Production and Profitability

Net sale average, labour rate and a breakdown of cost of production for the last 4 years are given in Table 7.

Table 7. *Net sale average (NSA,Rs.), Labour rate (LR,Rs) and a break down of Cost of Production (COP,Rs) for years 1991,1992,1993 and 1994*

	1991	1992	1993	1994*
1. Labour Rate	50.26	58.19	72.24	72.24
2. COP	44.69	44.68	35.15	33.11
2.1 Tapping	13.94	14.17	13.91	14.96
2.2 Manufacture	7.03	6.07	8.76	7.07
2.3 General Charges	18.37	19.07	6.57	6.73
2.4 Upkeep	5.35	5.37	5.35	4.35
3. NSA	23.52	35.15	39.01	51.61
4. Profit (Loss)	(21.17)	(9.53)	3.86	18.50

(* Figures given are to end of November)

The cost of production has declined over the past years (Table 7) despite of increased labour wages. Further, the NSA has increased significantly in 1994. To end November, the profit made per kg is Rs.18.50.