

The Rubber Research Institute of Sri Lanka



**Annual
Review** *1983*

THE RUBBER RESEARCH INSTITUTE OF SRI LANKA

ANNUAL REVIEW 1983

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Economic Research Unit,
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** On no pay leave overseas

RUBBER RESEARCH INSTITUTE OF SRI LANKA

DIRECTOR'S ANNUAL REVIEW

By

O. S. PERIES

The Rubber Research Institute of Sri Lanka (RRISL) is responsible for research on all aspects of the growth and production of the rubber tree and on the improvement of raw rubber properties to increase the national income from the rubber industry. The research interests of the Institute can be conveniently divided into two main areas, biological research, carried out mainly at Dartonfield, Agalawatta, and research into the chemistry and technological properties of rubber, carried out mainly at the Colombo Office, in Ratmalana.

Biological research covers the varied subjects of breeding high yielding disease and wind resistant clones, that can grow under the different climatic and soil conditions in the rubber growing areas of Sri Lanka, nursery practices, stock-scion effects, phenotype environment interactions, planting methods, growth and growth regulators, tapping, yield stimulants, replanting cycles, soil covers, nitrogen fixation, soil conservation, fertilizers and their application, soil and foliar analyses, economics of fertilizer use, diseases, weather and its effects on disease incidence and yield and other aspects of plant growth that can increase the per tree and per ha yields of rubber. The Chemistry and Technology Department carries out research on methods of manufacture of raw rubber, different types of rubber, modifications of the rubber molecule to extend its areas of utility, rubber blends, compounding of rubber for various user requirements, manufactured goods, quality control of raw rubber and rubber products and other aspects of natural rubber that would enhance its value per kg so that it would sell at a higher price. Therefore, the whole research work of the Institute is focussed on methods of increasing Sri Lanka's income from the rubber industry. Research & Development (R & D) is the only method of increasing the income from rubber as our land area is limited and all cultivable land is already in use.

The emphasis placed on each aspect of research depends on various factors and is always decided by discussion and agreement between the Scientific Staff. The progress made in recent years by the Institute on certain key areas of research, has made it possible for us to place more emphasis on certain goals in plant growth and rubber chemistry, which are not only important at this stage of the development of the industry ; but are scientifically feasible, in view of the expanding knowledge and technological developments in other crops, in other parts of the world. Basic studies in plant breeding and genetics, techniques of tissue culture, concepts of integrated plant disease control, the effect of weather on disease incidence and severity, the use of radio isotopes in studies in plant

nutrition, the production of modified rubbers for specific markets, the provision of a wider spectrum of specifications for our rubber, and greater involvement in the rubber goods manufacturing industry, are a few of the areas on which we are placing greater emphasis at present ; because we are agreed that these are subjects that will give us rapid and valuable advances for the industry.

SCIENTIFIC COOPERATION

One of the most important innovations that was introduced at the RRISL in recent years is the acceptance that the Institute should not work in isolation, but be integrated with the scientific community of this country. The first fruits of this concept was the influx of students into the Institute. The training of graduate students during their final years and post graduate students for the MSc, MPhil and PhD degrees has become a regular feature at the RRISL, with distinct benefits for both parties to the contract. We keep in close touch with the Universities, get some important problems solved and make better use of our trained staff ; the Universities gain by our participation in teaching activities and training at post graduate levels. This has become such accepted practice that the Natural Resources Energy and Science Authority (NARESA) of Sri Lanka, the highest scientific administrative limb of the Government, has placed its special confidence in us by providing a large number of scholarships for post graduate study at this Institute.

We have now carried this cooperative effort a step further by granting post graduate scholarships for students to carry out studies on specific subjects, leading to the MSc, MPhil and PhD degrees. This will enable us to get specific problems solved and enable our staff to contribute to the national effort, by using their expertise to train research staff. Another spin off from this scheme is that we should be able to select good scientists, with a flair for research, to remain with us on a permanent basis, after they complete their post graduate studies. This would be a key contribution to the upgrading of our staff capability. The potential benefits from this scheme for the rubber industry is enormous. Cooperation between scientists is an essential element of research and teaching ; because all research scientists need to discuss their work with their colleagues at some stage, if their work is to progress and blossom. There is also the assistance of colleagues, who provide the services a researcher requires, in large research stations; however, at our Institute, apart from the Biometry Unit, this kind of cooperation must come from the special expertise of other research officers in the station *e.g.* in analytical chemistry, or plant growth substances, or from colleagues outside. We have been successful in building bridges to the latter by constant contact, teaching, and joint projects. A special effort is being made in the last named area of joint research ; because there is a wealth of untapped expertise in the country and we cannot afford to have all the specialists we require on our own payroll. Therefore, cooperation has become the keynote to progress with us. Our most important link here has been the teaching staff of the Universities, where our part of the contribution is the courses provided by the Research Officers and the University contribution is expert knowledge.

Teaching undergraduates and training post graduate students act as stimulating exercises for the Institute's staff and, of course, the contribution to the Universities is critical ; because, very often there are few in the country, who can assist the Universities

in certain specialized subjects, other than our staff. The gain to the Rubber Research Board (RRB) is that the preparation that is necessary to do University teaching, helps research staff to sharpen their knowledge by wide reading ; as one's thoughts have to be well organised and critically sound to teach a course, where one has to be ready to answer any question on the subject. We expect that this kind of collaboration between the Institute and Universities will lead to joint research, which will be of mutual benefit.

SELECTED RESEARCH PROJECTS

The Institute has continued its wide programme of research to solve the problems facing the industry and provide a bigger income from the area under rubber. In this effort, we have carefully selected subjects that will make a major impact of lasting effect on crop development and estate management. Our basic effort is always to understand the physical, chemical and biological factors governing the growth and yield of *Hevea* and the interactions between the environment, the crop and the soil, so that we can provide better, higher yielding rubber varieties to the planter and also give him the methods of management to obtain optimum profits. The preparation of rubber with specialized technological properties that can be sold at a premium is the other aspect of the Institute's responsibilities. It is a pleasure to record the progress made in 1983, by referring to some highlights.

Plant Breeding

Genotype - environment interactions : This study was started to find out the effect of the environment on clones of different parentage. Good progress has been made in this study and the 1983 results have shown that the genetic composition of the plant and the interaction between the plant and its environment contribute almost equally to its performance in the field, while the influence of the environment alone is twice that of its genetic composition in this regard. This shows the extreme importance of the environment on the performance of different clones. This area of research, which was pioneered by the RRISL for *Hevea*, has shown the clear importance of the environment on crop growth and yield and the necessity for the selection of different clones for the different climatic regimes in a country even as small as Sri Lanka.

Diallel crosses : The results to date have indicated that there are differences in the expression of genes, between crosses of identical families for each character. Here we were considering the factor for yield. This shows that the same parent clones can produce F₁ progeny with different yield potentials and that this character is genetically controlled. This is an observation first recorded in these reviews, and the impact of this factor on breeding *Hevea* will be significant.

New clones: Three of our clones: RRIC 100, RRIC 102 and RRIC 110 have emerged as the best three clones in the international clone trials, planted in Indonesia, Thailand and other countries. Two of these clones : RRIC 100 and RRIC 102 have given more than 2000 kg per ha in their early years of tapping. On the basis of these yields, Indonesia has already recommended RRIC 102 for planting in that country.

Our South American leaf blight (SALB) resistant clones, particularly RRIC 121, are continuing to give high yields in test tapping areas. It is important to increase the

acreage under this clone, so that it can be rapidly introduced into commercial planting. The larger estates should now plant up to 5 ha of this clone on a test basis.

Budwood of new clones was received from foreign countries, the material from China is resistant to wind damage and can grow under extremely cold conditions, and the material from the Ivory Coast is resistant to SALB. All these clones will provide suitable material for our breeding programmes.

Plant Science

Stock - scion effects : It has been found that, although stock-scion effects are not significant on girth, flowering and latex properties, they affect yields significantly. Therefore, further studies are envisaged to find the most suitable stock-scion combinations to enhance yields.

Methods of crown budding have been perfected, and it has been found that the crown, apart from the effect it has on other factors, already reported in these Reviews in previous years, has an important influence on yield and latex colour. It has been decided to scale down the studies on crown budding ; as data on the most important aspects of it have already been recorded, and the technique is now well understood so that it can be used in this country, if the necessity arises. Therefore, the effort is being transferred to other areas of greater importance.

Planting : The rapid establishment and quick growth of green budded stumps have been amply proved. Studies are being carried out on the root development of green budded plants and the early indications are that they develop a better root system, as the shock to the plant is much less, because it is uprooted at an earlier stage. The other important aspect is the reduction of 1 year of nursery time. There may be some problems in synchronizing the budding time with the time of planting ; but we do not anticipate a major problem here.

Green buddings in polybags would be the ideal planting material, for all rubber growing areas, particularly in the drier regions of Kegalle and other places like Moneragala ; but bare root green buddings should be the planting material of choice in future for the wet districts too. All estates should start switching over to green budded material for planting as soon as possible. This Institute would be happy to assist in training personnel for green budding, if there is any problem that estates face in this regard.

Fundamental studies : The basic studies on tissue culture have been given much greater emphasis at the Institute, and it has been decided to engage a special research student to undertake these studies, in addition to the regular Research Officer of the Institute, who is likely to go to the UK for specialized studies on this project, in collaboration with an expert on the subject, in view of the importance we place on it. The high cost of equipment, and the infrastructure required for these studies will always be a hindrance to their rapid progress in this country.

Studies on photosynthetic rates and gas exchange have been undertaken, in order to study the relationship between these fundamental characteristics and the yield of rubber trees. It was also thought, that it is important to characterise the clones on these criteria for a better understanding of their functional ability.

Plant Pathology

White root disease (WRD): It has been well established for a long time now that the incidence of WRD can be reduced by carefully removing the root debris of the old crop at the time of replanting. It has now been proved that the rate of decay of old stumps can be increased by the application of 2, 4, 5 - T in deisel, to the cut stumps. However, we are not in favour of cutting trees at ground level or higher, prior to replanting, as the method of uprooting by a "Monkey Grubber" has been proved to be significantly better, for the control of WRD.

The change of planting distances at every replanting cycle is an important method of reducing the incidence of WRD. We have shown that shifting the planting row to the interrow area of the previous stand reduces the incidence of WRD significantly and that, wherever a new tree is placed near the site of a tree in the old stand, the risk of WRD is significantly increased.

Crop - climate - disease: One of the most important collaborative studies undertaken by the Institute with outside assistance is that on the impact of climate on crop yield and disease incidence, which is being carried out as a joint project between the RRISL, the University of Colombo and the Tropical Agriculture Meteorology Group of the University of Reading, UK. In this study the old weather data from rubber estates have been collected and are being analysed to find the temporal and spatial variation between rainfall, disease incidence and yield.

The present results have shown that the mean yields are lowest in February. A relationship between yield and wintering, along with the impact of rainfall is indicated here. It has also been found that there are 18 or more days in January of each year, with less than 15 mm of rainfall in 1 out of 6 years; and regression analyses have shown that yields are low in those years with low rainfall.

Soils and Plant Nutrition

Soil and foliar analyses: The method of fertilizer recommendation on the basis of soil and foliar analyses has become very popular in Sri Lanka, and there was a great demand for our services on this subject in 1983. We are making the necessary infrastructure studies to extend this facility to all smallholders, by carrying out sample surveys in the different rubber growing areas.

Magnesium deficiency: Symptoms of magnesium deficiency were observed on an unprecedented scale on rubber trees of all ages in 1983. Our studies have indicated that this is because the separate doses of magnesium fertilizer required, where urea containing fertilizer mixtures were used, were not applied in many cases. We are making an exhaustive study on this subject; but in the meantime all estates were advised to check their fertilizer schedules carefully and apply the necessary quantities of Mg fertilizers at the correct time, to control this disorder.

Brown bast: Latex and bark analyses have shown that there was an imbalance of potassium, calcium and magnesium in brown bast affected trees. Studies are continuing to find out whether this nutrient imbalance is a cause or effect of the disorder.

Our multidisciplinary study on brown bast has now shown that this condition :

- (a) is definitely correlated with high intensity tapping ;
- (b) is not caused by a virus or other pathogen ;
- (c) can occur in groups of trees in a restricted area ;
- (d) is accompanied by an imbalance of K, Mg and Ca in affected trees ;
- (e) gives rise to latex with certain special characteristics ;
- (f) results in higher activity of ATP-ase in diseased trees ;
- (g) results in the phenolics of affected trees having a greater effect on ATP-ase than those from healthy trees ; and that
- (h) the condition is reversible in its early stages, if the intensity of tapping is reduced.

Rubber Chemistry

Special purpose rubbers : Commercial quantities of papain coagulated rubber, a speciality deproteinised rubber, developed by the Department, were exported to Europe, at a premium price. We participated in the radiation vulcanization programme, undertaken in collaboration with Japan and Indonesia, to develop this technology for practical application. There is considerable potential in this process and one of our Officers is undergoing training on the subject at the facility in Jakarta, Indonesia, at present. Several new areas of research have been made possible through these studies, including the binding of antioxidants to the natural rubber (NR) molecule at the latex stage, development of extra clear films of vulcanized rubber and the production of a superior grade of rubber with controlled gel content.

Superior processing rubber ; A number of methods were perfected to prepare NR with superior processing properties. The use of polymeric additives, copolymer blends and the use of microcellular crumbs, have shown promise in imparting superior processing properties to NR. Progress in the technology of manufacturing special grades of constant viscosity (CV) rubber and granular NR are highlighted in this Review.

Solar energy : The use of solar energy to dry wet laces of NR was developed much further during the year, and a detailed design of full sized solar collectors for drying towers has been completed, the collectors built and field tested. The solar collectors are on display at Dartonfield and we welcome inquiries on this subject.

Rubber product development : The development in this area was mainly in the prevention of bloom in rubber products and design of NR compounds for specific applications. A room temperature-cured rubber hose was developed and after exposure to sunlight, it was found that satisfactory physical properties could be achieved. Studies on metal anacardates derived from the locally available raw material, cashew nut shell liquid (CNSL), as vulcanization activators were continued.

Biochemistry : Biochemical research was concentrated on studies on phospholipids, latex proteins, effluent disposal and enzymatic deproteinization of NR. A special study in relation to brown bast disease of the rubber tree was also carried out.

Cess

The Rubber Research Cess was increased from 07 cts per kg of rubber exported from the country to 15 cts per kg on 7 July 1983. This will give the RRB an income sufficient to sustain the research programme of the Institute for the next few years. This will also enable it to provide some support to extension work, although the bulk of that work will have to be funded by the Ministry of Plantation Industries in the future too. One of the major areas for investment in the next few years will be for training of staff ; because the real strength of a research station lies in its staff, not its buildings or equipment. The station should be built round the staff and in the coming years some heavy investment must be made to build up the core staff and make allowance for some wastage too ; because that human factor apparently cannot be avoided.

Organisation of research

It is important to increase the staff of the Institute to cope with the new responsibilities placed on it from time to time, and serve the requirements of the industry. The most important areas of expansion are plant breeding, plant physiology, biochemistry and rubber chemistry. The other essential area for staff expansion is to ensure that, in spite of any eventuality there must be sufficient trained staff to make full use of the valuable equipment available at the Institute and get the most out of the support staff. After careful consideration it has been concluded that the Institute should recruit ten more graduate staff, two each for the Rubber Chemistry, Biochemistry, Plant Breeding and Plant Science Departments and one each for Soils and Plant Pathology. This recruitment followed by post graduate training of two officers per year, will give the Institute the minimum staff to satisfy its obligations to the industry in the foreseeable future.

The Institute's research programmes have been re-drawn to convert many of the key investigations into multidisciplinary ones. Further action is being taken to bring the large laboratory based studies together so that there will be inter-departmental collaboration to make the most use of such investigations. In the area of field experiments too, every effort is being made to get the maximum benefits from them, by encouraging several Departments to be involved in each, so that many aspects from growth and yield to rubber characteristics can be studied in the same experiment.

Research assessment

A group of eminent scientists consisting of : Professors I. Balasooriya (Kelaniya), R. N. de Fonseka (Colombo), R. S. Ramakrishna (Colombo), Drs R. L. Wickremasinghe, Director National Institute of Plantation Management (former Director, TRI) and L. B. de Silva, Medical Research Institute, carried out the periodical research assessment of the staff in November/December. The reports are confidential ; therefore, it is not correct to comment in detail on the team's report. However, it is very heartening to report that the visiting scientists found that our staff were making a vital contribution to the development of the industry and that much of the research was of high calibre. The visitors expressed their approval on the balance struck in the research programmes between pure and applied research. They were also very happy to note that most of the key research personnel have stayed on with the Institute and that any staff that had left

can be considered as normal wastage in any organization of this nature. The panel noted that this was in large measure due to the management expertise at the Institute and commended the RRB for its constant interest in the individual members of the staff and its obvious interest in keeping each content, as far as possible.

Research support

Isotope laboratory : A new laboratory was equipped and started working on the use of radio isotopes in investigations on plant growth. The Institute records with sincere gratitude its debt to the International Atomic Energy Agency (IAEA), Vienna, Austria, and the Atomic Energy Authority (AEA) of Sri Lanka for the gift of the valuable equipment for this laboratory. We are particularly indebted to Dr Douglas Nethsinghe of the IAEA and Dr Granville Dharmawardena of the AEA, for their splendid support and their personal interest in providing us with the equipment. We are also grateful to the Hon Mr Cyril Mathew, Minister of Industries and Scientific Affairs, for the encouragement given us, by visiting the Institute to declare open this laboratory.

We are now fully equipped to undertake intensive studies on the use of radio isotopes in plant growth. A number of Departments were waiting in line to use the facilities.

Computer : A fairly sophisticated computer was installed at the Institute, so as to enable the staff to undertake involved analyses of data, and to store valuable information for future use. This computer is able to store data and link up with the larger computer at the Statistics Unit of the Colombo University, so that the more complicated analyses can be done there. This facility too will expand the scope of the work that can be undertaken at the Institute.

STAFF COMMITMENTS

University lectures

A large number of staff members gave courses on their specialities to University students at both post graduate and undergraduate levels. The writer considers these contacts with the Universities as mutually beneficial, and the Institute is actively looking for opportunities for collaborative studies with University staff, so that we can effectively have more trained staff to solve the problems the industry faces.

Joint meetings

Regular meetings with Visiting Agents and Estate Superintendents, where the latest recommendations of the Institute are discussed with the persons who implement the advice have now become an important part of our annual programme of work. Several meetings were held during 1983, both at the top management level and with the implementing staff, in Colombo, the planting districts and on individual estates. These meetings and demonstrations have made a definite impact on the management of estates.

The research staff of the Institute was also involved in the training of extension staff and smallholders. The new Training Centre at Nivitigalakele and the Auditorium in Colombo have facilitated the training of staff and smallholders to a marked degree.

Nursery inspections

A special unit was started in the Plant Science Department to carry out inspections of all budwood and stock nurseries on estates, as well as those registered under the names of private individuals. We are justly concerned that the planting material, used for replanting under the subsidy scheme, is true to type ; as the planted material will be static for up to 30 years and, therefore, should be the best available at the time. All budwood nurseries are being carefully inspected to identify the clones and estates as well as private nurseries are being encouraged to multiply the RRIC 100 series clones.

Stock nurseries are being inspected to ensure that quality material is provided to smallholders under the World Bank sponsored Smallholder Rubber Rehabilitation Project (SRRP) for replanting senile rubber.

We are happy to place on record the cordial response we are receiving from estates and private land owners in the nursery inspection scheme. This augurs well for the necessary effort required in the next few years to popularize the new high-yielding clones, developed by the Institute.

Factory visits

The Rubber Chemistry Department has made an important contribution to the upgrading of crepe rubber produced on estates. A scheme for regular visits to crepe rubber factories was initiated during the year, and this will be built up in such a way as to ensure at least two visits to each crepe rubber factory every year.

Exhibitions

The research staff also took a keen interest in presenting their work at exhibitions so that young students in schools and rural folk will become aware of the contributions made by scientific research to the development of an important national industry. Some young student may be a potential research worker, and we are hoping that the exhibitions will plant the seed of inquiry in such a mind, and if this happens even occasionally, then our efforts would have been amply rewarded.

STAFF

The Director, the Heads of Departments and all Senior and Intermediate Staff Officers were on duty throughout the year, except where reference is made below :

Dr O. S. Peries, Director, assessed the work of the Rubber Research Centre, Thailand, from 9 April to 25 May, as FAO Consultant. He also visited China during this period to attend the 1983 IRRDB meetings.

Dr A. de S. Liyanage, Deputy Director (Research) and Head of Plant Pathology Department attended the 5th meeting of the ANRPC Technical Committee on South American leaf blight held at Kottayam, South India, from 26 - 28 July. He also attended the 4th International Congress of Plant Pathology at Melbourne, Australia, from 15 - 27 August.

Mr S. W. Karunaratne, Head of Rubber Chemistry Department was on sabbatical leave for 6-months up to 4 May following a course of training in radiation vulcanization in Japan. He attended the UNDP Experts meeting at the RRIM, 30 - 31 May, to finalize the report on the data from short term test-evaluation of radiation vulcanized natural rubber. Mr Karunaratne was also away in Indonesia from 4 - 12 October delivering a series of lectures on "Technology of Natural Rubber Latex", to the trainees on radiation vulcanization of NR.

Dr A. Coomarasamy, Rubber Chemist, attended the Indian Rubber Manufacturers Research Association Conference held in Madras, India, from 25 - 26 November.

Dr N. Yogaratnam, Head of Soils and Plant Nutrition Department, was on 6-months sabbatical leave up to 29 January, having worked as the Chief Agronomist at the Tree Crops Research Station of the Ministry of Agriculture and Water Development in Zambia.

Dr W. S. E. Fernando, Rubber Chemist, attended the ISO/TC 45 meeting in Milan, Italy, from 29 September to 8 October.

Dr M. K. S. A. Samaraweera, Agricultural Chemist, followed a training programme on Fertilizer Efficiency Research in the Tropics in Malaysia from 30 April to 26 May.

Mr C. K. Jayasinghe, Assistant Plant Pathologist, followed a training course on Nitrogen Fixation at the University of Western Australia and returned to the Island in October. These studies will form part of his requirements for the degree of PhD at the University of Western Australia.

Mr W. N. Wickremasinghe, Assistant Statistician, followed a course of study leading to the MSc at the Iowa State University, USA, and returned to the Island in June.

Mr P. A. D. T. Vimalasiri, Assistant Specification Officer, is following a course of training in Chemistry and Technology of Polymer Processing at the University of New South Wales, Australia.

Mr A. Dahanayake, Regional Advisory Officer, attended an International Course on Rural Extension in the Netherlands from 26 June to 23 July.

Mr M. D. R. J. Goonetilleka, Assistant Rubber Chemist, has returned to the Island after his post-graduate studies leading to the degree of MSc at the University of Aston.

Mr E. D. I. H. Perera, Assistant Rubber Chemist, is following a course of training in Chemical Engineering on Alternative Energies at the University of Reading in the United Kingdom from 26 August.

Mrs N. I. S. Liyanage, Assistant Plant Pathologist, left the Island on 6 November to follow a course of training in Plant Pathology at the Imperial College of Science and Technology, London.

Mr S. L. Weerasinghe, Senior Technical Officer, Rubber Chemistry Department, returned to the Island after following a 10-months course of training in Malaysia.

Mr M. C. S. Perera, Assistant Rubber Chemist, is following a 3-year course of training in Chemistry and Technology of Polymer Processing at the Australian National University.

Mr B. M. S. G. Peiris, Senior Experimental Assistant of the Genetics and Plant Breeding Department, followed a course of training in Plant Genetic Resources in Japan for approx 2 1/2 months, commencing 26 May.

Mr H. N. K. K. Chandralal, Experimental Officer of the Rubber Chemistry Department, is following a 6-months course of training in "Demonstration on Radiation Vulcanization of Natural Rubber Latex" in Indonesia.

Mr B. D. Ponnampereuma, Transport Assistant, is on 2 years no-pay leave up to 16 August 1984, having accepted a contracted assignment in Saudi Arabia as Collection Route Supervisor.

Mr P. P. Jayasinghe, Experimental Officer, Rubber Chemistry Department was on 1 year's no-pay leave in Sweden up to end November.

Mr G. A. Kannangara, Clerk Accounts Department, is on another 1 year's no-pay leave up to 12 March 1984, having accepted a contracted assignment in Saudi Arabia as Purchasing Officer.

Mr K. D. J. Siriwardena, Driver, is on 2 years no-pay leave up to 10 September 1984 having accepted a contracted assignment in Saudi Arabia as a driver.

The salaried staff of the Institute at the end of the year (1983) was as follows :

Officers in Grade I - VI	..	42
Officers in Grade VII - XV	..	120
Officers in Grade XVI - XIX	..	113
Total		<u>226</u>

Director's publications

The following publications were prepared by the Director with the assistance of the staff members named, for publication during the year:

Peries, O. S. (1983). The manipulation of soil and plant for the control of white root disease of *Hevea*. *Vidyodaya Journal of Science and Letters*. Special Jubilee Issue, 12, 401-411

Peries, O. S. (1983). The Rubber Scene - Prices, Crises and Recoveries. *Proc. of the Seminar on Marketing NR - Colombo*, Feb. 1983. *RRISL Bulletin* (In Press).

Peries, O. S. (1983). Marketing strategies for Sri Lanka rubber. *Proc. of the Seminar on Marketing of NR - Colombo*, Feb. 1983. *RRSL Bulletin* (In Press).

- Peries, O. S. (1983). *Handbook of Rubber Culture and Processing*. Eds. O. S. Peries and D. M. Fernando. Sri Lanka : RRI (In press).
- Peries, O. S. (1983). The method of planning and writing a scientific paper for publication. *National Science Council JI* (In press).
- Peries, O. S. (1983). Scientific data for publication in a Journal. *Natural Resources Energy and Science Authority* (In press).
- Peries, O. S. and Yogaratnam, N. (1983). Fertilizer use among perennial crops. *Proceedings of the 8th Consultative Group on the FAO Fertilizer Programme, Colombo*.
- Liyanage, A. de S. and Peries, O. S. (1983). Strategies used for the control of white root disease (*Rigidoporus lignosus*) in Sri Lanka. *Paper presented at the 4th International Plant Pathology Congress, Melbourne, Australia*.
- Liyanage, A. de S., Peries, O. S. and Liyanage, N. I. S. (1983). Towards biocontrol of root diseases, caused by *Rigidoporus lignosus*. *Paper presented at the 4th International Congress of Plant Pathology, Melbourne, Australia*.
- Liyanage, N. I. S., Peries, O. S., Liyanage, A. de S. and Wettasinghe, C. (1983). Observations on the development of the sporophore of *Rigidoporus lignosus* and the release and germination of basidiospores. *J. Rubb. Res. Inst. of Sri Lanka* 60, 55-63
- පීරිස්, ඔ. එස්. (1983). රබර් ලිය ස්වාභාවික රබර් කර්මාන්තයෙහි අතුරුනිෂ්පාදනයක් ලෙස. රබර් පුවත් 10, 21-23.

Abstracts

- Liyanage, N. I. S. and Peries, O. S. (1983), Distribution and spread of *Rigidoporus lignosus* on *Hevea brasiliensis*. *Proceedings of the 39th Annual Sessions of the SLAAS*, December 1983. Part 1, 41.
- Peries, O. S. (1983). Adaptation to environment in powdery mildew fungi. *Proceedings of the 39th Annual Sessions of the SLAAS*, December 1983. Part 1, 42.

Reports

- Peries, O. S. *et al* (1983). Areas planted with rubber to be switched to tea. Special Report prepared at the request of the Hon Minister of Plantation Industries to be presented to Parliament.
- Peries, O. S. (1983). Director's Annual Review for 1982.

Director's duties

Apart from his day to day research and administrative duties, O. S. Peries served on the following bodies during the year :

Member of the Rubber Research Board.

Member of the Natural Resources, Energy and Science Authority of Sri Lanka.

Member of the Board of Governors, Ceylon Institute of Scientific and Industrial Research.

Member of the Coconut Research Board.

Member of the Board of Management of the Post Graduate Institute of Agriculture.

Member of the Board of the National Institute of Plantation Management.

Member of the Rubber Replanting Advisory Board.

Member of the Steering Committee of the Smallholder Rubber Replanting Project.

Editor, Journal of the Rubber Research Institute of Sri Lanka.

Editor, Journal of the National Institute of Plantation Management.

Editor, National Academy of Sciences, Sri Lanka.

REVIEW OF THE PLANT SCIENCE DEPARTMENT

By

CHANDRA SAMARANAYAKE

SUMMARY

A survey carried out to study the pattern of distribution of brown bast affected trees has indicated that, in some of the clones studied, the affected trees occurred in clusters.

Two of the recently introduced high yielding clones which were tapped on higher frequencies than normally recommended, responded with very high yields. They continued to give similar yields during the second year as well, but are showing signs of increased incidence of brown bast.

Results from rootstock-scion and crown budding experiments have indicated a significant rootstock and crown effect on yield.

The international notation to describe tapping systems was revised by the International Rubber Research and Development Board in 1981. The new notation is more descriptive and takes into account most aspects of the exploitation system adopted. The new method is used in this review to describe all exploitation systems, except for stimulation.

DETAILED REVIEW

Staff

Dr (Mrs) A. C. I. Samaranayake, Head of Department, Mr A. Nugawela and Mr A. G. A. de Soyza, Assistant Botanists, were on duty throughout the year.

Mr L. S. S. Pathiratne, Senior Technical Officer, was promoted to Experimental Officer on 15 June and was on duty throughout the year. Mr A. H. R. Jayaratne, Experimental Officer, Messrs M. C. Perera and R. B. Gunaratne, Senior Experimental Assistants, Messrs L. S. Kariyawasam, K. A. G. B. Ameratunge, R. P. Karunasena, Miss C. W. Ranasinghe, Miss G. A. S. Wijsekera, Technical Officers and Mr S. Wilbert, Experimental Assistant were on duty throughout the year. Mr U. S. Weerakoon was appointed Technical Officer, Nursery Inspection Unit on 15 September.

Visits

The Department staff made advisory visits to plantations and also made regular visits to experimental areas.

Mr L. S. S. Pathiratne, Mr R. B. Gunaratne and Mr U. S. Weerakoon inspected rootstock nurseries in estates managed by the Janatha Estates Development Board (JEDB), Sri Lanka State Plantations Corporation (SLSPC) and private nurseries that supply plants to the Smallholder Rubber Rehabilitation Project (SRRP).

Meetings

Chandra Samaranayake addressed the following meetings :

SLSPC Planter's Seminar, Galle Region - on " Propagation and exploitation of *Hevea* ".

JEDB Planter's Seminar, Kegalle Region - on " Green budding and the use of polybag grown plants ".

SLSPC Planter's Field day, Galle Region - on " Green budding and the use of polybag grown plants ".

JEDB, Planter's Field day, Avissawella Region - on " Green budding, the use of polybag grown plants and exploitation of *Hevea* ".

SLSPC, Visiting Agent's Seminar, Galle Region - Rubber Research Institute's recommendation on " Propagation, planting and exploitation ".

JEDB, Agricultural Advisor's Seminar - on " Nursery practices and planting and exploitation of *Hevea* ".

JEDB, Planter's Seminar, Avissawella Region - on " Propagation and exploitation of *Hevea* ".

Training courses were conducted by Chandra Samaranayake, A. G. A. de Soyza, A. Nugawela, A. H. R. Jyaratne and L. S. S. Pathiratne on propagation, nursery practices and exploitation for rubber smallholders, Rubber Extension Assistants, Rubber Extension Officers and Divisional Rubber Extension Officers of the Advisory Services Department of the Rubber Research Board, Co-operative Executives and Co-operative Managers organised by the Co-operative Development Department, Agricultural Instructors of the Department of Agriculture and Rubber Inspectors of the Rubber Controllers Department.

Messrs L. S. S. Pathiratne, R. B. Gunaratne, M. C. Perera and R. P. Karunasena conducted the field demonstrations for these training courses.

Two training classes for budders were conducted by Mr R. B. Gunaratne, Mr U. S. Weerakoon and Mr A. P. L. D. Michael for the JEDB, Avissawella Region and SLSPC, Galle Region.

Publications

A revised international notation for exploitation systems of *Hevea* and its use in Sri Lanka (1983). Prepared by A. G. A. de Soyza. *Bull. Rubb. Res. Inst. Sri Lanka*, 17, 1 - 11.

de Soyza, A. G. A. Exploitation of Rubber trees (1983). *Handbook of Rubber Culture and Processing*. pp 31 - 66. Eds. O. S. Peries and D. M. Fernando. Sri Lanka : RRI. (In press)

Samaranayake, Chandra. Propagation of *Hevea*, *Handbook of Rubber Culture and Processing*. pp 1 - 21. Eds. O. S. Peries and D. M. Fernando. Sri Lanka : RRI. (In press)

Samaranayake, Chandra and Abeywardene, V. (1983). Extent of exploitation of rubber trees prior to replanting in the smallholdings of Sri Lanka. *Bull. Rubb. Res. Inst. Sri Lanka* 18, (In press).

Laboratory Investigations

Tissue culture

Determination of nutrient requirements

Experiments carried out in 1982 were repeated in order to confirm the findings (Ann. Rev. 1982) on nitrogen, magnesium, calcium and zinc. Cultures do not appear to be very sensitive to nutrient levels, provided an element is not completely absent from the growth medium.

Experiments were started, to study the effect of day length on the formation of chlorophyll and also the photosynthetic capacity of petiole tissue cultured on liquid Murashige & Skoog (modified) medium, on filter paper bridges. Chlorophyll content was measured by means of spectrophotometry, whilst photosynthetic/respiratory capacity was measured using an Infra Red Gas Analyser (IRGA). (A. G. A. de Soyza and G. A. S. Wijesekera)

Anatomical studies (CC/ 77/ 1)

The purpose of this study was to investigate a number of clones in order to identify criteria if any, that could be used in the early selection of clones. Studies on the anatomy of bark, leaf and leaf petioles of the different clones under study were completed. Correlations between the anatomical variation between clones and yield are being investigated. (Chandra Samaranayake and K.A.G.B. Amaratunge)

Studies on photosynthesis of *Hevea*

Gas exchange studies

An Infra Red Gas Analyser (ADC, Model 225/2B/SS) was set up to determine gas exchange parameters, viz. photosynthetic rates, photorespiration rates, dark respiration rates and carbon dioxide compensation point using detached *Hevea* leaves.

Preliminary studies were carried out to find a method of pre-treatment for detached *Hevea* leaves in order to bring them into similar physiological condition. Gas exchange measurements were then recorded and the best air flow rate needed to obtain optimum gas exchange rates was determined.

The gas exchange parameters are being studied in clones RRIC 100, RRIC 103 RRIC 45, PB 86 and IAN 710 grown in pots in the open.

Transpiration rates, leaf diffusive resistances and leaf temperature are also being determined using a LiCor (Model 1600) Steady State Porometer, in order to study water use efficiency and related topics. (A. Nugawela)

Field Experiments

Tapping

PB 86, 1963 replantation, Nivitigalakele (T/75/3)

The aim of this experiment is to investigate the tappability of PB 86 at relative intensities higher than 100%, using half spiral cuts, and the merits of controlled vs uncontrolled systems of recovery tapping. Yield and brown bast data are summarised in Table 1.

Table 1. *Yield (kg/ha/yr) and brown bast (%) for 1983 (T/75/3)*

Tapping system	Yield kg/ha/yr	Brown bast (%)
1/2 S d/2	1449.6	12.5
1/2 S d/1	2038.3	32.5
1/2 S 2d/3	1870.0	17.5
1/2 S d/2 + Recovery tapping*	1816.9	15.0
1/2 S d/2 + Recovery tapping**	1249.3	12.5
LSD (0.1%)	319.4	

* Recovery of lost tapping days by daily tapping

** Recovery tapping spaced so that not more than 6 recovery tappings per month or two per week (controlled recovery tapping)

A total of 48 recovery tappings were carried out during the year, on both recovery tapping treatments. Controlled recovery tapping has given yields comparable to 1/2 S d/2 tapping without recovery but yields from both treatments were significantly lower than from tapping systems of higher relative intensities or 1/2 S d/2 with uncontrolled recovery tapping. On the other hand, brown bast incidence was greater in the higher yielding treatments, of which 1/2 S d/1 (200% relative intensity) with 32.5% trees affected by brown bast was commercially unacceptable. It should also be noted that brown bast has not been taken into account when calculating yields and that high incidence of brown bast would greatly depress actual yields. (A. G. A. de Soyza and S. Wilbert).

Eight clones, 1970 replantation, Nivitigalakele (T/77/2)

The effect of puncture and short cut tapping was compared against the conventional half spiral tapping system on eight clones. Data on yield (kg/ha/yr) and girth increase (cm) are shown in Table 2. Three treatment changes have been made, in that treatment 1, 4 and 5 were d/3 in 1982 and were changed over to alternate daily tapping (d/2) at the beginning of this year.

Table 2. Yield (kg/ha/yr) and girth increment (cm) (T/77/2)

Tapping system	Clone							
	RRIC 101	RRIC 100	RRIC 13	RRIC 45	PR 252	AV 1734	IRCI 2	WR 101
1/2 S d/2	1509 (2.7)	1774 (2.8)	1316 (3.3)	1332 (4.1)	839 (1.0)	998 (3.2)	1334 (2.1)	943 (2.0)
1/2 S d/2	1382 (3.1)	1731 (4.2)	1177 (3.3)	1036 (4.3)	852 (1.2)	969 (2.5)	1319 (2.2)	847 (2.1)
1/4 S d/2+E	1066 (2.7)	1291 (3.6)	1007 (3.8)	694 (5.3)	613 (2.0)	763 (2.6)	1143 (2.5)	645 (2.9)
6 Pg/100 (0.5) d/2+E	575 (4.1)	638 (4.0)	419 (4.6)	348 (5.2)	547 (2.0)	390 (3.4)	755 (4.0)	368 (4.7)
9 Pg/150 (0.5) d/2+E	812 (3.9)	935 (3.4)	562 (4.4)	494 (5.1)	730 (2.3)	552 (3.3)	1136 (3.5)	511 (6.7)

LSD to compare a. Tapping systems within a clone ;

Yield LSD (0.1%) : 204 Girth LSD (5%) 1.4

b. Clones within a tapping system ;

Yield LSD (0.1%) : 257 Girth LSD (5%) 1.6

Clone RRIC 100 has given yields which are significantly higher than any other clone in this experiment when tapped conventionally without stimulation. When tapped on stimulated quarter spirals, treatment 3, IRCI 2 gives yields comparable to RRIC 100 which gave highest yields on this tapping system too. In both puncture tapping treatments, IRCI 2 gave the highest yields.

The four RRIC clones have performed well, along with IRCI 2, on conventional, unstimulated tapping. RRIC 45 did not respond well to tapping with stimulation, whilst RRIC 13 did not respond well to puncture tapping.

These same clones have also shown best girthing, with RRIC 45 giving highest girth increase, followed by RRIC 13, RRIC 100, RRIC 101 and IRCI 2 under almost all tapping treatments. (A. G. A. de Soyza and S. Wilbert)

RRIC 101, 1969 replantation, Eladuwa (T/78/1)

This experiment is being carried out to determine the best tapping system for the clone RRIC 101 which is high yielding and low plugging ; hence sensitive to brown bast (see Ann. Rev. 1979 for experimental details). Yield data for 1983 are summarised in Table 3.

Table 3. Yield data from tapping experiment T/78/1

Tapping system	Yield		Total
	(kg/ha/yr)		
	L	H	
1/2 S d/3	1761		1761
1/2 S d/2	2800		2800
2 x 1/2 S d/2 (2 x y)	2281		2281
2 x 1/2 S d/2 (2 x y)	2830		2830
2 x 1/2 S d/2 (2 x t) 53 cm	2836	1934	2385
2 x 1/2 S d/2 (2 x t) 53 cm	2093	1587	1840
2 x 1/2 S d/2 (2 x t) 106 cm	2748	1894	2321
2 x 1/2 S d/2 (2 x t) 106 cm	2179	1596	1887
6 Pg/100 (0.5) d/2			2563
	LSD (1%)		537

Highest yields were given on the 1/2 S d/2 system although puncture tapping resulted in statistically comparable yields. As brown bast incidence was low with puncture tapping, this system may be of advantage for this clone. Double cut systems did not appear to be of any particular benefit. (A G. A. de Soyza and M. C. Perera)

RRIC 100, 1969 replantation, Eladuwa (T/78/2)

This experiment was carried out to investigate the effect of tapping at high relative intensities, with and without change over of tapping panel at each tapping. Yield data are summarized in Table 4.

Table 4. Yield data from tapping experiment T/78/2

Tapping system	Yield		Total
	kg/ha/yr		
	L	H	
1/2 S d/2	3676		3676
1/2 S d/1	6753		6753
2 x 1/2 S d/1 (2 x t) 53 cm	4309	2509	6818
2 x 1/2 S d/1 (2 x t) 106 cm	3077	2087	5164
	LSD (0.1%)		1238

Intensive tapping continued to give very good yields, significantly higher than 1/2 S d/2 tapping. Lower cuts continue to yield significantly more than higher cuts. However, there appeared to be an increase in the incidence of brown bast which would cause a decrease in actual yields. This latter aspect is being closely monitored. (A. G. A. de Soyza and M. C. Perera)

RRIC 103, 1969 replantation, Eladuwa (T/78/3)

Conventional tapping systems, puncture tapping, short cut tapping with stimulation and change over systems are being investigated, in this experiment on RRIC 103. Intensive tapping systems are now being used. Yield data are summarized in Table 5.

Table 5. Yield data from tapping experiment T/78/3

Tapping system	Yield		Total
	L	H	
1/2 S d/2	2571		2571
1/2 S d/1	4634		4634
1/2 S d/1	4829		4829
2 x 1/2 S d/2 (2 x t)	2800	1892	4692
2 x 1/2 S d/2 (2 x t)	2942	1939	4608
12 Pg/200 (0.5) d/2 + E			3024
1/4 S d/1 + E	6409		6409
	LSD (0.1%)		721

The 1/2S d/2 tapping treatment has given the lowest yields this year, although not significantly different from puncture tapping yields. 1/4S d/1 + E has given the highest yields, significantly greater than any other treatment. While intensive tapping appears to continue to give high yields, double cut systems do not appear to have any particular advantage over single cut tapping systems. Lower cuts of double cut systems gave significantly greater yields than do the higher cuts. There was evidence to suggest that brown bast incidence was increasing, especially in the more intensive tapping treatments, and this aspect is being closely monitored. (A. G. A. de Soyza and M. C. Perera)

PB 86, 1974 replantation, Eladuwa (T/81/1)

This experiment is being carried out to investigate the use of puncture tapping on a large scale in comparison with the conventional tapping method.

Puncture tapping of trees 35 cm or more in girth has resulted in higher kg/area yields than conventional tapping of trees 45 cm or more in girth, during the dry 4 months of the 12 month period whilst yields in terms of g per tree per month were always greater with conventional tapping. Puncture tapped trees have a higher girth increase than do conventionally tapped trees of the same initial girth.

Recording of daily yields was stopped on 1 April 1983, from which time recordings of volume and dry rubber content (DRC) were taken twice a month. (A. G. A. de Soyza, Chandra Samaranayake, M. C. Perera and S. Wilbert)

PB 86, 1973 replantation, Dartonfield, (T/78/4)

This experiment is being carried out to investigate the effect of three levels of Ethrel (stimulant) and three numbers of punctures per 1 m band, 1/2S d/2 and 1/2S d/4 served as controls. Yield data for 1983 are summarized in Table 6.

Table 6. Yield data for 1983 of experiment T/78/4

Treatment	Yield (g/t/t)
Puncture tapping	
0.5 g/tree, Ethrel (E ₁)	18.3
1.0 g/tree, Ethrel (E ₂)	19.1
2.0 g/tree, Ethrel (E ₃)	17.8
5 punctures/m band/tree (P ₁)	18.0
10 punctures/m band/tree (P ₂)	19.1
15 punctures/m band/tree (P ₃)	18.1
Conventional tapping	
1/2 S d/2	33.4
1/2 S d/4	30.0
g/t/t - grams/tree/tapping	

There were no significant differences in yield between the puncture tapping treatments, although these were significantly lower than the two conventional tapping controls. (A. G. A. de Soyza and A. H. R. Jayaratne)

Interaction of clones and tapping systems, St. George (CT/77/3)

The purpose of this experiment is to ascertain the most effective tapping system for different clones. Fifteen clones are tested in this experiment. The following tapping treatments were introduced during the year.

- Treatments :
- (1) 1/2 S d/3
 - (2) 1/2 S d/2
 - (3) 1/2 S d/2 with provision for change over of panels
 - (4) 1/2 S d/2 for 8 months & Pg/100 (0.5) d/2 + E for 4 months
 - (5) Pg/100 (0.5) d/2 + E

There seems to be a significant interaction between clones and tapping systems. (Chandra Samaranayake, A. G. A. de Soyza, L. S. S. Pathiratne, C. W. Ranasinghe and N. D. Yawanis)

Brown bast

RRIC 101, 1976 replantation, Eladuwa (BB/77/1)

This area was planted in 1977 with budded rubber of the clone RRIC 101. The bud material was derived from mother plants which were ; (a) high yielding (b) low yielding or (c) brown bast affected, growing in the 1969 replanting of the same estate (see T/78/1). These budded plants were planted randomly in the field.

The area was brought into tapping on the 1/2 S d/3 system during the latter part of the year. Important data being collected included yield (by cup coagulation) and sucrose content of latex serum. (A. G. A. de Soyza and R. P. Karunasena)

RRIC 101, 1976 replantation, Eladuwa (BB/83/1)

Individual tree yields, latex flow rate and incidence of brown bast are being recorded to study characters of trees that are sensitive to brown bast. (Chandra Samaranayake, L. S. Kariyawasam, A. H. R. Jayaratne, K. A. G. B. Ameratunge, C. W. Ranasinghe and S. Wijesekera)

Survey on brown bast incidence

A survey was carried out on 53 estates from the various rubber growing districts to study the pattern of distribution of brown bast affected trees in six *Hevea* clones. Five of the six clones studied exhibited a clustered distribution of affected trees. (Chandra Samaranayake, A. G. A. de Soyza, A. H. R. Jayaratne and S. Wilbert)

Upward tapping

The special tapping knife devised for controlled upward tapping (modified Vietnam gouge) was compared with the Michie Golledge knife mounted on a long handle. Yield data and bark consumption measured over a 6-month period indicated no significant difference in yield and bark consumption between the two knives. (A. G. A. de Soyza, Chandra Samaranayake and R. P. Karunasena)

Yield stimulation

Yield stimulants on renewed bark

Two concentrations of Ethrel viz., 2.5 % and 5%, two frequencies and two methods of application were tested in this experiment started in 1981. Yield data recorded, indicated no significant response to treatment. (A. H. R. Jayaratne and S. Wilbert)

Tree spacing and density

Tree spacing and density, Millewa (CD/77/1)

Clones RRIC 101, 103 and PB 86 were established at six spacings and densities on a 3 x 6 factorial experiment with three replicates. Each plot accommodated 64 - 156 plants depending on the density. Two outer rows in each plot were considered as guard rows. Tapping cuts were marked on the trees and the area was made ready for tapping. The estate management experienced certain difficulties and tapping was postponed till 1984. Girth of effective trees at 6 1/2 years of age indicated a highly significant interaction between clones and spacings. (Chandra Samaranayake, L. S. S. Pathiratne and N. D. Yawanis)

Propagation

Stock-scion relationships

Stock-scion experiment, St. George (St. sc/75/4)

Clones RRIC 45, 52, PB 86 and Wagga 6278 have been budded on to clonal seedling rootstocks of RRIC 45, 52, PB 86 and Wagga 6278 in all possible combinations.

The trees in this experiment have been in tapping since 1981. Yield data recorded for the year indicated that there was a significant stock-scion interaction on yield. Girth of scions at 8 1/2 years from planting showed no significant rootstock effect on growth

of the scion. Latex properties of samples removed from different stock-scion combinations showed no significant rootstock effect on latex properties of the scion. (Chandra Samaranyake, R. B. Gunaratne and L. S. Kariyawasam)

Stock-scion experiment, Frocester (St. sc/80/6)

Clones RRIC 100, 101, 102, 103, 111, RRIC 52, PB 86 have been budded on to seedling rootstocks of the same clones in all possible combinations. Growth in girth of scions was measured 3 years from planting.

A large number of plants flowered during the year and no significant rootstock effect on flowering was observed. (Chandra Samaranyake, R. B. Gunaratne and U. S. Weerakoon)

Stock-scion experiment, Moraliya (St. sc/81/7)

Clones RRIC 100, 101, 103, PB 86 and GT 1 have been budded on to seedling rootstocks of the same clones in all possible combinations. Growth in girth of plants at 2 years from planting showed no significant rootstock effect. (Chandra Samaranyake, L. S. Kariyawasam and R. B. Gunaratne)

Crown budding

Crown budding experiment, St. George (CB/75/1)

This experiment has been in tapping since 1981. Yield data recorded indicated that certain crowns are capable of significantly influencing the yield of the trunk. (Chandra Samaranyake and R. B. Gunaratne)

Improvements in planting techniques

Plants in polybags, Belmont (RI/78/1)

Growth of plants raised in polybags up to 5-6 whorl stage were compared with bare root budded stumps, after transplanting in the field. Polybagged plants had retained their superiority in growth over the bare root budded stumps. (Chandra Samaranyake and L. S. Kariyawasam)

Use of stumped buddings, Eladuwa (RI/78/2)

Growth of budded stumps and stumped buddings were compared in this experiment which was laid down in the field during the North East planting season in 1978. Stumped buddings reached a tappable girth of 50 cm, 5 years after planting whereas budded stumps took about 6 months longer. Plants in this experiment were damaged by cattle on several occasions. Therefore, results from this experiment cannot be taken as typical. (Chandra Samaranyake and K. A. G. B. Ameratunge)

Stumped buddings large scale, Neuchatel (RI/81/3)

Green budded stumps which serve as the control were planted in the field in May 1982 and stumped buddings in June 1983. Field establishment success of stumped buddings have been very high with less than 1% failures. (Chandra Samaranyake, R. B. Gunaratne and K. A. G. B. Ameratunge)

Comparison of planting techniques, Peenakande (GB/74/2)

Several methods of establishing rubber in the field were compared in this experiment. Growth of plants 3 years after planting in the field indicated that plants budded at stake in the field and seedlings grown and budded in polybags and then transplanted in the field were superior to bare root green and brown budded stumps. (Chandra Samaranyake and L. S. Kariyawasam)

Green buddings in polybags and bare root stumps, Elston (PB/81/3)

Bare root green budded stumps and budded stumps raised in polybags for 6 months were compared after transplanting in the field. Field establishment success of 99 % was achieved with polybag grown plants as compared to 89 % with bare root stumps. Bare root budded stumps which were transplanted in the field at the time of planting budded stumps in polybags have shown significantly better growth than the polybag grown plants which were transplanted in the field 6 months later. (Chandra Samaranyake, R. B. Gunaratne and L. S. Kariyawasam)

Brown buddings in polybags, Gallewatte (PB/81/4)

In this experiment polybag grown budded plants and bare root budded stumps transplanted in the field at the same time were compared. Growth of plants measured 2 years after planting show that polybag grown plants were superior in growth to bare root plants. (Chandra Samaranyake and S. Wilbert)

Green buddings vs brown buddings, Geekiyanakande (PB/81/5)

The growth of green and brown bare root stumps and green and brown budded stumps grown in polybags were compared after transplanting in the field. The bare root plants which were transplanted in the field at the time of planting budded stumps in polybags and transplanted in the field 1 year later show significantly better growth in the field. (Chandra Samaranyake and K. A. G. B. Ameratunge)

Clone characters

Field observations, Eladuwa (CC/77/1)

The purpose of this study was to investigate a number of clones in order to identify criteria, if any, that could be used in the early selection of clones. These trees were tapped for a few months in 1983, when individual tree yields were recorded. (Chandra Samaranyake, L. S. Kariyawasam and C. W. Ranasinghe)

REVIEW OF THE INTERCROPPING DEPARTMENT

By

L. B. CHANDRASEKERA

SUMMARY

Intercropping *Hevea* replantings with banana and passion fruit has not shown any statistically significant effect on growth of *Hevea* budgrafts up to the 3rd year from planting. Pineapples of the Kew variety when interplanted with *Hevea* budgrafts have taken approximately 24 months from planting to come into bearing. Intercropping trials with green gram and maize in the wet zone have not been a success. Interplanting *Hevea* with papaw appeared to be promising.

DETAILED REVIEW

Staff

Mr L. B. Chandrasekera, Head of Intercropping Department, Messrs U. K. D. Lewis and W. T. Silva, Experimental Assistants were on duty throughout the year.

Visits

The technical staff of the Department paid advisory visits to estates and small-holdings and to experimental areas where necessary.

Meetings

The Head of Department gave talks on intercropping at the following meetings :

Galle District, Agricultural Advisers' Conference.

The Janatha Estates Development Board Seminar in Colombo.

He also delivered a series of lectures on various aspects of intercropping to Rubber Extension Officers.

A 3-day training course on intercropping was arranged for two officers from Bangladesh, who are at the Rubber Research Institute for training in estate management.

Publications

Chandrasekera, L. B. Intercropping, *Handbook of Rubber Culture and Processing*. pp113-120, Eds. O. S. Peries and D. M. Fernando. Sri Lanka : RRI (In press).

Reports

Chandrasekera, L. B. (1982). Review of the Intercropping Department.

Field Experiments

Intercropping with banana, passion fruit and coffee (IC/80/1, IC/80/2 and IC/80/3)

The design of these three experiments and of the cultural details are described on pages 23 and 24 of the Annual Review for 1981.

The first girth measurements of *Hevea* budgrafts in the various plots were taken in November 1983, at 3 years of age and the results are summarized in Table 1.

Table 1. *Mean girth (cm) of Hevea budgrafts at 3 years of age in three field experiments (IC/80/1, IC/80/2, IC/80/3)*

Crop	Field experiment no.		
	IC/80/1	IC/80/2	IC/80/3
	Mean girths		
Banana	21.75	21.18	29.82
Passion fruit	21.61	19.93	29.58
Coffee	21.77	21.53	30.50
Control	21.15	19.13	31.22
Mean girth of all treatments	21.71	20.88	29.97
Mean girth of control	21.15	19.13	31.22

The differences in mean girths for various treatments in the three experiments were statistically not significant. However, to experiment IC/80/2 the pooled mean of 20.88 cm recorded for all treated plots was significantly different from the mean girth of 19.13 cm for the control plots.

Passion fruit and banana began to bear at the end of 1 year in 1981. The yields recorded for the third year of this experiment are given in Tables 2 and 3.

Table 2. *Yield of passion fruit (IC/80/2, IC/80/3)*

Districts	Estate	Field exp. number	Number of plants	Yield (kg)	Estimated value (Rs.)	Mean yield (kg/plant)
Kegalle	Pallegama	IC/80/3	132	301	1166.00	2.3
Ratnapura	Kiribatgalla	IC/80/2	92	796	1910.00	8.7

Table 3. *Yield of banana (IC/80/2, IC/80/3)*

Districts	Estate	Field exp. number	Number of trees	Number of bunches	Estimated value (Rs.)	Mean value per bunch (Rs.)
Kegalle	Pallegama	IC/80/3	240	34	188.70	5.55
Ratnapura	Kiribatgalla	IC/80/2	180	218	4336.35	19.89

The yields of both passion fruit and banana were adversely affected by the prolonged dry weather that was experienced during the early part of 1983.

The establishment of coffee was very poor. Hence no yields were recorded for any of the trials in the third year as well. (L. B. Chandrasekera, U. K. D. Lewis and W. T. Silva)

Experiments with passion fruit (IC/82/1)

This is a passion fruit density trial, the details of which are described on pages 24 and 25 of the Annual Review for 1982. This experiment, if successful, will provide for a maximum density of approximately 720 passion fruit vines per ha as compared with the present recommended density of 360 vines per ha. The passion fruit vines in this experiment began to bear in 1983 at the end of approximately 9 months growth. A mean yield of 12 kg fruit per vine was recorded. (L. B. Chandrasekera and W. T. Silva)

Experiments with papaw (IC/83/1)

Earlier intercropping trials with papaw failed owing to the difficulty of growing papaw using only inorganic fertilizers. A replicated trial was therefore set down in four smallholdings in the Kalutara District, where organic manure was used during the early growth stages of papaw seedlings. This was followed by the alternate use of organic and inorganic fertilizers. The growth of papaw during the 4 months of this experiment has been very satisfactory. (L. B. Chandrasekera, U. K. D. Lewis and W. T. Silva)

Experiments with pepper (IC/81/2, IC/83/2)

Full details of the experiment IC/81/2 are described on pages 25 and 26 of the Annual Review for 1982. Out of a total of 553 pepper vines planted in this experiment, only 120 vines were bearing in 1983. This was due to the deaths of many vines, occurring in 1982 and 1983; because of the unusually long spells of dry weather that prevailed during these years.

Another experiment (IC/83/2) was set down in 1983 with the following treatments :

1. One row of pepper between each pair of rubber rows.
2. One row of banana between each pair of rubber rows.
3. One row of pepper alternating with banana, in the row, between each pair of rubber rows.
4. Control-rubber only.

The experimental design is a randomised layout replicated five times : the purpose of this experiment is to evaluate possibilities of mixed cropping where pepper will also benefit at the early stages from the light shade provided by the bananas. (L. B. Chandrasekera, U. K. D. Lewis and W. T. Silva)

Experiments with pineapple (IC/81/3)

Full details of this experiment are described on page 26 of the Annual Review for 1982. Pineapple, at the end of 24 months from planting began to bear fruit in 1983. A total of 2938 fruits were harvested the value of which has been estimated to be Rs. 14,690.00. It is still too early to assess the growth of rubber in the various treatment plots. (L. B. Chandrasekera and U. K. D. Lewis)

Experiments with cacao (IC/81/1)

The experimental details of this trial are given on page 32 of the Annual Review for 1981. It has so far not been possible to establish cacao successfully in this experiment even with temporary shade being provided by banana plants. A major contributory factor for this has been the long spells of unusually dry weather that was experienced in Sri Lanka during the years 1982 and 1983. (L. B. Chandrasekera and U. K. D. Lewis)

Experiments with annuals - green gram and maize (IC/83/1)

These treatments formed a part of a replicated trial set down in four smallholdings in the Kalutara District. Both green gram and maize were planted during the mid-North-East monsoon rainy season in November 1983. The green gram failed to grow owing to *Fusarium* attacks. Much of the maize seedlings were destroyed by rabbit damage. It is proposed to carry out a second planting of these two crops in January 1984. (L. B. Chandrasekera, U. K. D. Lewis and W. T. Silva)

Experiments with betel (IC/83/1)

Planting four rows of betel between each pair of rubber rows formed one of the treatments in the experiment described under green gram and maize. Due to the dry weather that prevailed immediately after planting there were many casualties which had to be supplied later on. Betel being a perennial crop with a ready market available locally should prove to be popular among the smallholders in the wet zone. (L. B. Chandrasekera, U. K. D. Lewis and W. T. Silva)

Smallholder trials

All smallholder demonstration plots that were interplanted with banana and passion fruit in 1979 went out of production after 4 years in 1983. In order to replace these a few more smallholder plots were established in 1983. A list of smallholder demonstration plots that are maintained at present are given in Table 4.

Table 4. *Smallholder demonstration plots intercropped with banana, passion fruit and pepper*

District	Village	Year planted	Crop	Extent (ha)
Kalutara	Palatota	1981	Banana	0.8
Kalutara	Palatota	1981	Passion fruit	1.0
Kalutara	Bellana	1982	Banana	0.25
Kalutara	Panthiya	1982	Passion fruit	0.25
Galle	Batapola	1982	Passion fruit	0.5
Ratnapura	Ketandola	1982	Banana	0.5
Kalutara	Agalawatta	1983	Banana	0.25
Kalutara	Bellana	1983	Pepper	0.25

The income derived by smallholders from some of their intercropped plots is summarized in Table 5.

Table 5. *Income derived from intercropped smallholdings*

District	Crop	Year planted	Extent (ha)	Expenditure in 1983 (Rs)	Income in 1983 (Rs)
Kalutara	Banana	1981	0.8	1186.00	2471.00
Kalutara	Passion fruit	1981	1.0	482.00	1302.00
Galle	Passion fruit	1982	0.5	805.86	1440.00

REVIEW OF THE GENETICS AND PLANT BREEDING DEPARTMENT

By

D. M. FERNANDO

SUMMARY

Over 15,000 m of budwood of the RRIC 100 series clones was released to growers from the Institute during the year. An export of 500 m of budwood of RRIC 100 was effected to Bangladesh through a local firm. Four clones were obtained from the Peoples Republic of China in exchange for local clones. Only two were successfully established. Fourteen clones of the Acre, Rondonia and Guatemala series including those from the latest Brazillian collection were sent by the Ivory Coast in exchange for RRIC 102, 103, 110, sent to Institute De Recherches Sur Le Caoutchouc (IRCA) Ivory Coast in 1976. RRIC 104 and RRIC 107 showed promising growth in clone trials. RRIC 102 and RRIC 103 showed no appreciable reduction of yields on Pannel C (renewed bark).

DETAILED REVIEW

Staff

Mr D. M. Fernando, Assistant Director and Head of the Department and Dr N. E. M. Jayasekera, Geneticist and Plant Breeder were on duty throughout the year. Miss S. C. Alagoda assumed duties as Assistant Geneticist and Plant Breeder on 2 October, 1983. Mr K. B. A. Karunasekera, Experimental Officer was on duty throughout the year. Mr B. M. S. G. Peiris, Senior Experimental Assistant followed a course for a period of 10 weeks in Japan on conservation of germ-plasm. Technical Officers, Messrs K. W. Rупatunga and I. D. M. J. Sarath Kumara, Experimental Assistants, Messrs D. S. Gamage and A. K. M. S. Senaratne and Field Attendants, Messrs W. D. Armon and D. S. Dedduwakumara, were on duty throughout the year. Miss Malkanthi Kahandawa continued as Clerk/Typist for the Department.

Research students

Mr S. Ratnasiri worked under the supervision of D. M. Fernando for a final year research project entitled "A study of a population of *Hevea* seedlings originating from South American leaf blight (SALB) resistant parents". Miss S. M. Hettiarachchi and Miss G. Sayakkara worked under the supervision of N. E. M. Jayasekera on two final year research projects entitled "A study of selection technique in *Hevea* breeding" and "A study of genotype-environment interaction in *Hevea* yields". All three students were from Ruhuna University.

Training

A team of four Clone Inspectors from the Rubber Reasearch Centre, Thailand, viz., Messrs Chakarn Saengruksawong (leader), Rutas Dansagoon, Kanan Raengruriys, and Jit Sri Mala, were assisted in identification of RRIC 100 series clones over a period

of 14 days. Two Estate Superintendents from Bangladesh were also shown aspects of *Hevea* breeding over a period of 3 weeks.

Extension

D. M. Fernando spoke at Agricultural Advisers Meetings convened by the Sri Lanka State Plantation Corporation (SLSPC) at Galle and Janatha Estate Development Board (JEDB) at Colombo. N. E. M. Jayasekera spoke on clones at eleven Co-operative Inspector groups and four extension programmes at the training centre at Nivitigalakele.

Publications

Fernando, D. M. Rubber planting material, *Hand book of Rubber Culture and Processing*, pp 23-30, Eds. O. S. Peries and D. M. Fernando. Sri Lanka : RRI (In press)

Jayasekera, N. E. M. (1983). A basis for selecting *Hevea* clones stable to unpredictable agroclimatic variability, *Silvae Geneticae*. 32, 181

Reports

Fernando, D. M. (1982). Annual Review of the Genetics and Plant Breeding Department.

General

Planting material

Over 15,000 meters of budwood of RRIC 100, 103, 121, were released from the Institute nurseries to growers. Tapping of RRIC 102 and RRIC 103 on renewed bark (Panel C) commenced in 1983 ; bark thickness, yield and rate of girthing, was satisfactory in comparison with the control clones RRIM 623 and RRIC 45. Very promising yields were reported from estate plantings of RRIC 100, 102 and 103.

Clone exchange

Clones IAN 873, *H. nitida* (dwarf), RRIC 121 and RRIC 130 were despatched to the Peoples Republic of China in exchange for 93 - 114 (cold tolerant) and SCATC 7 - 20 - 59 (high yielding) ; Haiken 1 (wind resistant) and SCATC 88 - 13 (high yielding) were found to have deteriorated and replacement has been requested. In exchange for RRIC 100, 102, 103, 110 requested by the IRCA, Ivory Coast, in 1976, fourteen SALB resistant clones, including those from the latest collection by Brazilian scientists for Acre and Rondonia areas of Brazil, two clones from breeding programmes in Guatemala, and *H. pauciflora* clone P 122, were sent in September 1983 ; clones RO 60 and P 9 did not peel.

Laboratory Investigations

Renewed bark anatomy

Studies were started on the anatomy of the renewed bark of RRIC 100 series clones in view of the maintenance of high yields from the renewed bark of RRIC 102 and RRIC 103. (D. M. Fernando, S. C. Alagoda, and A. K. M. S. Senaratne)

Artificial pollination success

Studies were started on increasing fruit set from artificial pollinations. (S. C. Alagoda and D. M. Fernando)

Seed viability

Tetrazolium dyes were used to provide an easy indicator of seed viability. (S. C. Alagoda)

Field Experiments*

Selection of 1974 and 1975 hand pollinated (HP) seedlings (HPS/74-75/1)

Girth measurements were recorded from the small scale trials established in 1980 to evaluate clones selected from the 1974 HP seedling populations (see 1982 Annual Review).

The girth measurements from Moraliyoa where all 52 clones are being tested were analysed. Means, standard deviations (SD) and coefficient of variations (CV) of the four control clones are given in Table 1.

Table 1. Mean girth, SD and CV of control clones (HPS/74-75/1)

Control clone	Mean girth (cm)	SD	CV
RRIC 100	27.2	3.76	13.80
RRIC 103	28.9	1.90	6.56
RRIC 121	30.6	5.18	16.94
RRIM 600	24.6	4.01	16.34

The clone RRIC 121 had the highest mean girth followed by RRIC 103. The CV of RRIC 103 was very small when compared to the CV of RRIC 121. This indicates that out of the two best control clones, RRIC 103 is more consistent than RRIC 121.

Using the simple 't' test, the means of new clones which had higher mean measurements were compared with the mean measurements of the two best clones. When compared with RRIC 103, five new clones had significantly higher mean girth measurements (Table 2) while none of the new clones had significantly better mean girth when compared with RRIC 121.

Table 2. Comparison of mean girth of five new clones with RRIC 103

	Mean girth (cm)	t value	DF	Probability
Control RRIC 103	29.0	—	—	—
74-157	33.6	3.229	18	**
74-166	32.3	2.897	18	*
74-25	33.8	3.430	16	**
74-93	34.7	2.842	17	*
74-141	34.8	3.964	16	**

DF — Degrees of freedom

* - 5% - 2%

** - 2% - 1%

* The tapping notation used is in accordance with the recently revised system, by the IRRDB.

Girth and diameter measurements were recorded from the other small scale trials established to test new selections made from 1974 and 1975 HP seedling populations. (N. E. M. Jayasekera, K. B. Karunasekera and K. W. Rупatunge)

Selection from 1976 HP seedlings (HPS/76/2)

The 52 selections made from 1976 (HP) seedlings are in multiplication nurseries. (N. E. M. Jayasekera and K. W. Rупatunga)

Testing of RRIC 100 series clones (CET/79/1)

A girth measurement was recorded and the mean girth of each clone in each site is given in Table 3 along with site means over all clones and clone means over all four sites.

Table 3. *Mean girth (cm) of clones (CEF/79/1)*

Clone	Eladuwa	Elston	Peenkande	Hatbawe	Clone mean
RRIC 100	33.8	38.2	35.7	32.6	35.0
RRIC 101	37.4	39.9	35.4	34.3	36.7
RRIC 102	36.7	40.4	35.6	35.5	37.0
RRIC 103	34.7	39.7	36.9	36.2	36.8
RRIC 104	38.1	40.9	38.2	35.7	38.2
RRIC 105	35.2	36.5	33.6	32.4	34.3
RRIC 107	37.4	40.7	40.1	36.4	38.6
RRIC 118	32.1	35.9	33.2	33.4	33.6
RRIM 600	31.1	34.2	30.0	31.1	31.6
PB 86	29.4	32.1	29.2	29.2	29.9
GT 1	32.6	37.9	29.5	31.3	32.8
Site mean	34.3	37.8	34.3	33.4	34.9

It is evident from Table 3 that RRIC 104 and 107 had highest mean measurements. This trend was also observed in the 1982 mean girth measurements. (N. E. M. Jayasekera, K. B. A. Karunasekera and K. W. Rупatunge)

Hand pollination programme from 1983 (HP/83/1)

Though arrangements were made to do the hand pollinations at Miriswatta State Plantation, it had to be abandoned due to unfavourable weather conditions.

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

During 1983 the trees on all sites of this experiment were test tapped. Mean yields of the ten clones in each site is given in Table 4. The last row in the Table gives the number of test tappings done in each site. The number of test tappings varied due to rain interference.

Table 4. Mean yields (g/t) and number of test tapping (GE/75/1)

Clone	Dens- worth	Miris- watta	Hunu- wella	Golinda	Ben- tota	Mon- rovia	Bibile	Clone mean
RRIC 36	45.50	35.14	29.88	22.90	28.70	38.60	33.10	33.40
RRIC 52	29.00	24.15	18.10	14.60	21.20	24.30	17.99	21.33
RRIC 100	39.90	39.50	24.71	21.80	32.10	41.00	29.12	32.59
RRIC 101	68.90	46.27	33.18	29.00	34.50	53.20	33.43	42.64
RRIC 102	48.90	46.86	36.62	22.20	42.60	46.00	31.02	39.17
RRIC 103	39.90	35.52	28.44	18.70	27.80	36.80	29.59	30.96
RRIM 600	41.30	35.31	31.78	25.90	33.90	38.70	30.17	33.86
RRIM 623	39.30	31.02	20.65	13.10	13.10	31.40	27.77	25.19
PB 86	28.50	31.12	24.43	23.10	23.60	35.00	25.18	27.27
IAN 45/710	33.40	41.51	27.95	19.50	30.80	28.10	25.41	29.52
Site mean	41.40	36.64	27.57	21.00	28.80	37.30	28.78	
No. of test tappings	7	8	8	7	8	8	8	

The total yield over the first 4 months of 1983 was subjected to an analysis of variance. In the analysis, for each clone, only six replicates each with one plant have been included from five sites. Moraliyoa and Bibile sites were excluded from the analysis due to lack of yield records from all 10 clones. The results of the analysis is given in Table 5.

Table 5. Analysis of variance of yield data over first four months of 1983

Source	DF	Mean square	Probability
Clones	9	33213.18	***
Environments	4	13664.90	***
Clone x environment	36	5510.75	***
Error	250	220.31	

Probability levels *** - 0.1 - 1.0%

The genetic environmental and genotype-environment interaction components were estimated and presented in Table 6, along with their percentage contribution to the total variation.

Table 6. Estimate of genetic, environmental and genotype-environment interaction and their percentage contribution to the total variation

Component	Estimates	Percentage
Genetic	923.41	21.65
Environmental	2240.77	52.52
Genotype x environment interaction	881.74	20.67

The genetic and genotype-environment interaction components are more or less equal in magnitude while the environment component is twice that of the genetic component.

The annual girth measurement was started in December and will be completed in the second week of January 1984. (N. E. M. Jayasekera, K. A. B. Karunasekera and K. W. Rupatunge)

Diallel progeny (GEN/78/1)

The seedling trees were marked for test tapping at the height of 45.72 cm (18 inches) irrespective of their girth. Tapping was started in September 1982 on 1/2 S, d 3 system with a tapping intensity of 67%.

The yield was recorded on three consecutive tapping days (5, 8, and 11 of January 1983), about 3 months after the opening of the tapping cut. The mean yields (based on the three test tappings) of the 16 families derived from the 4 x 4 diallel cross were subjected to an analysis of variance. The results of this are given in Table 7.

Table 7. *Analysis of variance of average yields of sixteen families*

Source	D F	Mean square	Probability
Between families	9	33.039	**
Within families	130	18.607	

Probability level : ** - 1.0 - 2.0%

The results indicate that there are genetic differences between diallel families for the character under consideration. (N. E. M. Jayasekera and I. D. M. J. Sarath Kumara)

Clone trials

Clone evaluation in Matale (VC/65/10)

There were no dry trees in this clearing. Yields of RRIC 103 and RRIC 118 on renewed bark were satisfactory (Table 8). Renewed bark yields of PB 86 have usually been uneconomic in this district. The experimental area is intercropped with cacao which gives the major income in the clearing. (D. M. Fernando and D. S. Gamage)

Table 8. *Mean girth and yield of clones (VC/65/10)*

(Tapped : 1/2 S, d2, B1 - 1)

Clone	Parentage	Trees tapped	Mean girth (cm)		Mean yield (g/t/t)			
			1982	1983	1980	1981	1982	1983
RRIC 103	RRIC 52 x PB 86	10	73.4	75.5	33.5	36.1	33.9	27.3
RRIC 118	RRIC 52 x RRIC 52	76	57.8	58.6	22.3	31.6	26.0	25.8
IAN 710	PB 86 x F 409	67	63.1	64.3	21.3	26.1	22.1	20.8
RRIC 116	RRIC 88 x FX 4098	53	69.1	70.5	20.2	21.5	18.3	17.3
1108	RRIC 52 x RRIC 7	34	65.0	66.1	15.7	22.2	17.5	18.0

Clone evaluation in Moneragala - Kumarawatte (VC/65/9)

Tapping on renewed bark showed the least incidence of dry trees on RRIC 102, Except for RRIC 101 the drying was of a mild and reversible type. The trees were smaller and both virgin and renewed bark was thicker than on the same clones planted in the wet zone. The growth and yield figures are given in Table 9. (D. M. Fernando and D. S. Gamage)

Table 9. *Mean girth and yield of clones (V/65/9)*
(Tapped : $\frac{1}{2}$ S, d2, B1 - 1)

Clone	Parantage	Trees tapped	Mean girth (cm)		Mean yield (g/t/t)		Dry trees (%)	
			1982	1983	1981	1982		1983
RRIC 103	RRIC 52 x PB 86	16	71.2	72.6	23.6	24.9	21.6	2
RRIC 102	RRIC 52 x RRIC 7	16	64.6	65.4	24.5	23.1	21.6	—
RRIC 104	RRIC 52 x Tjir 1	13	69.4	71.1	18.3	17.3	17.25	4
RRIC 101	Ch 26 x RRIC 7	21	62.2	63.8	17.7	18.7	13.7	2
RRIC 112	RRIC 41 x Ch 26	21	65.6	67.0	15.1	17.7	11.1	—
IAN 710	PB 86 x F 409	27	62.7	64.3	13.8	12.9	10.3	—
RRIC 45	RRIC 8 x Tjir 1	23	65.5	66.5	12.8	15.1	10.0	1
RRIM 623	PB 49 x PilB 84	29	65.9	67.4	—	—	9.7	—

Clone evaluation in Bibile I (V/67/20)

Reversion of tapping intensity to 67% increased yields per annum and reduced the percentage of dry trees in this clearing. The clearing of 8.4 ha gave a yield of 1418 kg/ha for 1983. The yields from the different clones are given in Table 10. (D. M. Fernando and B. M. S. G. Peiris)

Table 10. *Mean girth, yield and dry trees of clones (V/67/20)*
(Tapped : $\frac{1}{2}$ S, d3)

Clone	Trees test-tapped	Mean girth (cm)			Mean yield (g/t/t)		Dry trees (%)
		1982	1983	1981	1982	1983	
RRIC 103	48	74.6	76.2	67.7	63.6	68.7	2
IAN 710	73	67.4	79.4	44.0	54.8	58.4	4
RRIC 112	70	70.0	71.0	45.7	53.7	52.2	5
RRIC 100	75	67.4	68.2	58.5	42.8	49.9	2
RRIC 101	68	68.8	69.8	50.3	47.1	47.9	10
RRIC 45	73	71.1	71.8	38.6	44.1	44.6	4

Clone evaluation in Bibile II (V/73/37)

In this trial, planted using polybags in 1973, RRIC 110 showed the best yields. The South American leaf blight resistant clone RRIC 117 also showed favourable yields (Table 11). RRIC 104 showed the best vigour in the Kumarawatte trial, but more observations are necessary before upgrading this clone above RRIC 100. Small scale planting of RRIC 104 on estates would be advisable. The differing number of replications require 3 different values for the least significant difference viz.,

Replication	Girth	Yield
4 each treatment	4.9	10.8
3 each treatment	5.7	12.5
4 with 3	5.3	11.7

Table 11. *Mean girth and yield – Bibile (E/73/37)*
(Tapped : $\frac{1}{2}$ S, d3)

Clone	Parentage	Trees tapped	No. of replications	Mean girth (cm) 1983	Mean yield (g/t/t) 1983
RRIC 110	LCB 1320 x RRIC 7	119	3	60.5	61.4
RRIC 117	RRIC 45 x IAN 873	46	3	56.1	42.7
RRIC 112	RRIC 41 x Ch 26	214	4	60.1	41.6
RRIC 104	RRIC 52 x Tjir 1	140	4	64.4	37.3
RRIC 103	RRIC 52 x PB 86	172	4	61.0	35.1
1461	T 792 x RRIC 52	125	4	59.8	34.7
506	RRIC 52 x PB 86	77	3	51.5	32.5
RRIC 102	RRIC 52 x RRIC 7	145	3	58.4	31.1
RRIC 105	RRIC 52x Tjir 1	120	3	59.4	21.5

Clone evaluation – Nivitigalakele (VC/67/14)

The yields from the control clone RRIM 623 were similar to commercial yields. RRIC 111 showed the effect of increased girth on yields. The yields of RRIC 102 and RRIC 111 are favourable especially as renewed bark is being tapped. The incidence of dry trees was the same as in the previous year (Table 12).

Table 12. *Mean girth, yield and dry trees Nivitigalakele (VC/67/14)*
(Tapped : $\frac{1}{2}$ S, d2, B1 – 1)

Clone	Parentage	Trees tapped	Mean girth (cm)		Mean yield (g/t/t) (kg/ha)			Dry trees (%)
			1982	1983	1982	1983	1983	
RRIC 101	Ch 26 x RRIC 7	310	71.6	72.8	39.8	28.8	1084	6.4
RRIC 102	RRIC 52 x RRIC 7	302	72.7	74.2	30.8	29.4	1312	4.4
RRIC 111	RRIC 52 x PB 5/139	392	78.6	81.1	24.8	31.0	1496	3.4
RRIM 623	PB 49 x PilB 84	141	73.2	75.0	22.2	19.5	961	6.9

Clone evaluation in RRI Sub-station, Kuruwita (VSM/67/5, VSM/68/21, VSM/69/28)

In the 1967 small scale trial RRIC 121 showed the best combination of yield and girth (Table 13).

Table 13. *Mean girth and yield of clones (VSM/67/5)*
(Tapped : $\frac{1}{2}$ S, d2)

Clone	Trees tapped	Mean girth (cm)		Mean yield (g/t/t)		
		1982	1983	1981	1982	1983
		RRIC 121	18	94.1	97.9	76.1
10570	14	82.3	83.7	52.3	47.6	63.5
5682	14	79.0	83.3	46.6	44.9	56.1
7281	16	76.8	79.9	48.1	54.7	49.6
10727	16	76.3	77.3	48.4	53.1	48.6
RRIM 623	29	71.3	72.8	56.2	63.1	47.1
8794	9	79.8	83.6	46.9	52.1	40.7
8501	8	91.1	95.6	30.2	34.7	39.0
8798	22	103.7	108.0	19.0	23.1	17.9

In the 1968 small scale clone trial RRIC 121 was again the best in girth and yield (Table 14).

Table 14. *Mean girth and yield (VSM/68/21)*
(Tapped : $\frac{1}{2}$ S, d2)

Clone	Trees tapped	Mean girth (cm)	Mean yield (g/t/t)	
		1983	1982	1983
		RRIC 121	6	105.2
RRIC 133	8	106.4	75.9	73.0
RRIC 130	15	76.7	79.3	68.9
RRIC 131	9	84.0	75.2	67.2
RRIC 123	14	86.6	61.3	66.5
RRIC 102	19	77.9	56.2	61.1
RRIC 110	17	81.3	64.9	56.3
6-541	12	88.1	59.2	54.5
7263	12	80.4	43.1	54.4
RRIC 113	7	82.2	36.5	50.6
RRIC 104	13	98.0	46.3	48.1
RRIC 45	16	71.7	46.7	45.4
RRIC 112	16	78.2	47.6	42.6
RRIC 120	18	71.8	38.0	37.9

In the 1969 clone trial (Table 15) RRIC 128 and RRIC 126, of which a little budwood was issued to estates, showed the best combination of growth and yields. (D. M. Fernando, B. M. S. E. Peiris and R. A. S. K. Ranatunga)

Table 15. *Mean girth and yields (VSM/69/28)*
(Tapped : $\frac{1}{2}$ S, d2)

Clone	Trees tapped	Mean girth (cm)		Mean yield (g/t/t)		
		1983	1981	1982	1983	
RRIC 128	16	71.0	78.8	79.8	77.3	
RRIC 126	14	82.3	60.6	65.1	70.6	
7-1189	14	69.5	51.2	50.4	63.0	
7-1413	18	76.6	55.8	59.5	59.8	
RRIC 124	16	71.0	71.4	48.9	55.6	
7-1415	15	73.6	59.9	50.3	53.7	
6-746	13	77.8	61.6	51.7	52.5	
RRIC 45	7	75.7	57.3	44.9	49.4	
RRIC 129	10	76.8	67.9	42.5	46.6	
7-1218	22	78.0	39.0	30.6	46.6	
7-1077	7	83.2	58.7	37.8	45.5	
7-1176	20	78.1	50.8	44.1	44.9	
RRIC 127	11	68.8	58.5	49.2	44.0	

Clone evaluation - Hedigalla (VC/67/19), (VC/68/23)

Both clearings were brought into tapping together and the comparatively low dry tree incidence of RRIC 103 is of interest (Table 16). RRIC 45 and RRIC 101 are past their maximum yields, whereas the increasing girth of RRIC 103 has maintained peak yield levels above 2000 kg/ha. (D. M. Fernando and W. D. Armon)

Table 16. *Mean girth, yields and dry trees (VC/67/19, VC/68/23)*
(Tapped : $\frac{1}{2}$ S, d2)

Clone	Year of planting	Trees tapped	Mean girth (cm)		Mean yield (g/t/t)		Dry trees (%)
			1983	1983	1983	1983	
RRIC 103	1967	211	85.1	54.4	2.7		
RRIC 45	1967	216	65.8	16.4	9.3		
RRIC 101	1967	147	68.8	21.2	9.5		
RRIC 103	1968	293	84.2	48.6	4.6		
RRIC 45	1968	270	66.5	19.8	10.2		
RRIC 101	1968	211	69.5	23.4	11.8		

Clone evaluation - Matugama, Strikandura (VC/69/26)

RRIC 102 and RRIC 103 recorded good yields well above RRIC 45 and RRIC 101 (Table 17) in the 7th year of tapping. (D. M. Fernando, D. S. Gamage)

Table 17. *Mean girth, yields and dry trees - Strikandura (VC/69/26)*
(Tapped : $\frac{1}{2}$ S, d2)

Clone	Trees tapped	Mean girth (cm)			Mean yield (g/t/t)			Dry trees (%)
		1982	1983	1981	1982	1983	kg/ha 1983	
RRIC 101	139	59.8	61.7	22.5	21.7	20.4	858	15
RRIC 102	181	68.8	70.2	25.7	30.1	28.8	1576	3
RRIC 103	170	69.2	70.5	26.3	28.8	29.5	1516	1.5
RRIC 45	171	59.4	60.5	17.2	21.7	20.0	1034	5

Clone evaluation - Hedigalla (VSM/69/30)

In this experiment the control clone RRIC 45 is distributed throughout the randomized 31 replications of the test clones. A paired "t" test showed that the yield of RRIC 100 was significantly better than that of the control at the 1% level; yields of RRIC 102 and RRIC 103 were better than those of the control at the 0.1% level. With reference to girth RRIC 100 was better than the control at the 5% level; while RRIC 102 and RRIC 103 were better again at the 0.1% level.

The mean values for girth and yield at the 7th year of tapping are given in Table 18.

Table 18. *Mean yield and girth - Hedigalla (VSM/69/30)*
(Tapped : $\frac{1}{4}$ S, d2)

Clone	Mean girth (cm)	Mean yield (g/t/t)
	1983	1983
RRIC 100	69.8	41.2
RRIC 101	67.7	31.6
RRIC 102	70.3	40.5
RRIC 103	77.6	49.7
1173	58.7	18.0
1458	70.6	27.6

The girth of clone RRIC 103 was better than that of all the others, while RRIC 102 was better than 1173 and both were better than all others at the 5% level. With reference to yield RRIC 103, RRIC 100 and RRIC 102 were better than 1173 and 1458 at the 5% level. (D. M. Fernando and W. D. Armon)

Clone evaluation - Eladuwa (VSM/69/29)

In this experiment, planted at the same time and on the same design as VSM/69/30 at Hedigalla, the girth of RRIC 100 was significantly below that of the control clone RRIC 45 and that of RRIC 103 was above the control clone at the 1% level.

The yield of RRIC 100 was not significantly above that of the control, RRIC 45; but the yield of RRIC 103 was significantly better than that of the control at the 0.1% level.

Comparing all test clones viz., RRIC 100, 1458, RRIC 112, 82, RRIC 103, and RRIC 101, RRIC 100 was significantly better than clone 1458, but RRIC 103 was better than all the other test clones at the 5% level. (D. M. Fernando and S. Senaratne)

International clone trial I. Neboda

A girth measurement was taken just prior to partitioning of this experiment (Table 19).

Table 19. *Mean girth (ICT/78/1)*

Clone	Mean girth (cm)	
	1982	1983
RRIC 103	36.9	45.2
RRIC 100	35.0	43.1
RRIC 101	35.7	43.4
RRIC 105	28.5	35.4
RRIC 110	36.6	45.1
RRIM 600	30.8	37.5
RRIM 703	37.7	44.4
RRIM 722	33.0	39.3
PR 306	33.5	40.2

International clone trial II. - Belmont (ICT/78/2)

The mean girth of trees in this trial are given in Table 20.

Table 20. *Mean girth Belmont, (ICT/78/2)*

Clone	Mean girth (cm)		
	1981	1982	1983
RRIC 103	20.2	29.8	40.1
RRIM 703	18.1	29.0	36.0
RRIC 100	18.7	28.5	35.9
PR 306	18.3	26.2	35.6
RRIC 110	18.6	24.1	32.4
RRIM 600	18.1	26.1	34.9
RRIC 105	17.5	26.0	32.8
RRIM 725	15.5	23.2	32.2
RRIC 113	12.2	19.4	27.5

International clone trial III. Belmont (ICT/79/3)

The mean girth of trees in this area are given in Table 21.

Table 21. *Mean girth - Belmont (ICT/79/3)*

Clone	Mean girth (cm)		
	1981	1982	1983
BPM 22	13.2	22.4	29.1
RRIC 101	13.6	22.3	25.8
RRIC 110	13.3	21.0	25.7
RRIC 121	10.6	19.9	25.7
RRIC 107	12.9	19.6	25.4
RRIM 717	11.3	18.5	24.2
RRIC 118	10.7	18.0	23.3
RRIC 117	10.5	17.6	22.7
BPM 24	11.3	17.0	22.3
RRIM 712	11.0	17.3	21.7
BPM 3	11.3	16.1	19.8
RRIM 600	10.6	15.9	19.7

RRIC 102 from the 1974 multilateral clone exchange has already been approved for small scale planting in Indonesia. (D. M. Fernando, S. C. Alagoda, and D. S. Gamage)

Small scale clone trial - Menikwatta (VSM/79/53)

In this trial seven clones have been planted in 25 randomized replicated single tree plots. The girth is given in Table 22.

Table 22. *Mean girth - Menikwatta (VSM/79/53)*

Clone	Mean girth (cm)
	1983
RRIC 100	26.5
S 5	25.8
BPM 24	25.5
S 1	24.6
S 4	24.0
RRIM 600	23.4
S 3	21.9

At 5% level, RRIC 100 was better than RRIM 600, the Tjikadoe selection S 5 was better than S 3 and BPM 24, one of the highest yielding clones from the 1974 International Exchange, was better than the selection S 3. (D. M. Fernando and A. K. M. S. Senaratne)

Commercial yields RRIC 100 series

Interesting figures were obtained from 2 smallholders (Table 23) who had planted RRIC 100. (D. M. Fernando and R. A. S. K. Ranatunge)

Table 23. *Yields from 2 smallholdings*

Clone	Holding 1	Holding 2
	RRIC 100	RRIC 100
Extent (ha)	0.4	0.8
Year of planting	1972	1970
First year of tapping	1977	1976
Tapping system	$\frac{1}{2}$ S, d1	$\frac{1}{2}$ S, d2
Existing trees	158	324
Dry trees (no.)	2	5
Crop - 1983 comm. (kg)	674	1190
kg/ha - 1983	1685	1487

At Tatuwalakande Estate the following figures were obtained (Table 24) for the 6th year of tapping on $\frac{1}{2}$ S, d2. (D. M. Fernando and B. M. S. G. Peiris).

Table 24. *Mean girth and yield, Tatuwalakande Estate*

Clone	Trees tapped	Mean girth	Mean yield
		(cm) 1983	(g/t/t) 1983
RRIC 121	34	75.0	68.6
RRIC 103	60	68.9	47.8
RRIC 100	51	65.5	43.3

At Gikiyanakande Estate, Neboda the following figures were obtained (Table 25) for tapping on renewed bark.

Table 25. *Mean yields and girth - 1967 clearing, Gikiyanakande*
(Tapped : $\frac{1}{2}$ S, d2, BI - 1)

Clone	Trees tapped	Mean girth	Mean yield	Dry trees
		(cm) 1983	(g/t/t) 1983	(%)
RRIC 103	371	89.8	67.9	6.7
RRIC 102	234	76.3	54.8	7.4
RRIM 623	247	80.3	54.1	8.3

The thickness of the renewed bark was within 1 mm of that of the virgin bark in all three clones. (D. M. Fernando and A. K. M. S. Senaratne)

At Pantiya Estate, Matugama, four 100 tree blocks of RRIC 103 when compared with five 100 tree blocks of RRIM 600 gave the following girth - yield data (Table 26) for the 8th year of tapping ($\frac{1}{2}$ S, d2). (D. M. Fernando and A. K. M. S. Senaratne)

Table 26. *Mean girth and yields - 1969 clearing, Pantiya*

Clone	Mean girth	Mean yield	Dry trees
	(cm) 1983	(g/t/t) 1983	(%)
RRIC 103	63.7	34.8	13.2
RRIM 600	58.3	29.9	13.8

Sampling of 25 trees each in large scale plots on a commercial estate during the relatively good cropping months of August to December gave the following data (Table 27) in the 3rd year of tapping. (D. M. Fernando and W. D. Armon)

Table 27. *Mean girth and yield from 1975 commercial area*
(Tapped : $\frac{1}{2}$ S, d/3)

Clone	Mean girth (cm)	yield (g/t/t)
RRIC 110	76.2	92.0
RRIC 100	69.9	89.0
RRIC 109	68.4	90.4
RRIC 102	61.6	68.5
RRIC 101	57.7	63.4

REVIEW OF THE PLANT PATHOLOGY DEPARTMENT

By

A de S. LIYANAGE

SUMMARY

The incidence of Oidium leaf disease caused by *Oidium heveae* was negligible. As a result of the increased pod formation, there was an outbreak of leaf fall and bark rot caused by *Phytophthora meadii*, throughout the rubber growing area.

There were differences in growth, germination, sporulation and morphological characteristics between several isolates of *Colletotrichum gloeosporioides*.

Studies were initiated on the isolation, culture, maintenance, preservation, estimation, multiplication and enumeration of species of rhizobia under both sterile and non-sterile conditions. Mutant markers have been developed to study the survival and competitive ability. Antisera were produced against two types of rhizobia.

Artificial defoliation, prior to wintering was carried out by thermal fogging with Thidizuron in diesel oil. Leaf abscission was induced about 4 days after fogging.

Proper removal of the sources of infection was sufficient to reduce the incidence of white root disease in a replanting. Application of sulphur at the time of planting can be effective only if most of the food bases are removed. 2, 4, 5 - T in diesel is effective in enhancing the decay of stumps cut at ground level. Changing the planting distance between replanting cycles also helps to reduce the incidence of white root disease.

Methodology is being developed to study crop - climate - disease relationships.

DETAILED REVIEW

Staff

The Head of the Department, Dr A. de S. Liyanage was on duty throughout the year. Mr C. K. Jayasinghe, Assistant Plant Pathologist, who was on study leave at the University of Western Australia, resumed work on 24 October. Mrs Indranee Liyanage, Assistant Plant Pathologist, was on duty until she left for post-graduate studies at the Imperial College of the University of London, on 7 November.

Senior Technical Officer, Mr Z. E. Irugalbandara, Technical Officer Mr W. Amaratunga who was promoted as Senior Technical Officer on the 9 March and Technical Officers Messrs S. Wettasingha, A. Dharmaratna, B. Fernando, S. S. Warnapura, E. A. T. Senadheera and Mrs J. L. P. Wettasingha were on duty throughout the year. Mrs P. Amarasekara, Clerk/Typist, was also on duty throughout the year.

Research students

Misses G. S. Gamage and N. M. A. Mallika from the Ruhuna University College, Mapalana, worked for 6-months, supervised by Dr O. S. Peries and A. de S. Liyanage, respectively, for their final year research projects. These were entitled "Soil amendment and its effects on the control of white root disease caused by *Rigidoporus lignosus* and "Studies on the variability of *Colletotrichum gloeosporioides* from rubber in Sri Lanka".

Visits

The following visits were undertaken by the Department staff :

Experimental	219
Advisory	35
Miscellaneous	122
Total	<u>376</u>

Meetings

A. de S. Liyanage attended the fifth meeting of the Association of Natural Rubber Producing Countries (ANRPC) Technical Committee on South American leaf blight held at the Rubber Research Institute of India (RRII) at Kottayam, India, from 22 - 29 July. He also took the opportunity to visit the laboratories at the RRII.

A. de S. Liyanage, attended the fourth International Congress of Plant Pathology held in Melbourne, Australia, from 15 - 24 August.

The Head of the Department served in the following committees.

Chairman of the Drafting Committee on Pesticides.

President of the Section B of the Sri Lanka Association for the Advancement of Science (SLAAS).

Member of the Formulary Committee.

Member of the Board of study on Agricultural Biology at the University of Peradeniya.

Member of the Academic Syndicate of the Postgraduate Institute, University of Peradeniya.

Member of the Agriculture Group of the Atomic Energy Authority (AEA).

Scientific Committee of the Rubber Research Institute (RRI) Estate Committee of the RRI.

He attended two seminars conducted for the Agricultural Advisers of the State Plantation Corporation Board IV, Galle and Janatha Estate Development Boards I and II in the Avissawella and Kegalle regions. He also attended Field Days conducted for Superintendents in the Galle, Kegalle and Avissawella regions.

The Head of the Department and the Assistant Plant Pathologists, C. K. Jayasingha and Indranee Liyanage were involved in training Rubber Extension Assistants, Rubber Extension Officers, Divisional Rubber Extension Officers, Senior Processing Advisors of the Advisory Services Department, Rubber Smallholders, Rubber Inspectors of the Rubber Controllers' Department and Agriculture Instructors of the Department of Agriculture. In Addition the Head of the Department was involved in training Co-operative Inspectors and Managers, and two Planters from Bangladesh.

Z. E. Irugalbandara followed a 3 week user introduction course on remote sensing techniques conducted by the Survey General's Department.

All the members of the staff took part in the Mahapola Exhibition held at Matugama and assisted in field demonstrations.

Publications

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Liyanage, A. de S. Diseases of rubber absent or uncommon in Sri Lanka, *Handbook of Rubber Culture and Processing*. pp 183 - 189. Eds. O. S. Peries and D. M. Fernando. Sri Lanka: RRI. (In press)

Liyanage, A. de S. Disorders of nonparasitic origin, *Handbook of Rubber Culture and Processing*. pp 169 - 174. Eds. O. S. Peries and D. M. Fernando. Sri Lanka : RRI. (In press).

Liyanage, Indraneel. Conditions caused by physical injuries, *Handbook of Rubber Culture and Processing*. pp 175 - 182. Eds. O. S. Peries and D. M. Fernando. Sri Lanka : RRI. (In press).

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Abstracts

Liyanage, A. de S. (1983). An epidemiological approach to the control of *Oidium heveae* in rubber. *Proceedings of the thirty ninth Annual Sessions of the SLAAS*, December, Part 1. 40.

Liyanage, N. I. S. and Peries, O. S. (1983). Distribution and spread of *Rigidoporus lignosus* on *Hevea brasiliensis*. *Proceedings of the thirty ninth Annual Sessions of the SLAAS*, December, Part 1, 41.

Peries, O. S. (1983). Adaptation to environment in powdery mildew fungi. *Proceedings of the thirty ninth Annual Sessions of the SLAAS*, December Part 1, 42.

Reports

Liyanage, A. de S. (1982). Annual Review of the Plant Pathology Department.

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General

Extremely dry weather that prevailed at the beginning of the year resulted in early and even wintering. Consequently, most clones escaped an attack of *Oidium* leaf fall caused by *Oidium heveae*. However, in most areas pod set was also poor as flowers were shed, presumably due to conditions of moisture stress. There was a mild incidence of leaf fall and bark rot caused by *Phytophthora meadii* in isolated pockets in all rubber growing districts. Increasing numbers of estates reported secondary leaf fall caused by *Colletotrichum gloeosporioides* in seedlings immediately after planting. White and black root diseases caused by *Rigidoporus lignosus* and *Xylaria thwaitesii*, respectively, continued to cause damage both in immature and mature rubber plantations. Still another estate in the Kegalle District reported an outbreak of black root disease.

Scale insects are a major problem in seedling nurseries, especially during the dry periods.

Laboratory Investigations

Diseased specimens

The following specimens were sent to the Institute, for identifications :

	Identity of the disease	Number of specimens
Fungi	<i>Oidium heveae</i>	3
	<i>Colletotrichum gloeosporioides</i>	1
	<i>Botryodiplodia theobromae</i>	1
	<i>Fusarium solani</i>	1
Pests	Cockchafer grubs	1

Biology

Phytophthora meadii

Nomenclature (P/76/1)

Twenty nine isolates were collected, from Kelani Valley, Kalutara, Galle and Ratnapura Districts. Isolates were obtained from RRIC 36, RRIC 45, 88, 100, 101, 103, PB 86, PB 28/59, RRIM 600, 707, LCB 1320, GT 1. These isolates are being used for a comparative study with isolates collected from some other rubber growing countries. (N. I. S. Liyanage and A. Dharmaratna)

Colletotrichum gloeosporioides

Growth of isolates (G/76/2)

On the basis of growth on Potato Dextrose Agar (PDA), it was possible to separate the 15 isolates studied into two groups, fast and slow growing types. Only one isolate grew fast and the rest were slow growing. Difference between isolates varied significantly with time. The colony growth increased in a linear fashion with time, with approximately the same growth rate per day, but the fast growing isolate had a higher growth rate. The incremental growth was high in the fast growing isolate but it was less in the slow growing group. The highest growth increment for all isolates was seen between 72 - 96 h. (A. de S. Liyanage and N. M. A. Mallika)

Colony morphology (G/76/2)

All isolates produced pink spore pustules on PDA, 72 h after incubation. The fast growing isolate had thicker mycelia than others and spores were produced in concentric circles. Distinct zones of heavily sporulating areas alternated with non-sporulating areas. Distinct colour differences in the mycelia were also observed. In some isolates the entire colony appeared black, while in some others only the leading edge was black. However, in most isolates the colony assumed a whitish appearance in the early stages of growth but on ageing it turned grey or black. (A. de S. Liyanage and N. M.A. Mallika)

Growth characteristics (G/76/2)

The mycelial thickness differed significantly between isolates. Using Duncan's Multiple range test, the isolates were grouped into three categories according to their mean thickness ; thick ($>3.9 \mu\text{m}$), intermediate ($2.3 - 3.9 \mu\text{m}$), and thin ($<2.3 \mu\text{m}$).

Most of the isolates fell in to the intermediate category, five and two isolates fell in to the low and high thickness groups, respectively.

Using Duncan's multiple range test, the isolates were grouped into three significantly different categories, on the basis of sporulation.

The length, breadth and length/breadth ratio of conidia showed a highly significant difference between isolates. However, isolates did not fall into identical groups, when they were separated on the length and breadth ratio of conidia. Thus, either length or breadth can be used to discriminate among isolates.

Spore germination occurred 3 h after inoculation. The germinability of spores was very low in some isolates while in some others they germinated readily. Isolates can be separated in to three groups viz. fast, medium and slow growing ones on the basis of their germ tube development. Significant differences were observed between isolates and these differences vary with the period of incubation in a non-linear pattern. In all isolates, germination was complete in 6 h, thereafter the germ tube length increased rapidly and by 15 h there was profuse branching of the germ tubes. Appressoria were formed 6 h after incubation, in some isolates.

Colony growth on the leaves also showed significant interaction between isolates, clones and period of incubation. Maximum growth of all isolates was seen on leaves of the clone PB 86 while the lowest growth was recorded on leaves of the clone RRIC 100. However, at early stages of growth the difference between clones was not clearly distinguishable. There was a rapid increase in colony growth of all clones upto 9 h beyond which only a slight increase in growth was evident in all clones, except in the clone PB 86. The number of appressoria formed on resistant clones was higher than on leaves of susceptible clones. These observations confirm the previous findings.

The leaves of the clone PB 86 showed more black lesions due to infection than those of clone RRIC 103, 72 h after inoculation. Pink spore pustules were seen on the clones PB 86 and RRIC 100, 96 h after inoculation. The leaves of the clone RRIC 100 showed a few lesions 120 h after inoculation, but sporulation was absent. However, a few spores were produced on the 6th day. (A. de S. Liyanage and N. M.A.Mallika)

Rigidoporus lignosus

Growth characteristics (F/75/1)

Growth of isolates differed significantly with time.

Growth of all isolates increased significantly reaching a maximum around $28 \pm 2^\circ\text{C}$. All isolates did not grow at 15°C and the fungus was killed at 40°C .

The fungus did not grow, when inoculum plugs were placed directly on sterilized and non sterilized soils. However, when inoculum plugs were placed on sterilized cover slips on non sterilized soil well formed rhizomorphs were observed. They were thick and distinct unlike the silky thread-like mycelia on sterilized soil. The rhizomorphs formed on non sterilized soil disintegrated while those formed on sterilized soil remained intact.

Growth of all isolates *in vitro* increased with increasing pH levels with maximum growth being recorded at pH 8. Growth was inhibited at pH 3 and 4.

A similar growth pattern was observed on sterilized and non sterilized soils adjusted to different pH levels. However, in non sterilized soil, thick rhizomorphs were formed but they were thin and silky in sterilized soil. At pH 3 and 4 some species of *Trichoderma* were prominent and species of *Aspergillus* and *Penicillium* and some unidentified fungi were observed at pH values ranging between 6–10. (O. S. Peries and G. S. Gamage)

Control

Rigidoporus lignosus

Effect of sulphur (F/76/7)

After amendment of soil with sulphur, soil pH decreased rapidly in both sterilized and non sterilized soil. When inoculum plugs of the fungus were placed 2 weeks after the addition of sulphur, white strands of mycelia and thick rhizomorphs were formed on sterilized and non sterilized soils, respectively, 5 days after the placement of inoculum plugs. However, on the 8th day several other types of fungi appeared on non sterilized soil. When inoculum was placed 4 weeks after the addition of sulphur, inoculum disintegrated. The number of colonies of *Penicillium* spp., *Aspergillus* spp., unidentified fungal spp., and a few *Trichoderma* spp., was high before the addition of sulphur. However, after the amendment with sulphur *Trichoderma* spp., almost doubled and the other species declined.

Trichoderma spp., and *Penicillium* spp., showed antagonistic effects causing lysis of mycelium of *R. lignosus*. All these observations confirm the previous findings. (O. S. Peries and G. S. Gamage)

The use of sulphur (S), pentachloronitrobenzene (PCNB) and Terraclor (T) singly and in combination was tried as a dust sprinkled on soil, soil drench and mixing soil with the fungicides. The pH of the soil before the amendment was 6.4. The pH was reduced appreciably in 6 weeks when the soil was drenched, other treatments were less effective. The pH level recorded in 6 weeks for PCNB, PCNB + S, T, T + S and S used as a drench was 5.0, 3.3, 5.9, 4.4 and 3.1, respectively. The change in the microflora was also monitored and the number of colonies of *Aspergillus* spp., *Penicillium* spp., *Trichoderma* spp., and unidentified fungi were higher in all three treatments when compared with the control. *In vitro* studies showed that 2% PCNB was sufficient to inhibit the growth of *R. lignosus*. (A. de. S. Liyanage and S. S. Warnapura)

Rhizobia spp.

Nutritional studies (N/81/1)

A marked increase of dry matter yield was observed in *P. phaseoloides* with the addition of nitrogen. The nitrogen response curve was not sigmoidal, suggesting that there is no threshold value for nitrogen absorption in the sand used for the experiment. (C K. Jayasinghe)

Authentication of cultures (N/81/1)

A number of experiments were conducted to authenticate bacterial cultures obtained from Sri Lanka and Australia and also to find out a satisfactory rooting medium for *P. phaseoloides* to observe nodulation with different inocula under sterile conditions. (C. K. Jayasinghe)

Estimation of indigenous flora (N/81/1)

The experiments were done using Lancelian soils collected from Australia, to estimate the flora effective for *P. phaseoloides*. This soil had a poor indigenous rhizobial flora, equal to 4 cells per 1 g of soils. (C. K. Jayasinghe)

Production of antibiotic markers (N/81/1)

Mutant markers, have been widely and successfully used for studies on strain survival and competition in the presence of naturalized populations. Mutants were obtained and when they had acquired the expected level of streptomycin resistance (200 ppm), they were exposed to chloramphenicol to develop resistance up to 200 ppm depending on the strain.

Six strains of *Rhizobia* effective on *P. phaseoloides*, have been found.

Morphological characters in strain identification (N/81/1)

Morphology in culture was studied on single cell isolates of Sri Lankan strains and CB 756 on Yeast Manitol Agar (YMA). All strains except RRISL 09 and its mutants did not exhibit any morphological variations. They were found to be similar in size and shape, elevation and colour. Colonies of RRISL 09 and its mutants had a unique elevation with button like raised centres. These cultures were more pigmented compared to the colonies of other strains. (C. K. Jayasinghe)

Production of serological markers (N/81/1)

Antisera were produced against two types of *Rhizobium* spp., the first isolated from *P. phaseoloides* and the other *Rhizobium* spp., type CB 756. (C. K. Jayasinghe)

Serological relationships of tropical isolates of cowpea complex and some of their antibiotic resistant mutants (N/81/1)

Characteristic types of precipitation bands developed with the agar diffusion method. The shape, number, diffusion pattern and intensity of the bands developed in different reactions were characteristic and constant in different replications. Both strains produced only one strong precipitin band with homologous antisera and cross reactions did not occur at all.

The antibiotic resistant mutant of CB 756 formed a fused precipitin band identical in shape and density with its parent. The precipitin band of RRISL 09 str²⁰⁰ was relatively stronger when compared to the parent, but both bands were fused without forming a spur.

Miscellaneous investigations

Microflora on rubber leaves (M/81/1)

Leaf surface microflora on mature leaves of PB 86 were isolated, using malt extract, malt salt, potato dextrose, Czapek dox and nutrient agar. Eighty two fungal, nine bacterial and a few yeast colonies were isolated. This experiment is being continued for apple green as well as copper brown leaves. (A. de S. Liyanage and A. Dharmaratna)

Field Experiments

Epidemiology

Rigidoporus lignosus

Natural spread (F/76/5)

The rate of natural spread, from a known source of inoculum, for several estates located in different agro-climatic regions was studied. No new infections were recorded in any of the estates (see Annual Review 1982). There was more damage in the wet districts than in dry areas. (A. de S. Liyanage, O. S. Peries, N. I. S. Liyanage, S. S. Warnapura and E. A. T. Senadheera)

Detection by remote sensing techniques (F/83/1)

The use of infrared films was tried out to explore the possibility of detecting trees in the initial stages of infection by *R. lignosus*. Preliminary studies have indicated that this technique could be successfully employed in early detection. This project was done in collaboration with the Sri Lanka - Swiss Remote Sensing Project of the Survey General's Department. (A. de S. Liyanage, R. Humble and Z. E. Irugalbandara)

Control

Oidium heveae

Artificial defoliation by fogging (O/76/3)

Two fogging machines *i.e.* Tiga (Tifa Ltd., U.S.A.) and Leco "120 D" (Lowndes Engineering Co., U.S.A.) were tested at Millewa Estate, to determine the suitability of these machines to cause artificial defoliation under local conditions. Fogging was done with Thidizuron (Dropp, Schering Co., Germany), using diesel as the carrier oil; 1.6 kg of Thidizuron was used for each plot.

Leaf abscission was induced about 4 days after fogging the defoliant. Both machines performed equally well, with maximum defoliation occurring 7 and 10 days after fogging with the Leco and Tiga, respectively. Most of the leaves fell over a period of about 17 days. The horizontal and vertical drift was judged by the height and the number of interrows covered by the fog, respectively. It was observed that Leco gave better coverage, when the vehicle was driven at a speed of 5 mph. The Tiga delivered the 6.1 of the defoliant in 5½ min, compared to 7 min in the Leco. (A. de S. Liyanage, S. Wettasingha, A. Dharmaratne and B. Fernando)

Rigidoporus lignosus

Clearing and disease incidence (F/75/1)

The incidence of white root disease was low, when the infected roots in the old stand were uprooted and burnt or uprooted and stacked. Two to three fold increase in the number of trees infected in the new clearing was evident, when the stumps were left in the soil. Application of sulphur does not help to reduce the infection, unless the inocula are removed. Application of "Collar Protectant" on the budded stump, at the time of planting increased the mortality rate. However, it was less when sulphur was applied. The incidence of the disease was low in plants which received these two treatments.

In another series of experiments, cut stumps were treated with Borax, urea, 2, 4, 5-T and compared with uprooting and burning the stumps and leaving them behind without any treatment. Treatment with 2, 4, 5-T caused rapid decay. The incidence of white root disease was high when the stumps were left behind, especially if the infection in the old stand was high. There was very little or no infection in the dry areas. (A. de S. Liyanage and W. Amaratunga)

Treatment of infected patches and disease incidence (F/76/4)

Results of experiments done at several estates indicated that removal of infected root debris reduced the new infections in the replanting, especially when sulphur was applied to the planting hole. Careful removal of infected roots from the periphery of an infected patch in the old stand reduced the new infections appreciably. However, failure to remove the sources of infection led to a high incidence, despite the application of sulphur. The application of sulphur had little or no effect when the food base was carefully removed. It was also observed that when the infected debris was removed from the rows bordering infected patches, the number of infected plants in the replanting was significantly lowered. (A. de S. Liyanage, S. S. Warnapura and E. A. T. Senadheera)

Effect of nitrogenous fertilizers and sulphur (F/81/12)

The effect of the recommended dosage and double the dosage of ammonium sulphate and urea with and without sulphur on the effect of soil pH and viability of inoculum was examined. The results obtained so far have not indicated any difference between these treatments. (A. de S. Liyanage, S. S. Warnapura and E. A. T. Senadheera)

Planting distance and disease incidence (F/80/1)

The cumulative loss of trees due to white root disease is shown in Table 2.

Table 2. *Cumulative loss of trees at different planting distances (F/80/1)*

Planting distance (m)	Estate			
	1	2	3	4
(1) 4.6 x 4.9	2.7	1.7	1.4	0.1 (1)
(2) 3.7 x 6.1	2.1	(2) 3.5	(2) 4.5	0.4
(3) 3.1 x 7.3	(3) 2.8	3.1	0.6	0.2
(4) 2.4 x 9.2	0.8	1.8	4.4	0.8

* Spacing of the old stand shown in parentheses.

Changing the planting distance between replanting cycles help to reduce the incidence, except when a planting row of the replanting coincides with infected debris in the old stand. In such an event the spread within the row is high as seen for the planting distance 2.4 x 9.2 m, in estate 3. (A. de S. Liyanage, S. S. Warnapura and E. A. T. Senadheera)

Miscellaneous

Rainfall and crop data

Daily rainfall and yield records have been collected for a number of estates in the Kalutara, Ratnapura and Kegalle Districts. These records and other information on disease incidence are continually being discarded due to lack of sufficient storage space in the estates. The RRI recognised the value of the data and started a programme to computerise these records which will allow studies on temporal and spatial variation between rainfall, disease and yield to be undertaken. Those collaborating in this project are the Tropical Agricultural Meteorology Group, University of Reading and the Statistical Section, University of Colombo. The Methodology for the crop climate studies is still being developed. In the meantime, examination of raw rainfall data indicated high values in December 1964 and on isolated peak in February 1968. When the mean yield per tapping day was examined it was lowest in February. Use of daily rainfall and monthly evaporation data showed that there are 18 or more consecutive days in January with less than 15 mm in 1 year in 6. Regression studies showed that these years were the same as those in which the mean yield per tapping day was also low. (A. de S. Liyanage, Ann Leaker and Savithri Abeysekara)

REVIEW OF THE SOILS AND PLANT NUTRITION DEPARTMENT

By

N. YOGARATNAM

SUMMARY

The study of the responses of rubber trees to factors affecting the supply of nutrients and water and to soil management practices has been the main concern of the Department. Research on analytical methods is another important subject that has been handled by us.

Growth analyses of immature plants in replantings continued to indicate significant linear and curvilinear responses to applications of potassium and curvilinear responses (diminishing returns) to application of nitrogen and phosphorus. These effects were however similar in PB 86 and all the RRIC 100 series clones tested.

Yield data obtained from four field experiments showed variable results. Significant yield responses to applications of N and K were seen in some experiments. Significant PK interaction on yield was also observed on Agalawatte soils. This emphasises the importance of the use of fertilizers to mature rubber on a discriminatory basis, taking into consideration such variable factors as soil type, clone, age of the plant and management practices.

Some soil management practices such as establishment of legumes continued to show their beneficial effects on growth. The beneficial effects of phosphate, applied to covers during the immature period, were not visible 8 years after the rubber was planted. Application of potassium fertilizer direct to the rubber tree appears to be as efficient as its application to the ground covers, especially on K deficient soils.

Cation exchange capacity of rubber leaves was determined by the method of acid washing and titration. From this work it appeared that only very small amounts of Ca and Mg present in leaves were associated with the exchange sites and therefore in mobile forms. Analysis of bark and latex of trees affected by the physiological disorder, brown bast indicated that this disorder was likely to be associated with an imbalance of K, Ca and Mg in the trees.

Preliminary investigations connected with studies on soil-plant-water relations indicated that the Neutron Moisture Meter count rates were likely to be influenced by the location of access tubes on dry days. The available water storage capacity and available soil water in relation to rainfall have also been worked out for the Boralu soils.

The foliar survey programme which commenced in June, provided data for fertilizer recommendations for 4268 hectares.

DETAILED REVIEW

Staff

The Head of the Department, Dr N. Yogaratnam, the Agricultural Chemist Dr M. K. S. A. Samaraweera and the Assistant Soils Chemist, Mrs L. Samarappuli were on duty throughout the year.

The Experimental Officers, W. C. Dayaratne, A. M. A. Perera, S. Gunasekera and Percy Silva and the Technical Officers, S. Wasanthadewa, I. Denawaka, C. Maheepala, S. N. Silva, H. V. K. Rodrigo, D. Udaratagedera, J. G. de Mel and P. Karunadasa were on duty throughout the year.

Mr S. Abeyratne, Clerk/Typist resigned his post. Miss L. Rupasinghe, joined the Department as Clerk/typist on a temporary basis.

Research students

S. M. Weerasooriya from the Faculty of Agriculture, Peradeniya University, A. Kapila N. Zoysa, W. M. Ranjani Yapa and T. S. Mahanama from the Ruhuna University worked on the following projects in partial fulfilment of the requirement of the specialization course in soil science :

- Mahanama, T. S. .. The sulphur status of some soils in the rubber growing areas of Sri Lanka.
- Weerasooriya, S. M. .. Effects of fertilizers on the performance of mature rubber in Agalawatta series soil.
- Yapa, W. M. Ranjani .. Effects of fertilizers on growth and nutrient uptake of immature rubber.
- Zoysa, N. A. Kapila .. A study of some morphological, physical and chemical characteristics of the rubber growing soils in Sri Lanka.

Visits

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

The Agricultural Chemist participated in a programme on "Fertilizer efficiency research in the tropics" held in Malaysia in May 1983. This programme was organized by the International Fertilizer Development Corporation (IFDC) in collaboration with the University of Pertanian, Malaysia. He also visited the Rubber Research Institute of Malaysia (RRIM) during his stay in Malaysia.

Meetings

The research staff participated in the following meetings, seminars and training courses :

Seminars and field days

SLSPC Planters' Seminar, Galle region.
JEDB Planters' Seminar, Kegalle region.
SLSPC Planters' field day, Galle region.
JEDB Planters' field day, Avissawella region.
SLSPC Visiting Agents' Seminar, Galle region.
JEDB Agricultural Advisors' Seminar, Colombo.
JEDB Planters' Seminar, Avissawella region.
Eighth consultation on the FAO fertilizer programme, Colombo.

Training programme for the following :

Rubber Smallholders under the SRRP.
Rubber Extension Officers of the ASD.
Co-operative Executives and Co-operative Managers of the Co-operative Development Department.
Agricultural Instructors of the Agricultural Department.
Rubber Inspectors of the Rubber Controllers' Department.
Students of the soil science specialization course from the Ruhuna Campus and post graduate students from Jayewardenapura University.
Fertilizer dealer trainers organized by the National Fertilizer Secretariat (NFS)

The research staff also served on the following working groups and committees :

Co-ordinating committee on fertilizer suppliers of the Ministry of Plan Implementation.
Technical Committee of the Tender Board of the Ceylon Fertilizer Corporation.
Technical Committee of the Bureau of Ceylon Standards of the Ministry of Industries and Scientific Affairs.
Agriculture Group of the Atomic Energy Authority (AEA) of Sri Lanka.
Working Groups on " Phosphate fertilizer efficiency studies ", " The use of ^{15}N in soil/plant studies " and " Studies related to the use of Neutron Moisture Meter for assessing availability and conservation of soil water in plantation crops in Sri Lanka ", Co-ordinated by the AEA of Sri Lanka.
The Council, Institute of Biology, Sri Lanka.
Steering committee of fertilizer credit scheme for tea and rubber smallholders, Ministry of Plantation Industries.
Local technical committee on the biological control of *Salvinia molesta* by the insect *Cryptobagous singularis*.
Committee for popularisation of science of the Sri Lanka Association for the Advancement of Science.
Soil Science Society of Sri Lanka.

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Reports

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Laboratory Investigations

Analytical Chemistry

Routine analyses

Routine chemical analyses of soil and leaf samples from survey, experimental and advisory work, of the Department were done. Requests from other research Departments of the Institute, other research Institutions, Universities, the Janatha Estates Development Board, Ceylon Fertilizer Corporation and the Bureau of Standards of Sri Lanka, were also carried out. A breakdown of the number of samples analysed is given in Table 1. (A. M. A. Perera, D. Udaratagedara and H. V. K. Rodrigo)

Table 1. *Details of chemical analyses done in 1983*

Department/Institution	Samples	Nutrients :		CEB Mechanical analysis Org. C, pH etc.
		N,P,K,Ca, Mg & Mn	Trace elements	
Soils & Plant Nutrition	Leaf	2132	286 (S only)	—
	Soil	340	286 (S only)	210
Plant Science	Leaf	120 (P only)	—	—
Plant Pathology	Soil	84	84 (S only)	—
Biochemistry	Soil	100	—	—
	Rubber	20	—	—
	Water	—	3	—
Dept. of Agriculture	Leaf	120	120 (Fe only)	—
	Soil	120	120 (Fe only)	—
Coconut Research Institute	Soil	105	105 (Al only)	—
University of Sri Jayewardenapura	Soil	80	—	—
Bureau of Standards	Fertilizer	12	—	—
Ceylon Fertilizer Corporation	Fertilizer	5	—	—

Analytical methods

Statistically designed experiments were carried out to find the optimum conditions for the determination of nutrients such as N, P, K, Mg, Ca, Mn, Zn, Cu, Mo, Fe, in different tissues. The organic matter in the tissues was destructed either by wet digestion or by dry ashing and a summary of the methods employed is given below :

(1) Dry ashing : the variables were:

- (a) Ashing temperature (four levels)
- (b) Ashing time (four levels)
- (c) Composition of the ashing aid (four levels)

(2) Wet digestion : Three digestion mixtures were used:

- (a) HNO_3 : HClO_4
- (b) H_2SO_4 : Se : H_2O_2
- (c) H_2SO_4 : HClO_4 and in each case the variables were:
 - (i) Composition of acid mixture (four levels)
 - (ii) Digestion time (three levels)
 - (iii) Digestion temperature (four levels)

Classical methods as well as newer instrumental methods were used for assaying the nutrient contents.

The effects of these factors and possible interactions on the extraction of the nutrients were studied by the analysis of variance. The suitability of a procedure was determined by the coefficient of variance. In addition the precision and accuracy of a method, and the minimum detectable quantity of a substance were also considered.

The development of mathematical relationships that link the analytical value of the nutrient content in a given tissue with the conditions used for destruction of organic matter and the analytical method employed, is in progress.

e.g. If leaf nitrogen content is X_N^L

Step 1 is:

$$X_N^L = a + b_1T + b_2C + b_3t + b_4TC + b_5Ct + b_6Tt + b_7TCt + E_1 + E_2$$

Where T = temperature

C = composition of the acid mixture used for wet digestion.

t = digestion time.

a, b₁, b₂, b₇ are constants.

E₁ is the random error.

E₂ error associated with the analytical method.

A, b, b₇ are to be computed by regression analysis. Where
 $A = a + E_2$

E₂ can be determined using the measurement errors. Finally we can approximate X_N^L by $\hat{A} + \hat{b}_1T + \dots + \hat{b}_7TCt$ Where "Λ" mean an estimate of the corresponding coefficients. Free energy of formation of different compounds and kinetics will also be considered. (M. K. S. A. Samaraweera in collaboration with W. N. Wickrema-singhe)

Determination of cation exchange capacity (CEC) of plant tissues : The cation exchange capacity of tissues can be determined by two methods. Method A is based on acid washing and titration and method B is based on isotope exchange. Since there were no facilities for isotope exchange, method A was employed. But this method could not be used for latex because the latex gets coagulated when H⁺ ions are added.

Acid washing technique : Disks were taken from fresh leaves using a paper puncher and washed with distilled water. A random sample of 20 disks were agitated in ice cold .01 N HCl, allowed to attain equilibrium. They were then thoroughly washed free of acid with distilled water, placed in 200 ml, 1M KCl and titrated with 0.01 N KOH to pH 7. After washing free of KCl, the disks were dried overnight at 80° C. The results are expressed as me. per 100g dry matter.

Powdered leaf samples : Powdered leaf samples were assayed as follows : 1 g was agitated with ice cold 0.01N HCl, filtered, washed until the filtrate was free of Cl⁻ ions, the residue was transferred into 200 ml 1.0 M KCl and titrated to pH 7 with 0.01N KOH.

The CEC of the leaves determined by using disks and powdered samples were in close agreement. Leaves taken from healthy plants have a CEC value of 10 me. per 100 g dry matter. The total K, Ca, Mg, contents of a rubber leaf can vary from 75 - 145 me. per 100 g dry matter. The sum of Ca and Mg contents in the same tissue can be 35 - 100 me. per 100 g dry matter.

Thus, relatively small amounts of Ca and Mg in leaves are associated with the exchange sites and hence only a small fraction is in the mobile form. The cation exchange sites in the leaves are carboxy groups (COO^-) of the uronic acids in the cell wall. It has been shown that in many tissues the uronic acid content is generally twice the CEC value. The recent work at the Macaulay Institute is interesting. They have found that the CEC value depends on the methods used to determine this parameter. Of the two methods employed, the acid washing method gives lower values than the isotope method. The CEC determined by the isotope dilution method gives twice the value obtained by the acid washing method and it can be compared with the uronic acid content. It is also reported that the synthesis of uronic acid is controlled by the hormonal status of the plant. Since the movement of Ca is via the cation exchange sites it is particularly important to study the CEC of different tissues within the plant. Using the Donnan Equilibrium it can be shown that tissues with higher CEC would selectively absorb more divalent ions than monovalent ions. (M. K. S. A. Samaraweera and S. N. Silva)

Brown bast studies

Ionic balance and mineral complexes

K, Ca and Mg contents in different tissues were determined. They were taken from the leaves of nutrient deficient plants, healthy plants and bark of the trees that are susceptible to brown bast.

As the first part of the study the nutrient composition of latex from the clone PB 86 was determined. Samples of latex were centrifuged at 12,000 rpm, during which it separated into three phases, the rubber cream the serum and the lutoid residue. But this separation was not very accurate as some rubber remained in the serum. Fresh weight, dry weight and nutrient composition of all three phases were determined. Latex was then treated with water, dilute acids, oxalates, phosphates and ethylenediaminetetraacetic acid (EDTA) that form complexes with some nutrients, and precipitate or extract some others. It was then centrifuged at 12,000 rpm and the composition of the phases determined.

The trees of the clone RRIC 101, in a 1970 replanting were grouped according to the latex yield, and flow as high (H) medium (M) and low (L) producers. Five trees from each group were selected for the uniformity of growth and latex samples and bark shavings were collected from them. The nutritional composition of uncentrifuged latex, different fractions of centrifuged latex and bark samples were determined.

Properties of latex from affected trees were also studied.

In an island wide survey, leaves from mature rubber trees were collected when they were fully developed and the nutrient content in them was determined. The total K, Ca and Mg content in leaves had a wide range from 70 - 145 me. per 100 g dry matter and the total amount of divalent cations could vary from 35 - 100 me. per 100 g dry matter.

Chemical analyses of normal latex and centrifuged latex (with and without the addition of chemicals) from healthy PB 86 trees had shown that, while there were at least three different compounds of Ca in latex, most of the K in it is in water soluble form. Mg behaves very much the same way as Ca. The nature of the equilibrium existing in these compounds has to be studied using ^{45}Ca .

When the latex samples produced by high, medium and low yielding trees from a population of the highly susceptible clone RRIC 100 were analysed for total K, Ca, Mg contents, we did not see any apparent difference in the composition. But analyses of centrifuged latex and bark indicate that (Table 2) this disorder is associated with an imbalance of K, Ca, Mg composition in the trees. Latex from affected trees tended to coagulate within a short time after the secretion and it is not possible to centrifuge this latex to produce three different fractions. (M. K. S. A. Samaraweera and S. N. Silva)

Table 2. *Composition of Hevea tissues*

Element	Clone	Nature of the tree	Concentration me. (100 g dry matter)			% Distribution	
			Bark	Latex	Rubber	Serum	Lutoid residue
K	RRIC 101	H Yielding	19-20	13-15	1.1	98.5	0.5
		M Yielding	19-23	13-15	1.0	91.0	8.0
		L Yielding	19-24	14-18	1.0	87.0	11.0
	PB 86	Normal	21	x	x	x	x
Ca	RRIC 101	H Yielding	57-62	0.8-0.9	21.0	14.0	65.0
		M Yielding	57-66	0.5-0.7	10.0	24.0	66.0
		L Yielding	58-63	0.6-3.9	13.0	20.0	67.0
	PB 86	Normal	151	x	x	x	x
Mg	RRIC 101	H Yielding	96-117	80-132	1.0	7.0	92.0
		M Yielding	87-101	69-101	15.0	5.0	79.0
		L Yielding	111-134	62-121	0.2	43.1	56.7
	PB 86	Normal	21	x	x	x	x

x. Not included as trees were grown in different locations and latex were not collected under similar conditions.

Sand culture

Seeds from clone PB 86 were germinated in nutrient free sand. Seedlings of equal height were transplanted in pots containing nutrient free sand. The plants were treated with modified Hewitt's solution and there were seven treatments replicated five times. One contained all the nutrients, while the remaining six contained all the nutrients except N, P, K, Ca, Mg and S, respectively, in each. Leaves were collected at different stages of visual symptoms of hunger signs, and the nutritional composition was determined. The bark of the 2-year old plants was pierced with a pen, about 20 holes per plant were made at a 30 cm height from the ground level and the latex was collected into filter papers, dried and the dry weight of latex samples was recorded. The plants were young and the latex yields were rather low. Significant differences were not seen in the latex production of these plants grown under different nutritional regimes. (M. K. S. A. Samaraweera, Mangalika de Costa and Chitra Maheepala)

Micronutrients

The effect of molybdenum on the nitrogen nutrition of *Pueraria* is being studied. Seeds were inoculated with a rhizobial culture prepared from bacteria isolated from the root nodules of *Pueraria* plants in Dartonfield. Ten seeds were germinated per pot in

nutrient free sand. There were two molybdenum treatments, (with and without Mo) and three nitrogen treatments, (N as NH_4^+ , N as NO_3^- and no N). Thus there were six treatments and five replicates. During the first 6 weeks after germination all the plants were treated with the appropriate nutrient solution with no nitrogen. The nitrogen treatments were introduced only after 6 weeks and the density of plants was reduced to four per pot, selected for uniformity of growth. The plants are harvested after 5 months and various assessments are being made. (M. K. S. A. Samaraweera and Sumitra Gunasekera)

Isotopes in plant nutrition and physiology

Equipment such as the liquid scintillation counter were received from the International Atomic Energy Agency. This equipment was installed in the new Isotope Laboratory. (M. K. S. A. Samaraweera, W. C. Dayaratne, S. Gunasekera, S. N. de Silva and C. Maheepala)

Soil - plant - water relations (SM/83/2)

A pot experiment has been started to study the effects of moisture stress on growth and nutrient uptake in immature rubber plants. Three levels of moisture and two levels of fertilizer mixture N, P, K and Mg will be applied in a factorial combination to single tree plots growing in empty tar barrels (diameter 60 cm and depth, 100 cm). The treatments will be replicated four times. Containers have been filled with Agalawatta series soil and polybag plants have been planted. Soil water tension in the containers will be monitored regularly by tensiometers that will be installed in each container. Regular assessments for leaf water potential (using a Scholander Pressure Bomb), rate of transpiration and chemical composition of leaves will be done. (L. Samarappuli, I. Denewaka and P. Karunadasa)

Field Experiments

Preliminary work on the following new projects were completed :

1. Nutrient requirements of mature rubber trees : an appraisal of methods of recommending fertilizers to mature rubber.
2. The study of the response of rubber trees in smallholdings to fertilizer application.
3. The study of the response of rubber trees in organised plantations to fertilizer.
4. Study of the potassium and magnesium deficiencies in young rubber.
(M. K. S. A. Samaraweera, W. C. Dayaratne and S. N. Silva)

Response to fertilizers

N, P, K, and Mg on growth of immature plants (F/76/1, F/76/3, F/76/4 and F/76/5)

Experiment F/76/1, started at Pembroke State Plantation, compares the effects of 5 levels of N, P, K and Mg on growth of PB 86 growing in Boralu series, in a central composite second order design. This experiment has been designed to study the response surface of the nutrients N, P, K, and Mg by fitting the function Y (girth response) = $b_0 \pm b_1N \pm b_2P \pm b_3K \pm b_4Mg \pm b_5N^2 \pm b_6P^2 \pm b_7K^2 \pm b_8 \pm Mg^2 \pm b_9Np \pm b_{10}NK \pm b_{11}PK$.

Fitting of the girth data obtained at the end of 1983 indicated : $Y = 39.5697 + 4.2582 N + 1.0446 P + 1.0407 K + 2.4365 Mg - 1.1179 N^2 + - 0.05879 K^2 - 0.1916 Mg^2 + 0.0988 NP + 0.4265 NK - 0.0088 NMg + 1.4175 PK - 0.272 PMg - 0.3275 KMg$.

According to this equation, least square estimates for maximum fertilizer levels, as given in the treatment code were : $N = 2.0334$, $P = 0.4654$, $K = 0.6792$ and $Mg = 5.4002$.

This would mean that the most effective fertilizer combination as indicated by the girth data obtained at the end of 1983 would be $N_2 P_1 K_1 Mg_6$. (N. Yogaratanm and F. P. W. Silva)

In three other experiments F/76/3, F/76/4 and F/76/5 growth as indicated by girth (Tables 3 to 5) of all RRIC 100 series clones was greater than that of PB 86 and there were significant responses to applications of N, P and K. These effects however were similar in all the clones tested. (N. Yogaratanm and J. G. de Mel)

Table 3. *Effect of three levels of N and P on mean girth of three clones (F/76/3)*

Clone	Mean girth (cm)	Level of N	Mean girth (cm)	Level of P	Mean girth (cm)
PB 86	47.6	N_0	47.5	P_0	47.7
RRIC 101	51.6	N_1	50.2***	P_1	51.3**
RRIC 102	52.8	N_2	54.3***	P_2	53.0**

In this and all other Tables, statistical evaluations indicated by *, ** and *** denote that the treatments are significantly different from the control at $P = 0.05$, 0.01 and 0.001 , level, respectively.

Table 4. *Effect of three levels of N and K on mean trunk girth of four clones (F/76/4)*

Clone	Mean girth (cm)	Level of N	Mean girth (cm)	Level of K	Mean girth (cm)
PB 86	46.1	N_0	49.52	K_0	46.03
RRIC 100	50.8	N_1	51.53**	K_1	53.05***
RRIC 101	54.1	N_2	52.28**	K_2	54.25***
RRIC 102	53.6				
		LSD	1.49	LSD	1.49

Table 5. *Effect of three levels of K on mean trunk girth of three clones (F/76/5)*

Clone	Mean girth (cm)	Level of K	Mean girth (cm)
PB 86	47.6	K_0	47.5
RRIC 100	55.4	K_1	54.3***
RRIC 101	54.9	K_2	55.1***

Investigations on K/Mg imbalance in immature rubber (F/83/1 to 4)

As nutrient imbalances in immature rubber plantations have been observed in the recent past, a detailed investigation was started to find out the causes for such imbalances and to recommend suitable remedial measures.

Four sites were selected from areas where plants showed deficiency symptoms in Mirishena State Plantation (F/83/1), Hedigalla State Plantation (F/83/2), Eduragalla State Plantation (F/83/3) and Anhettigama Estate in Deraniyagala (F/83/4). The Plants in the affected areas were divided into three categories, mild, moderate and severe in relation to the intensity of deficiency. Four levels of K and Mg were applied in a factorial combination to single tree plots in a fully randomized design with treatments replicated 25 to 50 times. All the experimental plants received uniform applications of N and P. (N. Yogaratnam, A. M. A. Perera, F. P. W. Silva, D. Udaratagedara and H. V. K. Rodrigo)

Different levels of N, P, K, and Mg on yield of mature rubber (F/61/1, F/61/2, F/76/8 and F/76/10)

Four experiments, to study the effects of fertilizers on yield of mature rubber were in progress covering Boralu, Agalawatte and Parambe soils. Yield data obtained in 1983 showed variable responses to applications of fertilizers under the conditions of these experiments.

Yield data obtained from experiment F/76/8 in which the effects of three levels of N, P, K, and Mg on yield of clone RRIC 45 growing on Agalawatte soils indicated (Table 6) significant response to application of nitrogen. Yield increase of 7% was observed when nitrogen was applied at the currently recommended rate and a further increase to 12% with application at double the currently recommended rate. There was also a significant PK interaction (Table 6) indicating that applications of P and K are likely to give higher yields when applied separately, but when applied together especially at P₂ and K₂ levels, reduction in yield can be observed possibly due to imbalance in the tree. (N. Yogaratnam, A. M. A. Perera, and J. G. de Mel)

Table 6. *Effect of three levels of nitrogen on growth and yield of clone RRIC 45 growing in Agalawatta soils (F/76/8)*

Nitrogen	Mean yield (Kg/ha)	Increase over control	Mean girth (cm)	Increase over control
N ₀	1338	100%	62.50	100%
N ₁	1432	107%	64.27**	103%
N ₂	1494*	112%	66.33**	106%

Table 7. *Effect of 3 levels of P and K on yield (kg/ha) of clone RRIC 45 growing in Agalawatte soils (F/76/8)*

	K ₀	K ₁	K ₂
P ₀	1320	1484	1491
P ₁	1458	1415	1347
P ₂	1538	1415	1325
LSD (P = 0.05) = 3.18			

Fertilizers in relation to stimulation (FS/72/1, FS/78/1 and FS/80/1)

The effect of different levels of N, P and K, in relation to stimulation with Ethrel, was examined in these experiments. There were no significant effect of fertilizer treatments on the yield in relation to stimulation with Ethrel during this year.

A similar experiment, FS/78/1, on Parambe Estate, Undugoda, was terminated this year. (N. Yogaratnam and F. P. W. Silva)

Economics of fertilizer application (F/76/15)

Experiment, F/76/15, where the treatments, (1) no fertilizer in the 1st year (2) no fertilizer in the 1st and 2nd years, (3) no fertilizer in the 1st, 2nd and 3rd years, (4) no fertilizer at all and (5) fertilizer every year, which was started in 1976 on mature rubber trees was continued. Fertilizers were applied only to the plots that should receive fertilizer every year *i.e.* treatment 5. Yield data obtained at the end of the year did not reveal any significant differences in yield due to treatments. (N. Yogaratnam and S. Wasanthadewa)

The smallholdings in Galle and Matara Districts were grouped according to their sizes and several smallholders were interviewed. A questionnaire was prepared to collect the basic information for the pilot study. (M. K. S. A. Samaraweera, W. C. Dayaratne in collaboration with Dr N. Fernando of The Central Bank and P. Samaranayake of the ASD)

Efficiency of fertilizer utilization (F/76/2 and F/76/17)

Experiments to study the effects of different sources of nutrients on growth and yield of rubber were continued.

Experiment, F/76/2, were designed to compare the effects of three forms of nitrogen, phosphate and magnesium on growth of PB 86 in Boralu soils. Girth measurements made at the end of 1983 have not indicated any significant effects of applied nutrients on growth. Therefore, no comparison can be made between the sources of nutrients from this data.

The effects of Eppawala rock phosphate and imported rock phosphate, each at two levels of P, on growth and yield of PB 86, growing on Boralu soils was studied in experiment F/76/7 at Eladuwa State Plantation. Girth data (Table 8) showed a significant response to application of phosphates, irrespective of the source of the material applied, but increasing the level of application to double the presently recommended rate did not give any improvement of girth. (N. Yogaratnam, A. M. A. Perera and J. G. de Mel)

Table 8. *Effect of imported rock phosphate and Eppawala rock phosphate on growth of PB 86 (F/76/17)*

Treatment	Mean girth (cm)
Nil Phosphate	55.2
Eppawala Rock Phosphate : Level 1	58.0**
Eppawala Rock Phosphate : Level 2	58.9**
Imported Rock Phosphate : Level 1	58.6**
Imported Rock Phosphate : Level 2	59.3**

Covers and cover management

Five experiments were in progress to study the effects of ground covers and cover management practices on growth and yield of rubber.

Types of covers (C/72/2, C/77/3 and C/77/6)

Experiment, C/72/2, was started to determine whether legumes are superior to naturals in promoting growth of immature rubber. If so, whether application of extra nitrogen to nonlegume covers would improve growth during the immature period and yield during early maturity of *Hevea*. Girth and yield data obtained in 1983 indicated that the beneficial effects of the treatments practised during the immature period had ceased to influence growth and yield of rubber in 1983. (N. Yogaratnam and J. G. de Mel)

Studies on the effect of various leguminous covers on growth were carried out at two sites. The control plots in these experiments were in naturals. In general, growth of trees in legumes was superior to the trees in naturals; except *Stylosanthus guyanensis (gracilis)* which continued to show a depressive effect on growth of immature plants in the experiment (C/77/6), located in the Kurunegala District, where the annual rainfall is much lower than in the Kalutara District. (N. Yogaratnam and J. G. de Mel)

Nutrition of legumes (C/70/2 and C/77/8)

Phosphate : The effect of applying phosphate to covers on the growth of *Hevea* was studied in one experiment (C/70/2). Phosphate application was discontinued in 1974. Data obtained in 1983 indicated that the beneficial effects of phosphate on growth and yield, seen earlier, did not persist any longer. This effect was seen only for a period of 8 years. (N. Yogaratnam and S. Wasanthadewa)

Potassium : A similar experiment to the above, but on the effect of application of K to legumes was also carried out (C/77/8). Unlike phosphate, the application of potassium direct to the rubber tree appeared to be as efficient as its application to the ground covers (Table 8), in particular on K deficient soils. (N. Yogaratnam and F. P. W. Silva)

Table 8. *Effect of K application on growth of PB 86 in Boralu soils (C/ 77/8)*

Treatment	Mean girth (cm)
K to rubber : Nil	45.01
Level 1	48.85**
K to cover : Nil	42.31
Level 1	48.95***
Level 2	49.54***

Soil - plant - water relations

Preliminary investigations connected with studies on soil - plant - water relations, were started on a 1980 replanting at Clyde State Plantation. In these studies the neutron probe will be used extensively to monitor soil water in field studies concerning the response of the plant to water stresses. Soils water deficit in the root zone will be estimated by the neutron probe whilst plant physiological and micrometeorological measurements will be maintained on the above ground part of the system.

Location of access tubes (SM/82/1)

Sampling bias may arise when, as a result of access tube location or mode of installation, the samples of the soil system are not representative of the whole water distribution of a site. Studies were started to determine the appropriate positions of access tubes in relation to planting points in rubber growing soils. Four trees were selected at random in a 3 year old replanting at Clyde State Plantation. Access tubes were installed at distances of 60 cm, 1.2 m and 1.8 m from the trunk of each plant in the north, south, east and west directions, making in all 12 positions in relation to each plant. Co-efficient of variation of count ratios, for 12 months from September 1982 indicate that during wet periods, the count ratio may not be influenced by the location of the access tubes under the condition of the experimental site.

But on dry days in general, distances 1.2 to 1.8 m from the tree would appear to give the most reliable information with increasing accuracy at lower depths (Fig 1).

As the growing rubber plants and ground cover vegetation may also cause changes in the soil water storage pattern, this study is being continued. (L. Samarappuli, I. Denawake and P. Karunadasa)

Calibration of the neutron moisture meter (SM/82/2)

Establishment of the basic calibration curve for the particular neutron probe and type of installation and for the general class of soil to be met in the experimental area is an important aspect of these studies.

Field calibrations were made by obtaining moisture meter reading in duplicate at appropriate depths. Soil samples for determining moisture content and bulk density were taken from corresponding depths on which moisture meter readings were taken, by digging a pit around the access tubes.

Calibration curves obtained from 29 readings taken over a period of 12 months, for the surface (0 - 10 cm) is, $0 = 0.41 \text{ CR} - 0.18$ (Fig. 2, 1 and 2) and for the sub surface soils (10 - 160 cm) is, $0 = 0.52 \text{ CR} - 0.39$. (L. Samarappuli, I. Denawake and P. Karunadasa)

Available water storage capacity of the soil (SM/82/3)

One of the objectives of a measurement programme based on the neutron meter is the estimation of one or more of the complex variables of the profile water balance such as run off, evapotranspiration, deep drainage and change in the soil water store. The profile water store is the difference between the upper and lower limits of water content to some specified depth, usually the root zone.

Fig. 3 illustrates the available water storage capacity (AWSC) of the experimental area over a period of 12 months from October 1982, which has an upper limit of 235.5 mm (field capacity) and a lower limit of 131.3 mm, thus yielding an AWSC of 104.2 mm. This is likely to be the amount of water available to the rubber plants under the conditions of the experimental site. Clearly these upper and lower limits are somewhat arbitrary, yet in practical terms the neutron probe has provided a useful estimate of the profile water store and the AWSC of the root zone. (L. Samarappuli, I. Denawaka and P. Karunadasa)

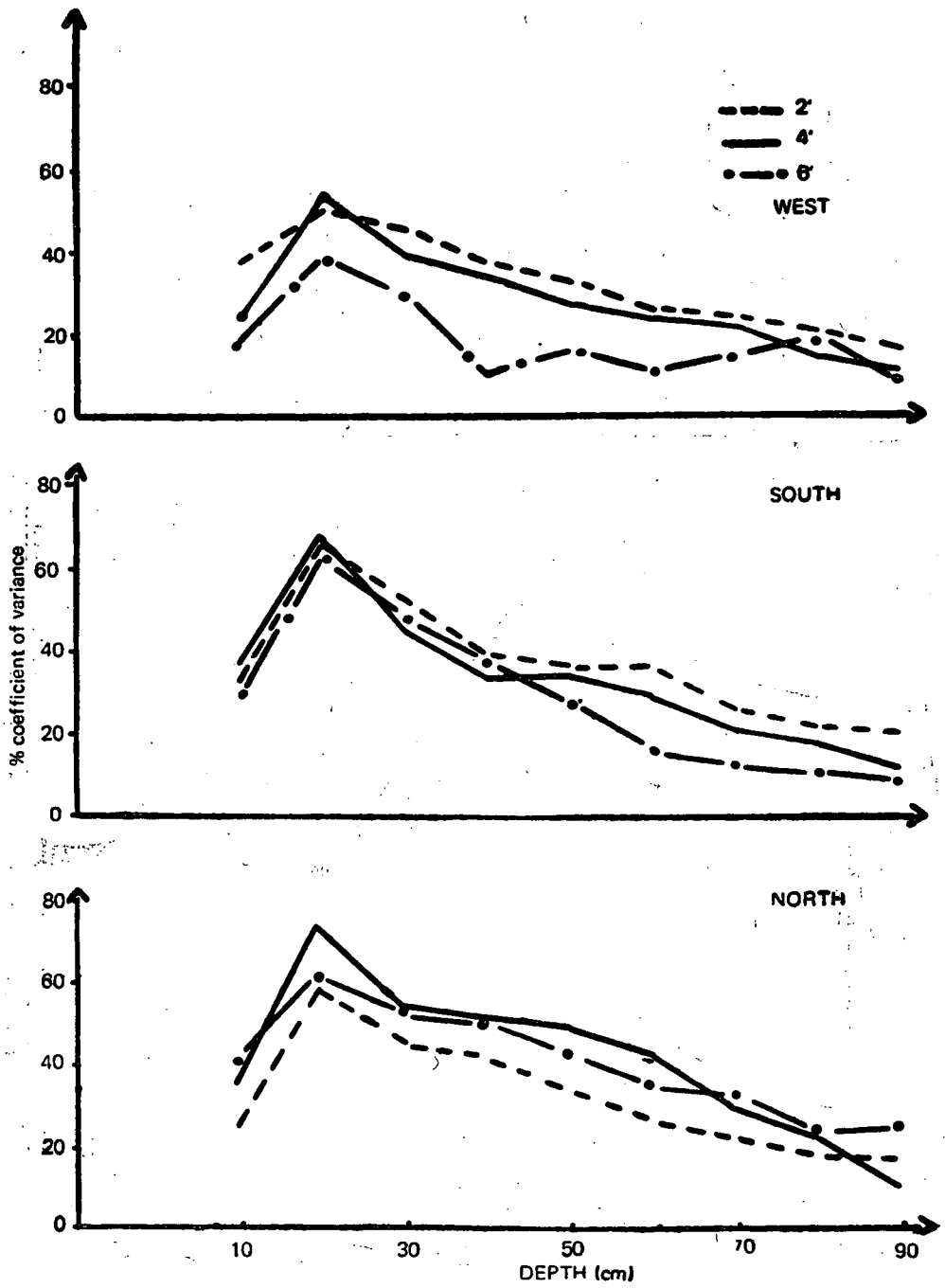


Fig. 1. Location of access tubes in relation to planting points in the field.

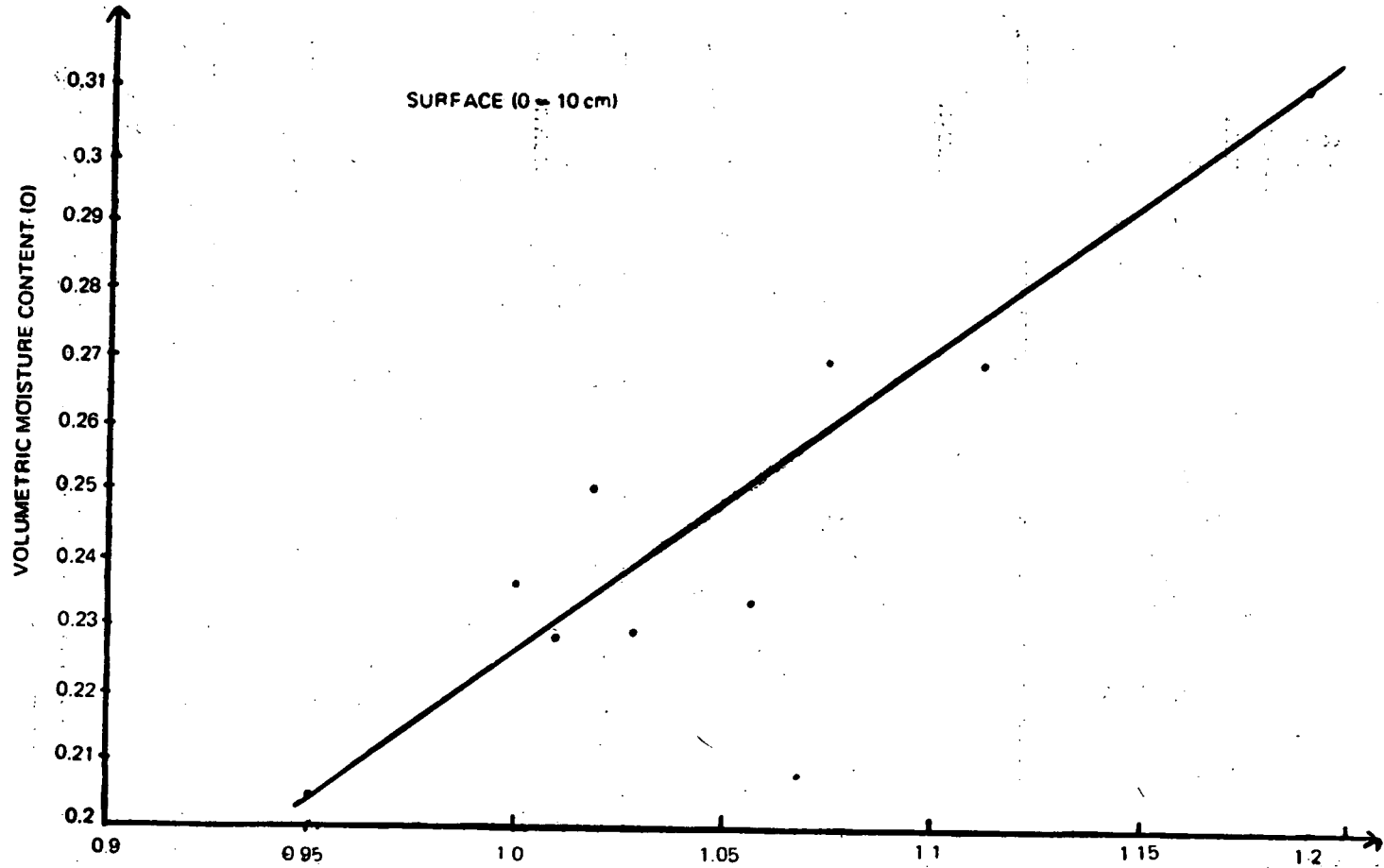


Fig. 2. (1) Field calibration of neutron moisture meter for the surface layer at 0-10cm depth in Boralu soils.

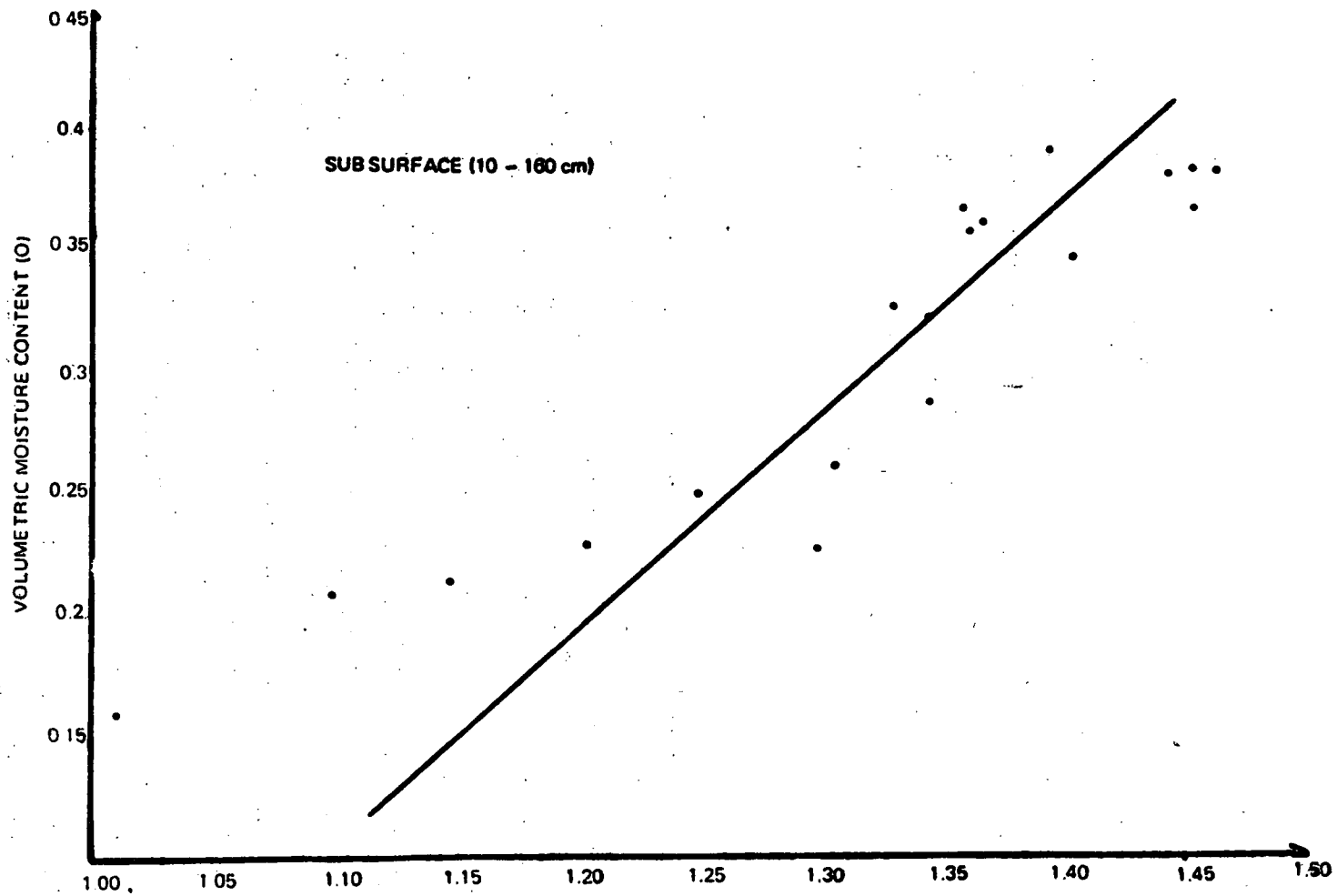


Fig. 2. (11) Field calibration of neutron moisture meter for the sub-surface layers at 10-160 cm depth in Boralu soils.

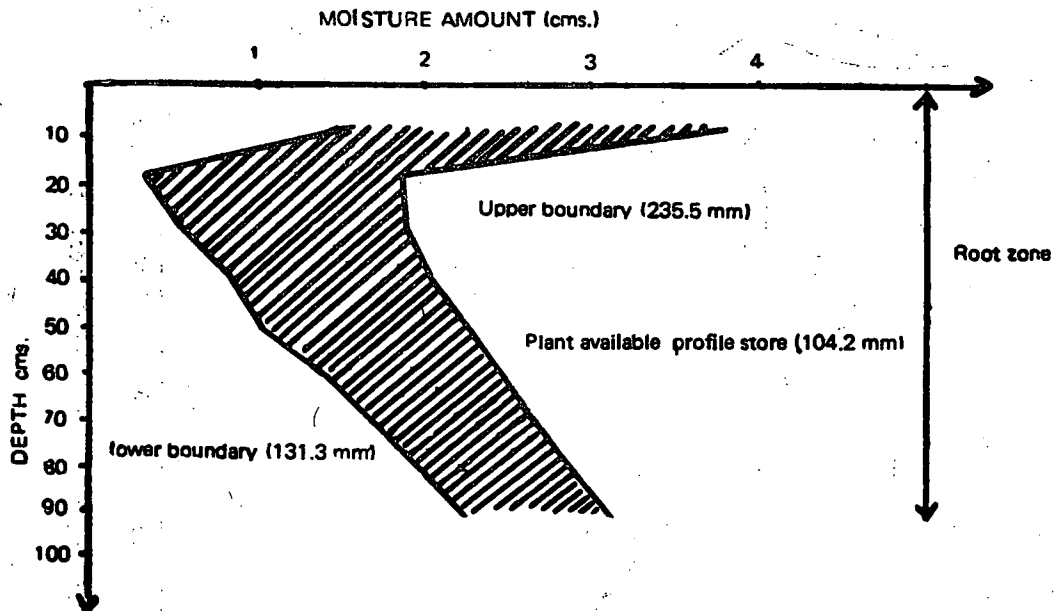


Fig. 3. The available water storage capacity (AWSC) for a Boralu soil profile.

Available soil water in relation to rainfall (SM/82/4)

In soil - plant - water relations, plant response is frequently correlated with either the soil water deficit or the proportion of available water remaining in the root zone.

Fig. 4, illustrates the available soil water and total rainfall for a 90 cm profile (which is generally the rooting depth of immature rubber) over a period of 12 months from October 1982, in the experimental area. There appears to be a clear relationship between available soil water and total rainfall during this period. This study would also provide information on the most appropriate periods for fertilizer application in relation to soil moisture. (L. Samarappuli, I. Denawaka and P. Karunadasa)

Water stress in relation to management practices on growth of immature rubber (SM/82/5)

This experiment (SM/82/1) was planned to study the effects of different soil management practices on water stress in immature rubber plantations. This was started in a 1980 replanting at Clyde State Plantation, where the effects of four ground cover management practices on clone PB 86 were studied in a randomized block design, the treatments being replicated three times.

The ground cover treatments were :

- | | |
|-------------------------|----------------------------|
| (1) Bare (clean weeded) | (3) Sown mixed legumes and |
| (2) Natural cover | (4) Dead mulch. |

Access tubes were installed in each plot (one per plot) and weekly assessments (count rate for soil water content) were made using a neutron meter, upto a depth of 90 cm.

A pressure bomb was used to assess leaf water potential and porometer to measure the rate of transpiration in the field. These assessments were also done regularly. Soil samples were collected at 6 monthly intervals to determine important physical and chemical characteristics, such as bulk density, organic carbon, and total nitrogen. Girth measurements were also made at 3 monthly intervals. It is too early to make any conclusions from these studies. (L. Samarappuli, I, Denawaka and P. Karunadasa)

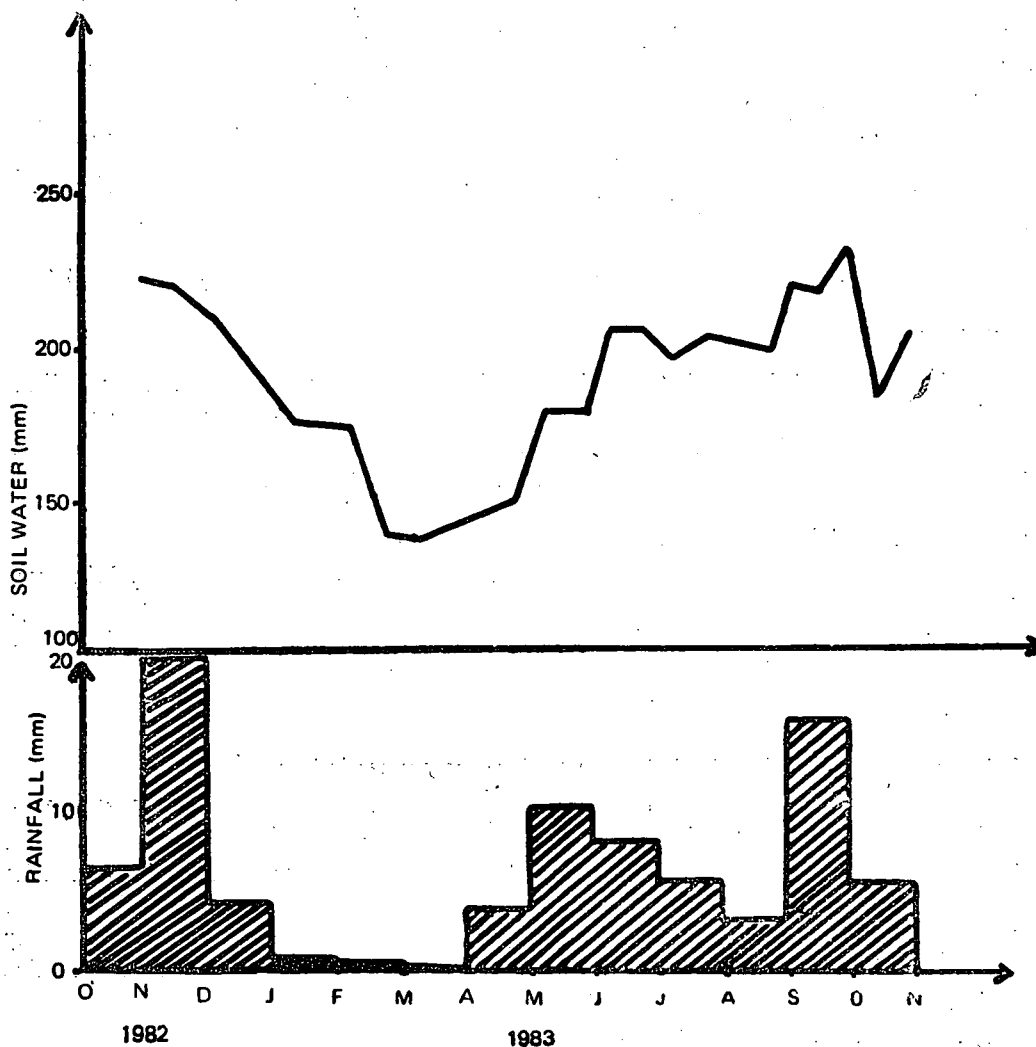


Fig. 4. Available soil water and rainfall for a Boralu soil profile.

Water stress on nutrient uptake by immature rubber (SM/83/1)

Another field experiment has also been planned and experimental plots have been demarcated at another site in Clyde State Plantation with similar soil characteristics as in the first experiment. In this experiment the effect of water stress on nutrient uptake by immature rubber plants will be studied in a 3³ factorial design in which the effect of three levels of N, P and K would be studied. Regular assessments for soil water content (using the neutron moisture meter), leaf water potential, rate of transpiration and chemical composition of leaves will be done. (L. Samarappuli, I. Denawaka and P. Karunadasa)

Water stress on latex production in mature rubber (SM/83/3)

Effects of water stress on latex production will be studied in this experiment, using the neutron moisture meter. Access tubes have already been installed in an on going fertilizer experimental area at Pembroke State Plantation in Kalutara. The soil in this area is of the Boralu type and the planting material is PB 86. Neutron moisture meter readings (count rate) will be made throughout the year and yield assessment will also be made regularly. This study is expected to provide information that would enable us to devise suitable agronomic or management practices to conserve soil moisture in mature rubber plantations. (L. Samarappuli and S. Wasanthadewa)

Other Investigations

Soil classification

Attempts are being made to classify the rubber growing soils of Sri Lanka according to the US - Taxonomy system. Soils of Boralu and Agalawatta series were selected for the first part of this study. Soil pits were opened and soil samples are being analysed. (M. K. S. A. Samaraweera, Percy Silva, S. N. Silva and Chitra Maheepala)

Components of yield

The study of how latex production is related to variables such as age of the tree, clone, size of the clearing, nutritional status of the tree and soil type was continued. (M. K. S. A. Samaraweera, Sumitra Gunasekera in collaboration with S. Jayawardena of Department of Mathematics, University of Colombo)

Extension

Soil and foliar survey for discriminatory fertilizer recommendations

All rubber plantations managed by the SPC and the JEDB are now fertilized on the basis of soil and foliar analyses. The foliar survey programme for 1983 commenced in June and estates covering 4268 ha were surveyed this year. Fertilizer recommendations based on this survey was sent to all the estates in December. In general, as in the past N and K fertilizers were recommended to most of the plantings and urea was the only source of nitrogen recommended during the year. (N. Yogaratnam, F. P. W. Silva and S. Wasanthadewa)

Nutrient deficiencies

Investigations were carried out to ascertain the cause for several cases of nutrient deficiencies that have been reported during this year. In about 98% of the areas that reported Mg deficiencies, it was found that either Mg containing fertilizers had not been

applied at all or they had been applied in insufficient quantities. Immediate remedial measures were recommended in all cases and those estates have been advised to follow the RRI recommendations on the application of magnesium as given in the RRI advisory circular on fertilizers for rubber. (N. Yogaratham, M. K. S. A. Samaraweera and F. P. W. Silva)

Fertilizer demonstrations

Demonstrations were conducted on the correct use of fertilizer at 25 smallholdings in Galle and Colombo Districts. (M. K. S. A. Samaraweera in collaboration with C. G. Silva of National Fertilizer Secretariat, A. Dahanayake and P. Samaranayake of Advisory Services Department)

Advice was given to the Government Film Unit and the Ministry of Industries and Scientific Affairs to produce a film on the use of urea as a fertilizer. (M. K. S. A. Samaraweera and W. C. Dayaratne)

REVIEW OF THE RUBBER CHEMISTRY DEPARTMENT

By

S. W. KARUNARATNE

SUMMARY

In spite of the constraint of manpower availability due to staff changes and movements especially in connection with overseas training, a lot has been achieved in both Research and Development. Commercial quantities of papain coagulated rubber, a speciality deproteinized natural rubber (DPNR) were exported to Europe. Pale crepe continues to command a premium price due to its purity and light colour. A water soluble bleaching agent for the production of quality crepe rubber has been successfully developed. Participation in the radiation vulcanization programme took pride of place in an effort to develop the technology to the point of practical applicability. Several new areas of research blossomed through these efforts including binding of antioxidants to the NR molecules at the latex stage, development of extra clear films of vulcanized rubber and the production of a superior grade of rubber with controlled gel content. A number of methods have been perfected to prepare natural rubber (NR) with superior processing properties. Use of polymeric additives, copolymer blends, a blend of radiation prevulcanized latex, ordinary latex and microcellular crumbs have shown promise in imparting superior processing properties to NR. Progress in the technology of manufacture of special grades of constant viscosity (CV) rubber and granular rubber are highlighted in the review. The use of solar energy to dry wet laces of NR is being perfected and full sized solar collector for a drying tower (capacity 2750 kg) are being tested at Dartonfield Estate. Raw rubber specifications and analysis formed a vital component of the activities of the Department and continuous monitoring of technically specified rubber (TSR) production along with inspection visits were carried out as usual during the year. Rubber product development was mainly concerned with the prevention of bloom in rubber products and design of rubber compounds for specific applications. A room temperature cured rubber hose was developed and after exposure to sunlight, it was found that satisfactory physical properties could be achieved. Studies on metal anacardates derived from locally available raw material, cashew nut shell liquid (CNSL) as vulcanization activators were continued. Biochemical research was concentrated on studies on phospholipids, latex proteins, effluent disposal and enzymatic deproteinization of NR. A special study on the free proline content in relation to brown bast, a disorder of the tapping panel of the rubber tree was initiated. Activities of the Department resulted in financial gains to the Institute during the year amounting to approximately Rupees one million. The main avenues of such gains were from specification analyses, other miscellaneous analyses and quality certification (Rs. 875,000), consultancy and miscellaneous charges for services rendered in rubber products manufacture.

DETAILED REVIEW

The work of the Department is divided into five main sections. The Rubber Chemistry Section is mainly concerned with studies oriented towards chemical modification of natural rubber. The Rubber Technology Section deals with technological studies and product development. The Specifications Unit is concerned mainly with the analysis of raw rubber. The Raw Rubber Development Unit (formerly referred to as the Crepe Rubber Development Unit) gives advice on the manufacture of raw rubber and the Biochemistry Unit is concerned with biochemical studies. These are by no means water tight compartments and the work of one section may overlap that of another Section, depending on the circumstances.

From the beginning of 1984 these sections will be separately identified with Sectional Heads, who will work under the overall direction of the Head of the Rubber Chemistry Department.

Staff

Dr P. A. J. Yapa, Biochemist continued to function as Acting Head of the Department until the Head of the Department Mr S. W. Karunaratne resumed duties on the 5 May, after overseas sabbatical leave. Dr P. A. J. Yapa went on no pay leave in May, for a study on disposal/utilisation of factory effluents in rubber plantations both in Sri Lanka and abroad, a project financially assisted by NORAD. He resumed duties in November. Unfortunately his overseas study was not carried out as planned in his programme.

Dr A. Coomarasamy, Rubber Chemist, and Dr L. M. K. Tillekeratne, Rubber Chemist/Specifications Officer and Dr W. S. E. Fernando, Rubber Chemist, were on duty throughout the year. Mr M. D. R. J. Goonetilaka, Assistant Rubber Chemist, returned from UK in October, after completing post graduate studies at the University of Aston in Birmingham. Mr M. C. S. Perera, Assistant Rubber Chemist continued his studies at the Australian National University. Mr P. A. D. T. Vimalasiri, Assistant Rubber Chemist/Assistant Specifications Officer, went to Australia for his post graduate studies. Assistant Rubber Chemist, Miss N. M. V. Kalyani, was, on duty throughout the year. Mr E. D. I. H. Perera, Assistant Rubber Chemist went to the UK for post graduate training at Reading University. Miss A. M. M. A. Abhayawickrema and Miss H. Gangodawila assumed duties as Assistant Rubber Chemists in April but resigned from their posts in October and December, respectively. Miss Thushini Gunasekera was appointed Assistant Biochemist in April. Mr L. B. K. Silva, Research Assistant, was on duty throughout the year. Mr D. D. N. B. Daya and Mr T. L. Gunaruwan Fernando joined the staff as Assistant Development Officers in April. Mr P. P. Jayasinghe, Experimental Officer was on no pay leave for a period of one year and resumed duties in December. Mr S. Kasinathan was on duty throughout the year. Mr H. N. K. K. Chandralal, Experimental Officer joined the Centre for Atomic Energy Research (CAIR) Indonesia on a 6-months period of training on radiation processing, commencing October. Mr K. A. R. M. Perera and Mrs C. P. Ediriwickrema continued to work as Experimental Officers throughout the year. Senior Technical Officers, Mr D. D. Madagama, Mr A. S. Dakumpitiya were on duty throughout the year. Mr S. L. Weerasinghe, Senior Technical Officer went for a training period of 9 months in Malaysia on rubber processing, from April 1983. Technical Officers Messrs W. D. Dharmasena, K. N. U. Mitrananda, P. H. Sarath Kumara, Mrs Manel

Nilaweera, Mrs N. Baduge, Mrs S. Weeraman, Mrs W. C. M. Kuruppu, Mrs R. L. Wanigathunga, Mrs M. K. Wickramapala, Miss S. I. Senanayake and Mr M. D. C. Seneviratne were on duty throughout the year. Mr P. D. J. Rodrigo, Specifications Assistant, was transferred to Biochemistry Section from Specifications Sections in April. Specifications Assistants Messrs W. A. S. Wijesekara, T. A. S. Siriwardena, G. Wanigathunge, R. Wickramaratna, K. K. Austin, W. Nandasena, B. Gunasiri were on duty throughout the year. Mr G. R. S. S. Gamlath, Mr L. G. Piyasena, and Miss K. C. S. Dissanayake continued to work as Instrument Technicians throughout the year. Due to the reorganisation of the Electronic servicing laboratory they functioned mainly as Technical Officers within the Department. Miss N. M. M. de Costa, Technical Officer was transferred to the Department with effect from 15 November. The Stores Assistant, Mrs L. Rukmani was on duty throughout the year. Clerk/Typist Mrs Anusha Paranavitha, Miss M. D. I. Premawathi and Casual Typist Miss Dilina Fernando were on duty throughout the year.

Dr N. C. C. Walpita continued to work part time as a Visiting Senior Research Officer (Chemical/Mechanical Engineer) throughout the year. The Chinese student, Mr Li Jiu Long continued his training throughout the year. NDT student, Miss W. R. L. H. Janz, started her in plant training in rubber technology with effect from December for a period of 6 months.

Research students

As usual the course of lectures for the MSc in polymer Science and Technology at the University of Sri Jayewardenepura was conducted mainly by the staff of the RRI. The Departmental staff is presently supervising the following projects undertaken by the MSc students.

- Identification and analysis of "bloom" in rubber products by Miss R. Sumathipala ; supervised by Mr S. W. Karunaratne and Dr W. S. E. Fernando.
- Technological evaluation of deproteinized rubber by Mr Dayantha de Silva ; supervised by Dr W. S. E. Fernando and Dr P. A. J. Yapa.
- Suitability of alkyd resins as processing aids in rubber compounding by Mr A. Samarasinghe ; supervised by W. S. E. Fernando.
- Pressure sensitive adhesives based on NR latex by Mr L. Botheju ; supervised by Mr S. W. Karunaratne and Dr A. Coomarasamy.
- Use of halogen compounds in polymerization reactions by Mr S. Seneviratne ; supervised by Dr A. Coomarasamy.
- Studies on crosslink characterization of vulcanized granular rubber compounds by Miss R. Narayanaswamy ; supervised by Dr A. Coomarasamy.
- Study of the storage softening and discolouration behaviour of crepe rubber by Mr L. A. Kodituwakku ; supervised by Dr L. M. K. Tillekeratne.

Meetings

The Head of the Department, Mr S. W. Karunaratne, attended a meeting held in Takasaki, Japan, on 1 February to formulate a programme for the test evaluation of irradiated NR latex. He was instrumental in setting up the infrastructure for such a programme and actively participated in its implementation while he was on sabbatical leave in Japan. He was also nominated, during his stay in Japan, to participate in a workshop held in Jakarta, Indonesia, in April on radiation processing. He was also invited to prepare and deliver a course of lectures in Indonesia, on latex chemistry and technology, emphasising the usefulness of the radiation vulcanization technique in the future development of the technology of latex processing, with respect to major end use applications. He conducted this lecture programme along with counterpart officers from the Rubber Research Institute of Malaysia (RRIM).

The Head of the Department served in the following bodies.

Chairman of the Drafting Committees of the Bureau of Standards on contraceptives, NR specifications and rubber bands.

Member of the Advisory Committee on rubber and rubber products set up by the Bureau of Standards.

Member of the Advisory Committee on rubber for the Export Development Board appointed by the Hon. Minister of Trade and Shipping.

Member of the Advisory Committee along with Dr L. M. K. Tillekeratne appointed by the Rubber Controller to update the subsidy scheme presently in operation for the development of raw rubber factories.

The Head of the Department also chaired the first session of a one day workshop on "Extrusion" conducted by the Plastics and Rubber Institute. Three Technical Officers from the Department participated at this workshop.

Dr W. S. E. Fernando participated in the ISO/TC 45 meeting held in Milan, Italy, from 28 September to 8 October. He took this opportunity to visit a few factories in Europe in connection with the promotion and marketing of pale crepe.

Dr A. Coomarasamy participated and presented a research paper at the Twelfth Indian Rubber Manufacturers Research Association (IRMRA) Rubber Conference, held in Madras, India, from 25 to 26 November.

The Department organised a one day seminar in February on the manufacture and marketing of NR. Arrangements are being made to publish the proceedings of the seminar in a special issue of the RRISL Bulletin.

The officers of the Department actively participated in several training programmes to assist the smallholders and officials attending to smallholder problems, connected with raw rubber manufacture. The officers of the Department also participated in several Conferences held for Planters and Agricultural Advisors.

Dr N. C. C. Walpita gave a talk on Energy in Agriculture at a Seminar organised by the Ceylon Electricity Board in mid-March.

The Head of the Department gave a talk on, " Extrusion and calandering of rubber " at a workshop organised by the Industrial Development Board. Miss Chitra Kuruppu Technical Officer participated in this workshop.

Mr T. L. Gunaruwan Fernando participated in a seminar/training programme on Energy Demand Manufacture and Conservation (EDMAC) conducted by the Ministry of Power and Energy from 7 to 17 December.

Dr A. Coomarasamy attended one meeting each of the Bureau of Ceylon Standards on plastics and rubber seed oil and four council meetings of the Institute of Chemistry.

Dr W. S. E. Fernando attended one meeting of the Rubber Advisory Council of the IDB.

Dr P. A. J. Yapa, as an elected member, attended one meeting of the Faculty of Applied Sciences at Sri Jayewardenapura University in January, two Committee meetings of the Section B, SLAAS, one meeting of the Committee for Popularization of Science, and one meeting of the EDB.

The lecture programme initiated by the Head of the Department was very popular. Among the speakers was the former Head of the Department, Mr M. Nadarajah. The Assistant Statistician Mr W. N. Wickramasinghe gave a series of three lectures on basic statistics to the staff of the Department.

Publications

Fernando, W. S. E., Li Jiu Long. Use of microcellular crumbs in profile extrusion. *J. Rubb. Res. Inst. Sri Lanka*. (In press)

Tillekaratne, L. M. K., Coomarasamy, A. (1983). Studies on Improvement of quality of smallholder rubber in Sri Lanka. *Bull. Rubb. Res. Inst. Sri Lanka*. 17, 18 - 23.

Coomarasamy, A., Jayawardena, A. M. I. The use of cashew nut shell liquid based antioxidants and an activator in natural rubber compounds. *Programme and papers, Twelfth IRMRA Rubber Conference*, November 1983, Madras, India.

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මද ? රබර් පුවත්, 10.

Abstracts

Karunaratne, S. W. (1983). Radiation prevulcanization of NR latex. *Proc. of the thirty-ninth Annual Session of the SLAAS*, December, Part I, 73.

Karunaratne, S. W., Daya, D. D. N. B., Nirmala, D. and Neelaweera, Manel (1983). Leaching of prevulcanized latex films. *Proc. of the thirty-ninth Annual Session of the SLAAS*, December, Part I, 72.

Karunaratne, S. W., Chandralal, H. N. K. K., Silva, L. B. K. and Hemekanthie Gangodawila (1983). Identification and characterization of the phenolic constituents of smoke which is deposited in R.S.S. *Proc. of the thirty-ninth Annual Session of the SLAAS*, December, Part I, 74.

Karunaratne, S. W. and Fernando, W. S. E. (1983). A linear gel/polymer system based on radiation prevulcanized NR latex. *Proc. of the thirty-ninth Annual Session of the SLAAS*, December, Part I, 73.

Kalyani, N. M. V., Coomasamy, A., Silva, L. B. K. and Chandralal, H. N. K. K. (1983). A preliminary investigation on the use of metal anacardates as vulcanization activators in NR compounds. *Proc. of the thirty-ninth Annual Session of the SLAAS*, December, Part I, 74.

Coomarasamy, A., Abhayawickrema, A. M. M., and Silva, L. B. K. (1983). Antioxidant activity and mechanism of action of some cardanol based Mannich bases and dithiocarbamates. *Proc. of the thirty-ninth Annual Session of the SLAAS*, December, Part I, 86.

Tillekaratne, L. M. K. and Vimalasiri, P. A. D. T., (1983). Water soluble mercaptan for use in the crepe rubber industry. *Proc. of the thirty-ninth Annual Session of the SLAAS*, December, Part I, 73.

Tillekaratne, L. M. K., Sarath Kumara, P. H., and Dekumpitiya, A. S., (1983). Contribution of sodium bisulphite or meta bisulphite to the raw rubber industry. *Proc. of the thirty-ninth Annual Session of the SLAAS*, December, Part I, 72.

Yapa, P. A. J., Kasinathan, S., and Balasubramaniam, K. (1983). A study on phospholipids and their significance in natural rubber. *Proc. of thirty-ninth Annual Session of the SLAAS*, December, Part I, 84.

Reports

Fernando, W. S. E. Report on the 31st session of the ISO TC/45.

Fernando, W. S. E. Markets for latex crepe rubber in Western Europe.

Patents

Tillekaratne, L. M. K., Vimalasiri, P. A. D. T. A new water soluble bleaching agent for crepe manufacture.

Coomarasamy, A., Fernando, W. S. E. The use of carboxylic polymers and their salts for improving the processability characteristics and properties of natural rubber.

Coomarasamy, A., Karunaratne, S. W., Jayawardena, A. M. I. A process for the preparation of antioxidants from cashew nut shell liquid.

Miscellaneous

New laboratory

The new wing of the Rubber Chemistry Department is still to be occupied, even though the building construction work was completed about 2 years ago. The delay in occupying the building has been due to a serious omission on the contractual obligation by the building contractor and service personnel. A telephone link to the new building is also essential and a request has been made to give priority to this as well.

In the meantime arrangements have been made for an Engineer from the University of Moratuwa to visit the electronics workshop every Monday in order to carry out urgent repairs to Electronics equipment with the assistance of the instrument technicians.

Central electronics servicing laboratory

The staff manning this unit was dispersed to different Sections in the Department to gainfully employ them in the work of the Department. They also took an active part in repairing equipment whenever the need arose. Dr Gnanalingam's report is awaited before a reorientation of the future activities of the unit is considered.

Exhibitions

- (a) The Rubber Chemistry Department together with other Departments of the Institute participated in the Mahapola Anniversary held at Matugama from 6 - 17 January.
- (b) The Department participated in "Chemistry, Industry and the Citizen", an exhibition organised by the Institute of Chemistry. The exhibition was held at the Institution of Engineers from 13 to 17 June. Exhibits depicting the role played by the Rubber Chemistry Department in the development of the rubber industry in Sri Lanka were displayed.

Radio talks

Mr S. W. Karunaratne and Dr L. M. K. Tillekaratne gave one radio talk each on rubber products manufacture and processing of raw rubber, respectively, in the programme "Resurgent Rubber" conducted by Mr Derrick Schokmann of Sri Lanka Broadcasting Corporation (SLBC).

A claim for the IBM award to be presented by the Natural Resources Energy and Science Authority (NRESA) was made on the basis of the contribution to R & D on NR by the officers of the Rubber Chemistry Department.

The following foreign guests visited the Rubber Chemistry Department during the quarter.

Dr S. Kohijiya	..	Kyoto Institute of Technology
Mr John Morris	..	John Morris Consultants Limited.
Dr A. Geneidy	..	Consultant, Bureau of Standards.
Mr Micheal Iddon	..	Iddon Brothers, UK.
Miss Christine Fulsbottom	..	Boston State University.
Dr A. Skarendahl	..	Natural Fibre Stockholm, Sweden
Mr C. P. Smith	..	Hickson and Welth, Castleford, UK

Research and Technology

Latex studies

Test evaluation of radiation pre-vulcanized latex (RPVL)

Eight different samples of radiation pre-vulcanized latex (RPVL), irradiated at different levels, from Japan and Indonesia were received in April. These samples were irradiated using gamma - rays from Co^{60} with CCl_4 as a sensitizer. No other chemicals have been added in the radiation process. In accordance with the decision taken at

the working group meeting held in Takasaki Japan, in February 1983, the Rubber Research Institute of Sri Lanka (RRISL), RRIM, and the Comite d' Action Interallie de la Resistance (CAIR), Indonesia, were asked to evaluate the physical properties of the cast films of RPVL. Work on this project was started early in April in a specially arranged air conditioned room at Ratmalana.

The RPVL films were cast on square glass plates having dimensions of 170 mm × 3 mm. The thickness of the dried film was 0.65 mm to 0.75 mm. In order to develop a technique to get the film in the correct range of thickness, a sample of sulphur pre-vulcanized latex was used. The amount of latex used was calculated on the basis of the weight of the dried film. The dried films were leached in water for 24 hours at room temperature and then heated at 70°C for 4 hours followed by heating at 100°C for 30 min. The following tests were carried out using the test pieces from these films:

- (1) Tensile strength before and after ageing (7 days at 70°C).
- (2) Tear strength.
- (3) Tension set.

The results of the test evaluation on RPVL can be summarised as follows; RPVL films have better clarity over the sulphur prevulcanized latex films. In general, a higher dose up to 5 M rads in the presence of CCl_4 (3 - 5% on rubber) gave superior physical properties. (S. W. Karunaratne, D. D. N. B. Daya, A. Coomarasamy, Manel Nilaweera, D. Nirmala and Chitra Kuruppu)

Radiation prevulcanization of natural rubber latex

Physical strength of films prepared from RPVL could be matched with conventional sulphur cured systems by using an optimum radiation dose of 5 M rads in the presence of CCl_4 sensitizer at a level of 3 to 5% on the dry rubber content. The films have to be heat treated to achieve optimum properties. Antioxidants such as bisphenols added to latex, subsequent to irradiation, improves the ageing resistance of the films.

Viscosity stability of irradiated latex is more consistent with Low Ammonia (LA) latex types containing secondary preservative systems compared to High Ammonia (HA) latex types.

This work was carried out at the Takasaki Radiation Chemistry Research Institute in Japan. (S. W. Karunaratne)

Microbiological examination of natural rubber latex

All types of rubber latices are liable to infection with micro-organisms. This study has been undertaken to compare the growth of micro-organisms in both HA latex and irradiated latex. The latex under test was serially diluted using quarter strength Ringer's solution as the diluent. Five serial tenfold dilutions were prepared. Aliquots of each dilution were mixed with freshly prepared sterile peptone dextrose agar media in a petridish, and incubated. Two petridishes were prepared from each dilution and examined. After each 3-day period of incubation all visible colonies were counted. Each spreader was counted as one colony. Both types of latices were found to be liable to microbial growth but the growth of microorganisms in irradiated latex was less than that in HA latex. This work is being continued. (S. W. Karunaratne, N. M. V. Kalyani, Indranee Liyanage, Chandrika Ediriwickrema)

Latex technology

Viscosity of compounded latex in latex thread manufacture

The viscosity of compounded latex plays a major role in the quality of threads obtained. This is very much so for threads of smaller diameter. The interaction of compounding ingredients and the materials used in the manufacture of centrifuged latex appear to play a major role in increasing the viscosity of compounded latex. Furthermore it has also been observed that these interactions are time dependant, increasing with the age of centrifuged latex.

A project was initiated with the assistance of Multistretch Ltd, to identify the most suitable method to prepare centrifuged latex for the production of latex thread. (W. S. E. Fernando, S. W. Karunaratne and W. D. Dharmasena)

Electrochemical studies of latex

Under the influence of an imposed electrical potential, natural rubber latex particles travel towards the anode and build up a wet layer of rubber because of its negative charge. Rate of deposition and thickness of the deposit depend on several factors such as current density, time, total conductivity of the bath and total solids content of the latex. Effect of current density and time on electro deposition of NH_3 stabilized latex was studied. The anode was of zinc and the cathodes were of carbon. It was found that the amount of the deposit increases directly with increasing current density and time. This work was carried out in the Department of Chemistry, University of Colombo under the guidance of Dr Hettiarachchi. Attempts were made to study the electrochemical behaviour of positively charged latex, which was prepared using cetyl trimethyl ammonium bromide as the stabilizer. (N. M. V. Kalyani and A. Coomasamy)

Studies on binding of antioxidants

The maleimide route

Our earlier work has shown that the maleimide antioxidants of both phenolic and amine types could be bound to the rubber chain by mechanochemical reactions or solution stage reactions in the presence of radical initiators such as benzoyl peroxide.

N, phenyl maleimide and N (4 - anilino phenyl) maleimide have been synthesized using a standard procedure. The synthesis of a new phenolic antioxidant ; N, (3 methyl 5 tertiary butyl 4 - hydroxyphenyl) maleimide has also been successfully completed up to the maleimic acid stage. Studies are under way on the use of gamma-irradiation to effect binding of the synthesised antioxidants on the NR chain. Mr R. Raveendra, vacation trainee, assisted in these studies. (A. Coomasamy, S. W. Karunaratne, Hemakanthi Gangodawila and H. C. Chandralal)

Antioxidants based on cashew nut shell liquid

The antioxidant activity of cardanol antioxidants N (8, 11 penta decadienyl) hydroxy benzyl dimethyl amine, its dithiocarbamate, N (8, 11 penta decadienyl) hydroxy benzyl morpholine and its dithiocarbamate, synthesised in the laboratory, were evaluated by carrying out oxygen absorption studies using cumene as the substrate. For comparison oxygen absorption studies were also carried out using commercial antioxidants, permanex

SP and permanex WSP. The results obtained in the studies, showed that the N (8, 11 penta decadienyl) hydroxy benzyl dimethyl amine and its dithiocarbamate are superior to the morpholine derivatives and styrenated phenol permanex SP but are slightly inferior to the commercial antioxidant permanex WSP.

These results are in agreement with the results on evaluation of antioxidant activity of these compounds carried out earlier in vulcanized rubber using the oxygen absorption technique, tensile ageing tests and stress relaxation measurements.

To evaluate the mechanism of action of the prepared cardanol antioxidants, experiments on antioxidant induced decomposition of cumene hydroperoxide were carried out and the products formed were analysed by GLC using 10% polyethylene glycol adipate on chromosorb W 80 - 100 mesh as the stationary phase with nitrogen as the carrier gas. Formation of relatively higher amounts of acetophenone, cumyl alcohol, methyl styrene and methanol, compared to phenol and acetone, is indicative of a radical mode of decomposition of cumene hydroperoxide in the presence of the synthesised cardanol antioxidants, suggesting a chain breaking mechanism for their antioxidant action. (A. Coomasamy, Mala Abhayawickrema and L. B. K. Silva)

Speciality crepe with bound antioxidants

3, 5 ditertiary butyl 4 - hydroxyphenyl propionyl hydrazide (TBPH) was obtained by treating 3, 5 ditertiary butyl 4 hydroxyphenyl propionate with hydrazine hydrate in methanol. TBPH was then incorporated into natural rubber as a dispersion at the latex stage.

The rubber obtained did not harden on accelerated storage hardening indicating a certain degree of incorporation of TBPH. The bound antioxidant was assessed by gel permeation chromatography (at the MRPRA) setting the UV detector at 280 nm, which is the absorption maximum of TBPH. These studies show that rubber containing 1 phr, of TBPH has 60 + 5% of it chemically bound to the natural rubber molecules.

The ageing studies show that the ageing resistance of the extracted samples compare favourably with those containing 1 phr Wingstay L. Boil/age resistance after ten washings show a fair degree of improvement over the control containing 1 phr Wingstay L. (W. S. E. Fernando. M. D. R. J. Goonatilleka and K. M. U. Mitrananda)

Preparation of superior processing (SP) rubber

Use of polymeric additives

The standard practice of improving the processing characteristics of NR, especially calendaring and extrusion is by incorporating about 20% of sulphur vulcanized rubber into NR usually in the form of SP rubbers. It has been claimed that the incorporation of polymers like polyvinyl alcohol or casein in to the unvulcanised matrix in place of prevulcanized latex, results in the improvement of the above mentioned processing characteristics. In the present study incorporation of aluminium alginate, aluminium poly acrylate, polymethyl methacrylate, partially converted into aluminium polymethacrylate acrylic copolymer (commercial sample), and sulphur prevulcanized rubber latex at 10% and 20%, respectively, in to NR in the latex stage have been carried out prior to coagulation/drying. Control samples have also been prepared. The tests on raw rubber properties revealed that the P_0 values of the rubber containing polymeric additives were

higher and the PRI values of the rubber containing polymeric aluminium salts were lower compared to the control samples. These results correlate well with the results obtained on raw rubber properties earlier, for granular rubber samples prepared, using the above mentioned polymers as encapsulating agents.

Extrusion studies carried out using the RRIM formulation for testing SP rubber and the MRPRA formulation for the production of light coloured extrusions, revealed that some of the rubber samples containing polymeric additives as aluminium salts showed superior processing characteristics compared to the control samples. Samples of NR containing commercial acrylic binder, having a very small percentage of carboxylate ions, were found to be inferior to the control samples. This indicates that a certain amount of crosslinking or gellation of polymeric additive by aluminium ions is essential for improved processing characteristics. (A. Coomarasamy, W. S. E. Fernando, L. B. K. Silva, T. L. G. Fernando, K. A. R. M. Perera, D. Mithrananda, D. Nirmla, Manel Nilaweera and D. Gamlath)

Copolymer blends

Blends containing 15% polyvinyl acetate acrylic acid copolymer and NR, were prepared by mixing latices and processing the coagulum as in normal crepe rubber manufacture. This blend improved the extrusion characteristics of natural rubber compounds. (W. S. E. Fernando, W. D. Dharmasena, D. D. Medagama and K. M. U. Mithrananda)

A linear gel/polymer system based on radiation prevulcanized NR latex (RPVL)

Radiation prevulcanized NR latex with controlled gel content can be prepared by varying the radiation dose. Effect of gel content on the extrusion properties of rubber prepared by mixing irradiated latex, with normal latex, prior to coagulation, is being studied. It is also observed that blended rubber has good ageing resistance. (S. W. Karunaratne and W. S. E. Fernando)

Use of microcellular crumbs

The investigations on the use of microcellular crumbs (a wasteful by product in the rubber industry) in rubber compounding, are now complete. The use of crumbs in admixture with NR gives proportionate improvement in the processing behaviour.

The presence of crumbs with inorganic fillers improved the degree of reinforcement to give better hardness, modulus, tear resistance, rebound resilience and abrasion resistance to vulcanizates. The crumbs improved the compatibility of filler and rubber than factice. Their incorporation as a compounding ingredient increased the rate of extrusion and controlled the die swell and shrinkage of extrudate. (W. S. E. Fernando, Li Jiu Long, and D. D. Medagama)

Preparation of CV Rubber

Preparation of low CV grades

Work on this project is in progress and a further 15 MT of CV crepe is being produced at the Dartonfield Estate Factory for export.

A project on the manufacture of CV 50 RSS rubber was also started owing to the great demand for such a grade in the Federal Republic of Germany. At the shippers godowns, sheet rubber into which a peptiser has been incorporated was subjected to heating at 100°C for 10 min to reduce the moisture content in the rubber. At this temperature the peptiser acts on the rubber to reduce the molecular weight and lower the viscosity. (L. M. K. Tillekeratne and A. S. Dakumpitiya)

Further studies on the preparation of low viscosity rubber

It has been reported that liquid natural rubber could be prepared from NR latex by carrying out oxidative depolymerization for several hours at high temperatures, in the presence of phenyl hydrazine. In the present investigation, phenyl hydrazine (1% on dry rubber) was added to NR latex, prior to coagulation with either 2% formic acid or papain. Crepe rubber obtained from these experiments showed a drop of 10 Mooney viscosity units compared to the control sample prepared from the same latex. (A. Coomarasamy, W. S. E. Fernando and S. Kasinathan)

Granular Rubber

Use of starch derivatives

A granular rubber was prepared by using starch derivatives as encapsulating agents. Raw rubber properties and technological properties of the starch encapsulated granular rubber are being studied.

The raw rubber and some technological properties of rubber containing 20% starch derivatives, prepared by coagulating with an aluminium salt solution, were tested. Here again the PRI values, scorch time and tensile strength values were found to be low compared to the control sample. (A. Coomarasamy, S. Kasinathan, L. B. K. Silva and A. Liyanarachchige)

Raw rubber development

General

The Crepe Rubber Development Unit was severely understaffed with almost all the officers in the unit undergoing post graduate and other specialised training, overseas. However, the normal advisory visits and subsidy visits were carried out as usual and advice was given to raw rubber producers on methods of improving the quality of raw rubber.

There were several instances of complaints from buyers about the quality of our crepe which is recognised universally as the best in the world. Efforts are now concentrated in overcoming these problems and to educate the consumers on the real merits of crepe rubber from Sri Lanka, compared to other grades of raw rubber.

The following research projects were carried out during the year.

Drying of crepe rubber

Conventional crepe drying systems

Measurements have been carried out on a number of boiler radiator systems at various estates, mainly to check on poor drying tower performance. It has been found that some of the local designs of boilers are inadequate. Also, most boiler radiator

systems are thermally very inefficient in modern terms. A programme has been started, using the boiler-radiator system at Dartonfield to confirm these results and to check the effect of possible improvements.

The use of solar energy

Detailed design for a full-sized solar collector for the drying tower at Dartonfield has been carried out and fabrication was started in mid-June. The collector will be in the form of 4 to 8 modules, each of 1.2 m x 6.0 m surface area. The collector will be completed and installed as soon as possible, within the existing resources and manpower constraints.

Performance of the full sized collector has been predicted using results from the model experiments at Ratmalana and theoretical results from the literature.

A heat storage system was designed and preliminary tests were carried out using a model storage system. The fabrication of the full sized solar heat storage unit will be carried out on the basis of the results of this model storage unit. Experiments are being continued in this report. (N. C. C. Walpita, T. L. G. Fernando and P. Laelwela)

Hard sole crepe

To improve the hardness of sole crepe produced in Sri Lanka, experiments were carried out at Dartonfield factory using hydrazine hydrate ($\text{NH}_2 \cdot \text{NH}_2 \cdot \text{H}_2\text{O}$) as a hardening agent. There was significant improvement in raw Mooney viscosity and plasticity with the addition of hydrazine hydrate. One of the disadvantages is the slight discolouration and further experiments will be carried out to improve the colour.

% $\text{NH}_2 \cdot \text{NH}_2 \cdot \text{H}_2\text{O}$ on DRC	P_0	P_{30}	PRI	Raw Mooney viscosity
0	38	15	39	53
0.035	45	15	33	68.5
0.070	53	15	28	77.5
0.105	51	19	33	83.5

(W. S. E. Fernando, M. D. R. J. Goonatilleke, W. D. Dharmasena)

Identification and characterisation of the constituents of smoke deposits on ribbed smoked sheets

The surface deposits of rubber smoked sheets obtained by extracting with acetone were analysed. The first step was the separation of the phenolic, acidic and neutral components. For this, the following procedure was used.

- (1) Addition of a saturated aqueous solution of sodium bicarbonate followed by the addition of ether the acidic components separate out as sodium salts.
- (2) Addition of a saturated solution of sodium carbonate to the ether layer from (1) Phenolic components go into the aqueous layer as phenates and the neutral components remain in the ethereal layer.

The acids in the aqueous layer from (1) were regenerated and converted to the corresponding methyl esters by refluxing with methyl alcohol, in the presence of concentrated sulphuric acid, with a view to separating them, using gas liquid chromatography. Gas liquid chromatograms of them were obtained using a Perking - Elmer F-17 chromatograph. The column was packed with 5% Di-(3, 3, 5 Tri methyl cyclohexyl) 0 - phthalate on chromosorb G AW.

A mixture of oleic, propionic and octonic acids was also converted to their methyl esters for the purpose of using them as authentic samples.

The phenols which were regenerated by acidifying the aqueous layer from (2), are being separated by thin layer chromatography, using silica gel - G as the solid phase and methylene chloride : cyclohexane (80 : 20) and chloroform as the solvent systems.

Spraying reagents that are being used are diazotised p - nitro aniline and ferric chloride/potassium ferricyanide.

Gas liquid chromatograms of the phenolic components were compared with authentic phenols, and a few phenols identified. (S. W. Karunaratne, H. N. K. K. Chandralal and L. B. K. Silva)

Development of bleaching agents

General work on the development of a water soluble bleaching agent for raw rubber is still in progress. Now it has been detected that:

- (a) The potassium salt of the tolyl mercaptan could be isolated and is more soluble than the sodium salt.
- (b) Method of manufacture is easier when a 10% solution of ethanol in water is used instead of pure water to dissolve the caustic soda in order to increase the solubility of the mercaptan.

Preparation of the sodium salt of tolyl mercaptan

Earlier, the preparation of the sodium salt of tolyl mercaptan was done by adding solid tolyl mercaptan to a 20% aqueous solution of sodium hydroxide at 60°C. This reaction needs excess NaOH which makes the solution strongly basic and therefore causes difficulties in subsequent acid coagulation of the latex. A better method is to add solid tolyl mercaptan (62 g) to 100 ml of 20% aqueous ethanolic NaOH solution and evaporate to dryness under vacuum, using a rotavapour.

Recorded M. Pt of tolyl mercaptan	..	44°C
Experimental M. Pt of tolyl mercaptan	...	42 - 43°C
M. Pt of the product was found to be above		250°C

As it was possible to add 62 g of tolyl mercaptan, it is reasonable to suggest that the reaction took place according to the molar ratio of the components. Therefore the sodium hydroxide that remains in excess will be less than in the earlier method.

Preparation of other metal salts

Barium, calcium, zinc, magnesium and potassium salts of tolyl mercaptan were prepared and their solubility and structural analysis are being studied by IR spectroscopy. The melting points of all the salts are found to be above 250°C. (L. M. K. Tillekeratne, Hemakanthi Gangodawila, A. Coomarasamy and H. N. K. K. Chandralal)

Practical applications

Initial research work on this project has been completed and the Superintendents and the Agricultural Advisers who have used the soluble bleaching agent have highly commended this new development. The new bleaching agent will be available in the market very soon. Due to the harmless nature of the soluble bleaching agent and due to its inoffensive odour, this chemical would be preferred to all the existing solvent based bleaching agents. The biggest advantage is the elimination of any form of toxicity or flammability hazard in the factory, in the handling of the new chemical. It even may be necessary to ban the use of obnoxious thiols as bleaching agents in the raw rubber industry on health grounds. Physical properties such as storage softening and storage discolouration of crepe rubber produced by using the modified bleaching agent is being studied in detail. (L. M. K. Tillekeratne)

P. tertiary butyl thiophenol as a bleaching agent

A 30% v/v solution of p. tertiary butyl thiophenol (PTBT) in low aromatic white spirit (LAWS) was made and the required 5% emulsion of this solution was prepared using Nexol surfactant as the emulsifier, at 0.5%. This emulsion was added at 0.05% and 0.06% by weight of the active component on rubber, respectively, to field latex samples which had been diluted with an equal volume of water and mixed well, prior to coagulation with 2% formic acid at a pH of 4.5. For comparison a control sample without any bleaching agent and a sample containing 0.05% by wt of tolyl mercaptan as the active ingredient, using a commercially available bleaching agent, were also prepared under the same set of conditions.

On examination of the dried crepe samples in lace form and blanket form, it was found that the bleaching effect of p. tertiary butyl thiophenol was superior to that of the commercial bleaching agent. For the manufacture of IX crepe rubber, after removal of a 10% fraction from mixed clonal latices, addition of 0.035% of PTBT on rubber was found to be quite adequate. The other advantages of PTBT is that it has a less pungent odour than the tolyl mercaptan (P. methyl thiophenol) and, also being a liquid, it can be directly emulsified or can be easily mixed with solvents and emulsified. It can also be reacted with alkali metal hydroxides to give a water soluble salt. (W. S. E. Fernando, A. Coomarasamy and W. D. Dharmasena)

Raw Rubber Specifications and analysis

TSR production

During the current year the following block rubber samples were tested from various TSR producers.

Code	Producer	No. of samples
AA	Sri Lanka (Cey) Rubber Manufacturing Co. Ltd.,	1664
AB	Cenat Block Rubber Factory, Paiyagala.	888
AC	Ceymac Rubber Co. Ltd., Colombo.	583
AD	Statcon Factory, Getahetta.	2356
AE	Sherman Sons Ltd., Block Rubber Factory, Ingiriya.	4723
	Sherman Sons Ltd., Block Rubber Factory, Colombo	270
AF	Ceymac Block Rubber Factory, Horana.	3082
AH	Lanka Star Rubber Co. Ltd., Parakaduwa.	1508

Analysis of masterbatches and miscellaneous samples

Altogether 622 masterbatch samples were analysed from AMW Ltd and Bergaungan Lanka Ltd.

In addition to this 302 miscellaneous rubber samples, 54 latex samples and 17 samples of rubber chemicals were also analysed.

Inspection visits

Inspection visits were made by the Specifications Officer to several block rubber factories. Special inspection visits were made to the Associated Traders block rubber factory in Colombo prior to enrolling the factory as a TSR producer in Sri Lanka.

Moisture balance in raw natural rubber

The study on the moisture intake in raw rubbers is still in progress. Experiments are now being conducted to block the groups which retain moisture in rubber through hydrogen bonding. This will be done by chemical means using blocking agents.

The results obtained so far in moisture uptake studies show that sheet rubber also gain moisture, when stored in humid atmospheres; but at a slower rate. Non toxic fungicides such as sodium benzoate and sodium propionate are being tried out to eliminate mould growth. The effect of the variation in pH on the development of mould is also another aspect which would be investigated into as the pH factor is also critical in funga growth. This work is being carried out in consultation with Dr R. L. Wickremasinghel, Director National Institute Plantation Management (NIPM). (L. M. K. Tillekeratne, Hemakanthi Gangodawila, H. P. Sarath Kumara and Hiranthi Jansz)

Rubber Product Studies

Resin soling compound

It was observed that incorporation of petroleum jelly (Ceylon Petroleum Corporation - P. 422) can successfully eliminate bloom in compositions yet chemically uncharacterised, as observed in resin soling compounds.

Further work is in progress to determine :

- (a) Maximum dosage required
- (b) Other formulations for which this procedure could be applied.

Further work on compound formulations for resin soling applications are in progress. Special adhesives are being tried out to give good binding under shear stress. (W. S. E. Fernando, S. W. Karunaratne, K. A. R. M. Perera and Li Jiu Long)

Tyre repair compound

Nihe batches (90 kg each) of a special tyre repair compound developed in this laboratory were supplied to Carson Cumberbatch and Company.

The following teething problems were encountered initially during usage.

- (1) Inconsistent cure behaviour of different compounds
- (2) Poor flow
- (3) Blooming of certain compounding ingredients after cure

The first two problems were solved by —

- (a) Masterbatching of some compounding ingredients
- (b) Adjusting the compounding procedure

Further studies have identified the cause of blooming of compounding ingredients in this compound. (W. S. E. Fernando and K. A. R. M. Perera)

Room temperature cured rubber hose

Attempts were made to develop a suitable room temperature vulcanization system to produce general purpose hose, containing PVA copolymer blends and microcellular crumbs as processing aids, respectively. These attempts were only partly successful. The system so far obtained needed some initiation for successful completion of cure in the factory floor. Exposure to direct sunlight for about 10 hours was found to be adequate to initiate the vulcanization reaction. The product obtained after 10 hours exposure to sunlight and 7 days on the factory floor was comparable to hose cured in an autoclave at 145°C for 30 minutes, using a conventional system. (W. S. E. Fernando, D. D. Medagama, W. D. Dharmasena and K. M. U. Mitrananda)

Technical assistance to Rubberite Ltd

Rubberite Ltd is involved in moulded rubber goods manufacture and one of their major problems is bloom, specially in moulded rubber heels components. Work was initiated to modify and reduce the curative system in order to overcome this problem. Technical assistance to Rubberite would be a continuing task on the basis of an agreement to constantly monitor and update the production processes with due consideration to economic viability. Three meetings were held with the management of Rubberite both at their factory and office and RRI laboratory. (S. W. Karunaratne, W. S. E. Fernando, K. A. R. M. Perera and D. D. Medagama)

Industrial extension

Oil seals, brake washers and rubber couplings were moulded according to specifications provided to us by the State Engineering Corporation. The moulds were provided by the corporation. (W. S. E. Fernando, and K. A. R. M. Perera)

Metal anacardates as activators for rubber vulcanization

Metal anacardates based on cashew nut shell liquid (CNSL) which is a reddish brown oil, extracted from the mesocarp of the cashew nut, consists of a mixture of phenolic substances. Its major constituent is anacardic acid (70%) and the other important components are cardol and cardanol.

Metal anacardates of zinc, magnesium, calcium and aluminium used in this study were synthesized by converting the anacardic acid in the CNSL into its sodium salt and subsequently reacting it with a solution containing the corresponding metal ions. In most of the experiments the metal anacardates obtained from CNSL were used without further purification and their effect as vulcanization activators was compared with that of stearic acid in NR based ACS 1 and tyre tread formulations and in Natsyn gum compounds. The activity has been found to be roughly in the following order Zn, Mg, Ca, Al. Stearic acid has been found to be superior to these metal derivatives in tread formulations, although the activities of stearic acid and zinc anacardate were comparable in gum compounds.

In the thermal ageing studies the vulcanizates containing calcium derivative showed better ageing resistance compared to the other vulcanizates. (N. M. V. Kalyani, A. Coomarasamy and L. B. K. Silva)

Biochemical Research

Studies on phospholipids

Studies on phospholipids were continued during the year. The types of rubber selected for analysis were acid coagulated rubber, autocoagulated rubber, polybag collected rubber and rubber obtained from latex treated with NaF.

Phospholipids of latex in various fractions, obtained by high speed centrifugation were extracted from rubber by solvent extraction and separated by TLC.

Of the three main fractions obtained by centrifugation of latex, the rubber phase had the highest phospholipid content. Chromatographic analysis indicated the presence of seven spots and three of them were identified as phosphotidyl choline, phosphotidyl ethanolamine, and phosphotidyl serine.

It was observed that phospholipase - D in *Hevea* latex, was destroyed or inhibited during bacterial growth in field latex. Phospholipase - D activities in sera obtained by a) centrifugation of latex (c - serum), b) freezing and thawing of latex (F - serum) c) freezing and thawing pallets of centrifuged latex (B - serum) were also determined. The highest activity was found in F - serum. The kinetic behaviour of phospholipids at various temperatures, pH values and various inhibitor systems was studied.

Choline chloride, ethanolamine, and phosphotidyl choline were found to accelerate the vulcanization reaction of crepe rubber. It was also observed that crepe rubber to which these phospholipids had been added also exhibited better raw rubber and technological properties than the control crepe rubber. The raw rubber properties and technological properties of polybag rubber and NaF treated rubber were better than the control rubber. (S. Kasinathan, P. A. J. Yapa and K. Balasubramaniam)

Latex proteins

Effect of wintering and yield stimulation by Ethrel on protein content/pattern was investigated. Proteins were separated by polycrylamide gel electrophoresis. No conclusive results were obtained although some protein bands apparently disappeared during wintering and also on stimulation. Further studies on this will be carried out next year. (P. A. J. Yapa and Sriyani I. Senanayake)

Effluent disposal

A new field experiment was initiated during the year at Frocester Estate, Govinna, to study the fertilizer potential of rubber factory effluents. The clone selected was RRIC 101. Yields of treated and untreated trees were recorded during the year. Soil samples were also collected before and after treatment, for analysis of various nutrient levels.

Arrangements were also made to study the effect of rubber serum treatment in upgrading the quality of compost. This experiment too will be carried out at Frocester Estate, Govinna. (P. A. J. Yapa, Chandrika Ediriwickrema, Sriyani I. Senanayake and P. D. J. Rodrigo)

Enzyme deprotenization of latex

Studies were continued, mainly to solve some of the practical problems encountered in large scale manufacture of DPNR by using papain treatment. The Estate Department of the Institute signed a contract for 25 tonnes of DPNR for a German buyer this year and the Rubber Chemistry Department assisted the Institute's factory in the manufacture of this first batch of DPNR on a commercial scale. Trials were also carried out to study the possibility of reducing the ash content further, in papain treated rubber and the results of a series of laboratory scale trials are summarized in Table 1. The use of Nonidet T was found to enhance the reduction of ash content. Experiments carried out towards the end of the year, clearly showed that the ash content of papain treated rubber can be reduced, almost to the level of acid coagulated rubber, by dilution of latex. Further trials are in progress. Enzyme treatment with papain was also used to prepare a general purpose rubber and samples were sent for evaluation by overseas consumers. It was found that the high zinc content reported in papain treated rubbers, by an overseas consumer does not arise from papain. Analysis of papain used for DPNR manufacture had a very low zinc content (14 ppm). Copper and iron contents were also low. (P. A. J. Yapa, C. P. Ediriwickrema, Sriyani I. Senanayake, M. D. C. Seneviratne and P. D. J. Rodrigo)

Table 1. *Raw rubber properties of papain treated rubber with and without addition of a surfactant (Nonidet)*

	Mean	Papain Range	Coefficient of variation %	Mean	Papain + Nonidet Range	Coefficient of variation %
Nitrogen %	.15	.14-.18	8.57	.14	.12-.17	10.6
Dirt %	.02	.01-.06	78.17	.01	.01-.06	80.2
Ash %	.29	.22-.36	13.06	.28	.22-.34	14.34
Wallace plasticity no.	50	40-63	14.01	*51	46-60	9.87
PRI	71	58-85	11.72	*72	62-84	9.30
Colour	4.6	2.5-9.0	45.02	4.6	1.5-9.0	53.42
Mooney viscosity	84	70-98	11.86	86	74-98	8.70

* Significant at 5% level, when papain and papain + Nonidet treatments were compared

Studies on brown bast

A study on the free proline content in relation to brown bast (BB) was initiated during the year. It is known that the free proline content increases with water stress. All the samples, leaf, bark and latex, for this study were collected from clone RRIC 101 at Eladuwa State Plantation. Free proline was extracted into sulphosalicylic acid and complexed with an acid ninhydrin solution. Preliminary results showed that the bark samples taken at different heights had a slightly higher level of free proline content (0 - 11 ppm range) in the brown bast tissue. Latex serum samples indicated a slightly higher free proline content (10 - 15 ppm range) in normal trees. A greenhouse experiment is being planned. (Thushini V. W. Goonasekera and P. A. J. Yapa)

A comparative study on the lipids of bottom fraction of normal and brown bast trees was initiated. Latex samples from normal and affected trees of clone RRIC 101 at Eladuwa State Plantation are being used in this study. Several solvent systems were tried out for the separation of lipids, extracted with chloroform/methanol petroleum ether : diethyl ether : acetic acid (90 : 10 : 1 v/v) and toluene were found to give good separations. Further work is in progress. (Thushini V. W. Goonasekera and P. A. J. Yapa)

Enzymology

The studies on ATP-ase were continued. The F-serum obtained from healthy (H), and brown bast (BB) trees was studied and the activity pattern was found to vary according to the clone used.

The ATP-ase activity was determined for the H and BB bark obtained from different heights. The results confirmed the earlier studies, which showed higher activity in diseased trees. The BB trees were also analysed for the presence of Ca, Mg, Mn, N, P, and K ions. The statistical analysis of these results showed a correlation with the results obtained from the studies on cationic dependence on the enzymic activity.

The bark extracts obtained from H and BB trees were tested for the presence of phenolics, by paper chromatography. Even though the H extracts contained more phenolic substances when compared with the diseased, the phenolics of diseased extracts had greater stimulatory effect on the enzyme ATP-ase than those of healthy extracts. (C. P. Ediriwickrema and P. A. J. Yapa)

REVIEW OF THE STATISTICS SECTION

By

W. N. WICKREMASINGHE

SUMMARY

Statistical assistance was provided in all the possible ways to all the research Departments of the Institute without interruption. Meteorological work was also carried out uninterrupted. The Consultant Biometrician, Mr V. Abeywardena, resigned from the services of the Institute after a long and valuable association with the Institute. The Assistant Statistician resumed duties in June, after post graduate studies abroad.

A paper was presented on "A study of effects and standard errors in crossed mating design", at the 50th Anniversary Conference of the Iowa State University (ISU) Statistical Laboratory. A report was submitted to the Director on the field and laboratory experiments of the Institute. Assistance is being provided in a survey on the economics of productions of smallholders.

DETAILED REVIEW

Staff

The Assistant Statistician, Mr W. N. Wickremasinghe, returned to the Institute in the beginning of June, after obtaining a Masters degree in Statistics from the Iowa State University, USA.

The Consultant Biometrician, Mr V. Abeywardena resigned from the Institute effective from 31 March. The Senior Technical Officer, Mr L. T. Peiris, Technical Officers, Mr R. A. P. Abayapala and Miss J. D. Nandanie, were all on duty throughout the year.

Lectures and seminars

The Assistant Statistician gave a seminar at the Plant Science Auditorium, on his MSc program abroad. He also gave a series of lectures on basic statistical methods to the Rubber Chemistry Department staff.

Publications

Arrangements were made to present a paper on "A study on the effects and standard errors in a crossed mating design" at the 50th anniversary conference of the Iowa State University Statistical Laboratory. This work was based on a creative component submitted to the Statistics Department of ISU, by the Assistant Statistician, as partial fulfilment for his MSc degree.

Statistical Work

Routine

During the first quarter, routine analytical work was carried out under the supervision of the Consultant Biometrician. This included some analyses using covariance adjustments in a crown budding experiment with unequal plot sizes and also the analysis of data from the survey on "Assessment of the extent of exploitation of rubber trees by smallholders", of the Plant Science Department. During 2nd quarter no officer was available for supervision. But, most of the research officers met the former Consultant Biometrician personally at his present working place and sought help for their analyses. This type of kind assistance, even at a personnel level, of the Biometrician, is greatly appreciated.

With the arrival of the Assistant Statistician in the beginning of the 3rd quarter, the Section resumed its normal functions of routine and special analyses.

A considerable time was spent on analyses of data of temporary research students attached to various Departments of the Institute.

Surveys and reports

On a request from the Director to assist in a survey on "Economics of smallholders" the Assistant Statistician prepared a questionnaire for this. The initial stages of the survey were done and the second stage was underway at the time of writing this report.

The Assistant Statistician visited all the field and laboratory experiments of the Institute and submitted a report to the Director, on request. He also submitted a note on the "Variability in *Hevea* Yield" to the Director, on request. Studies on this topic are being continued.

Meteorology

Routine meteorological work was continued uninterrupted throughout the year. The graph of rainfall temperature and sunshine duration at Dartonfield is shown in Fig. 1.

Miscellaneous

Senior Technical Officer, Mr L. T. Pieris and Technical Officer Mr R. A. P. Abayapala attended a 1 week course on "Regression, modelling and data" conducted by the University of Colombo. On satisfactory completion of the course, they obtained certificates from the University.

The Assistant Statistician started visiting Nivitigalakele sub-station once a week effective from October, on a request made by the Geneticist and Plant Breeder to assist him in his statistical analyses and designing.

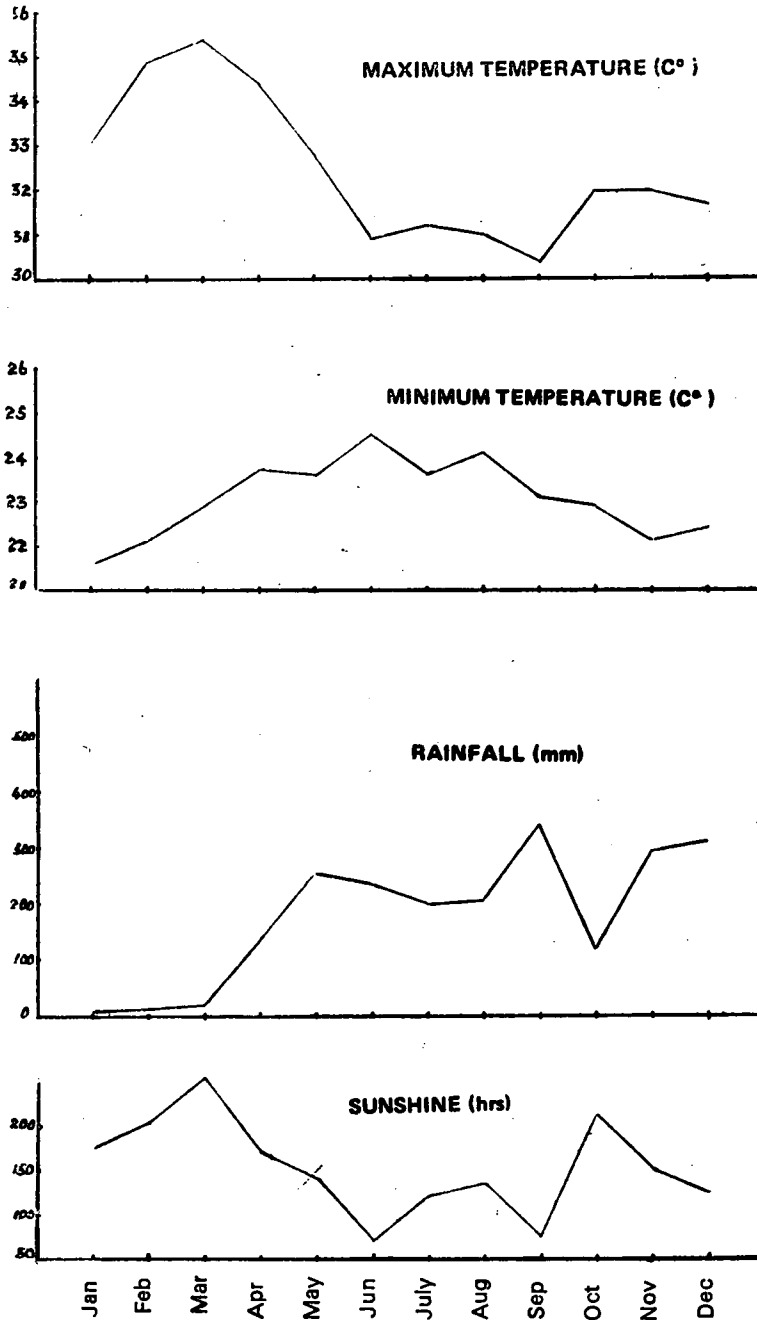


Fig. 1. Rainfall, duration of sunshine and temperature at Dartonfield.

REVIEW OF ESTATE DEPARTMENT

By

R. G. SIRIWARDANE

SUMMARY

The Institute's estate, Dartonfield Group, comprises of Dartonfield and Gallewatta Divisions in Agalawatta and Nivitigalakele Division in Matugama consisting of 336,22 ha. The planted area is 285.01 ha of which 204.60 ha were in bearing during the year.

Weather conditions that prevailed during the year were unfavourable for harvesting of crop. The severe drought experienced from January to April and the unusual distribution of rainfall, specially during August to December, during which period the intakes in normal years are higher, contributed to the drop in crop harvested.

The incidence of *Oidium* leaf disease was negligible, since wintering was early this year. The incidence of *Phytophthora* was also very low. Trees affected by white root disease were treated by using "Collar Protectant" fungicide.

Budwood of clones RRIC 100, 103, 121 and PB 86 were much in demand and issues to all estates and smallholders were made accordingly.

All agricultural operations were carried out in mature and immature areas and nurseries of the Group.

The estate made a profit of Rs. 5/15 per kilo during this season ; which was the highest since 1974.

DETAILED REVIEW

Staff

The Estate Superintendent, Mr R. G. Siriwardene was on duty throughout the year.

Mr A. A. Ariyaratne, Acting Chief Clerk, Messrs K. K. P. Gunawardana, K. D. Sumanasena and C. N. Wickremasinghe, Junior Assistant Clerks, Mr D. C. C. Jayasekara, Factory Officer, Mr D. S. Ranaweera, Assistant Factory Officer, Messrs N. L. D. Piyadasa, A. K. D. Hemapala, S. K. S. de Silva and H. M. Jayantha Premalal, Field Officers, Messrs J. A. Wimalasena and A. K. D. Wickremasinghe, Assistant Field Officers, Messrs T. Somaratne, S. R. Vadivel and W. D. D. Senanayake, Field Supervisors, Mr W. D. Sugathadasa, Tractor Driver, Miss M. Thambathy, Gallewatta Creche Attendant and Miss C. S. Hettiarachchi, Dartonfield Creche Attendant were on duty throughout the year.

Miss C. S. Hettiarachchi was absorbed in to the monthly paid cadre in January, as Creche Attendant of Dartonfield Division.

Miss M. Thambathy the Creche Attendant of Gallewatta Division resigned from the post on 31 December.

The Dartonfield Group cadre stood at 19 at the close of the year, made up as follows :

Senior Staff	1
Assistant Staff	15
Minor Staff	3
Total	19

Trainees

Two Bangladeshi Officers are being trained in Estate Management with effect from 1. July on a British Council Scholarship.

Meetings

The writer served in the Estate and Scientific Committee of the Rubber Research Institute and was involved in conducting lectures and field demonstrations for Rubber Extension Officers of the Rubber Research Institute and Agricultural Instructors of the Agricultural Development Authority at the Smallholders Rubber Rehabilitation Project training centre on Land Preparation, Field Establishment and upkeep of New Clearings.

Agricultural Adviser

The Agricultural Adviser, Mr. R. C. Peries, Director, J. E. D. B. No. 1, Regional Office, Avissawella, paid two visits to the property during the year under review. Reports on these visits were submitted to the Rubber Research Board.

A summary of the hectareage is given in Table 1.

Table 1. *Land distribution in Dartonfield Group*

	Dartonfield	Gallewatta	Nivitigalakele	Total
Mature area	27.70	133.48	43.42	204.60
Immature	17.09	42.14	6.19	65.42
Nurseries	9.06	1.80	4.13	14.99
	53.85	177.42	53.74	285.01
Paddy fields	—	1.25	—	1.25
Abandoned area	—	5.03	9.47	14.50
Swamps	—	—	1.21	1.21
Buildings	16.23	6.00	7.79	30.02
Roads	2.67	.50	.32	3.49
Streams/reservations	.03	—	—	.30
Jungle	—	—	.71	.71
Grand total	72.78	190.20	73.24	336.22

Rainfall figures (mm) for 1983 and 1982 are given in Table 2

Table 2. Rainfall distribution for 1982 & 1983 in Dartonfield Group

	Dartonfield		Gallewatta		Nivitigalakele	
	1983	1982	1983	1982	1983	1982
January	15.2	21.4	36.3	18.8	17.5	86.9
February	20.8	10.2	68.6	16.8	31.0	—
March	26.3	286.1	30.5	287.2	—	302.7
April	205.0	520.5	189.2	446.5	193.0	340.5
May	381.8	508.5	367.8	479.8	395.5	472.3
June	351.5	615.2	382.0	608.1	393.7	646.4
July	300.0	264.2	330.7	261.6	230.5	295.0
August	308.7	271.3	352.5	123.2	456.0	314.6
September	504.4	235.8	625.9	236.5	508.0	258.5
October	180.3	614.2	220.2	590.0	255.7	628.1
November	438.9	764.0	374.1	789.7	360.9	951.3
December	464.4	154.9	528.0	180.8	624.2	331.7
	3207.3	4266.8	3505.8	4039.0	3466.9	4628.0
Total wet days	191	228	190	207	138	146

The season began with a dry January; September and December proved to be the wettest months.

Crop

The harvested crop of 159442 kg this year fell short of the season's estimate by 60558 kg and stood at 72% of the estimated crop. Very severe drought experienced during the early part of the year and heavy and uneven distribution of rainfall, specially during cropping months contributed to heavy shortfall in crop. The yield data for the last 5 years are given in Table 3.

Table 3. Yield records from 1979 - 1983 (kg/ha)

	1983	1982	1981	1980	1979
Dartonfield	838	772	818	858	1058
Gallewatta	804	875	1233	1129	901
Nivitigalakele	667	864	953	944	803
Total	779	858	1105	967	836
Estimated	1052	1124	1064	983	970
Tapping (ha)	205	209	187	207	216

Tapping

Seventy nine (79) days tapping were lost due to unfavourable weather conditions and recovery tapping was done on forty nine (49) days. Tapping was carried out throughout the wintering period.

Tapping cuts were marked with appropriate guide-lines for bark consumption according to the systems of tapping adopted.

Stimulation with Ethrel was carried out by the Plant Science Department in the 1973 field of Dartonfield Division, and 1961 field of Gallewatte Division.

All the tapping panels were treated with Antimucin, Brunolinum Plantarium and red powder.

Manufacture

A summary of manufacture records during the year is given in Table 4.

Table 4. *Details of manufactured crop in Dartonfield*
Latex Grade Total crop

		(kg)	(%)
Pale crepe	No. 1	152549	96
Pale crepe	No. 2	750	1
Pale crepe	No. 3	5197	3
		158496	100
Smoked sheet	No. 1	5245½	99
Smoked sheet	No. 2	60	1
Smoked sheet	No. 3	—	—
		5305½	100
Scrap crepe	No. 1	4878	47
Scrap crepe	No. 2	4001	38
Scrap crepe	No. 3	10403	100
Total crop manufactured (inclusive) of 14762½ kg of bought latex)		174204½	100

15 mt of thin crepe was contracted for and supplied during the year.

30 mt of papain coagulated rubber was manufactured and supplied on a special request made by Messrs Associated Traders on a forward contract @ Rs. 23/50 per kilo.

The estate continued buying latex from the smallholders of the neighbourhood and the total bought latex manufactured at the end of the year was 14762½ kg.

Factory machinery

The speed of Mill No. 6 was reduced for Sole crepe manufacture.

Agricultural operations

Routing weeding, manufacturing and all other agricultural operations were carried out. The immature areas were in good condition and were maintained up to the required standard of sound agricultural practice. Growth was very satisfactory and the cover crops were maintained.

Roads

All motorable roads within the Group were maintained in good order throughout the year.

Pests and diseases

Oidium heveae : Wintering was early this year. No symptoms of *Oidium* leaf diseases was noticeable except on the later wintering clones such as the 1971 PB 28/59 area which suffered slight leaf fall.

Colletotrichum gloeosporioides : The incidence of *Colletotrichum* leaf disease was negligible.

Phytophthora meadii : Leaf fall was negligible.

Rigidoporous lignosus : A few scattered trees affected by *Rigidoporous lignosus* were detected specially in the 1980 and 1977 replantings and were treated with Collar Protectant.

Wind damage

The loss of trees due to wind damage on Dartonfield, Gallewatta and Nivitigalakele were 53, 164 and 08, respectively.

Replanting

The following replantings were completed during the season.

1983 Replanting - 5.15 ha - Clone RRIC 103 Dartonfield Division

1983 Replanting - .88 ha - Clone RRIC 103 Gallewatta Division

1984 Replanting - 4.50 ha Gallewatta Division

1984 Replanting - 4.48 ha Nivitigalakele Division

} Preliminary works on these areas were completed and the fields are ready for replanting in May/June 1984.

Nurseries

Nurseries established in Nivitigalakele and Dartonfield Divisions for 1984/85 replantings and to supply budwood for the smallholders were well maintained during the season.

Field and factory experiments

The Research Departments were given the necessary assistance in carrying out their field and technological experiments.

Labour and health

The health of the entire estate population was satisfactory during the year. The number of patients treated at the Medical Centre was 5443.

Vital statistics

Births	14
Still births	02
Infant deaths	02
Deaths of pre school children	Nil
Maternal deaths	Nil

Three new cottage type quarters were constructed at Gallewatta Division and repairs to line rooms and lavatories were attended to, where necessary.

Wages were paid during the year in accordance with the Wages Board Ordinance in force. Festival Advances were paid as required. Incentive Bonus and the Annual Holiday Pay Wages were paid to the labour in accordance with the Ordinance.

Accounts

The final accounts for the year 1983 are being carried out. The anticipated Revenue profit for the season would be about Rs. 800,000.

Estimates

Estimates for Capital and Revenue Expenditure for 1984 in respect of Dartonfield Group, were prepared and submitted by the writer to the Rubber Research Board for approval.

REVIEW OF THE LIBRARY AND PUBLICATIONS SECTION

By

VIJITHA JAYARATNE

SUMMARY

This year too the Library and Publications Section played an important role in communication and dissemination of information on every aspect of natural rubber.

Research communications were published regularly and the Institute's Handbook of Rubber Culture and Processing with valuable information will be released by early 1984.

Agricultural Information Network (AGRINET) and the National Information System for Agricultural Science (AGRIS) helped the Research Officers in obtaining current scientific information.

DETAILED REVIEW

Staff

Mrs V. S. Jayaratne, Librarian and Publications Officer, Miss L. T. Ramanaden, Library Assistant and Assistant Publications Officer attached to the Colombo Office Library and Mr D. C. Thambawita, Library Clerk at the Head Office Library were on duty throughout the year.

Acquisitions

This year too the subscription for periodicals was Rs. 300,000 and the number of books purchased had to be reduced, as the total allocation for books and periodicals was only Rs. 350,000. Only a few books could be ordered as the subscription for periodicals could not be curtailed because they are more useful for Research Officers than text books.

Two hundred and twenty four titles of current periodicals including abstracting and indexing periodicals were obtained during the year.

	Local	Overseas
On subscription	—	97
On exchange/gratis	32	115

Inter library loans

Several papers from various journals were acquired through this scheme, the total acquisitions being very much higher than in previous years. This shows that this scheme has benefited our Research Officers by providing scientific information whenever such was not available in the Institute's Library. In the wake of increasing subscription rates

it is also impossible to subscribe to all periodicals needed by the Institute Staff. A number of photocopies of papers from our journals were sent to other Libraries on similar requests.

Publications

The Institute's regular publications for all sectors of the natural rubber industry were issued on schedule. The following publications were distributed during the year.

Publications	Volume
Annual Review	1982
Journal	59 & 60
Bulletin	16 & 17
Rubber Pwath	9 & 10

The Bulletin will be published more frequently so that more details of research done on natural rubber could be disseminated to all sectors of the rubber industry including the smallholders within a short period. Altogether five Bulletins will be published within a year and each Bulletin will be allocated to each Department so that all research work done on all subjects relevant to natural rubber could be disseminated within the year.

Printing of the revised edition of the Handbook of Rubber Culture and Processing is in the last stages and will be released by early 1984. It gives detailed information on all aspects of rubber culture and processing and would be a valuable text book to all personnel in the rubber industry.

Information service

Disseminations of information

The library's main objective of collecting, organising and disseminating information was further strengthened during the year. Other than distributing the contents pages and indexing of relevant articles for the Research Officers, Agricultural Information Network (AGRINET) and the National Information System for Agricultural Science (AGRIS) helped to a great extent in obtaining information which could not be obtained from the Institute Library.

Agricultural Information Network

The Agricultural Information Network was successfully conducted this year too. Their main objective of contents page service was very helpful to us and with their user seminars to the Research Officers, we were able to gain more service from the Network. The last of the user seminars of the Research Institutes was held successfully at our Institute and our Research Officers were able to assess the service rendered by the AGRINET and obtain maximum benefits from their service. Photocopies of contents pages requested by our Research Officers were obtained from other libraries and through these contents pages they were able to get photocopies of papers they were interested in. This service fulfilled the objective of collecting and disseminating information at minimum cost and without delay.

National AGRIS Project

The National AGRIS Project too has helped by getting retrospective searches done for our Research Staff. During the years 1982 - 83, forty retrospective searches were done on various subjects relevant to their interest. Through the Selective Dissemination of Information Service (SDI) we continue to receive all references on all aspect of rubber. Copies of the Institute's Publications were sent to the Sri Lanka AGRIS project to be included as the reference input to AGRIS.

Normal work of classifying, cataloguing, indexing and acquisition continued uninterrupted though the staff was restricted to only the Librarian and the Library Clerk.