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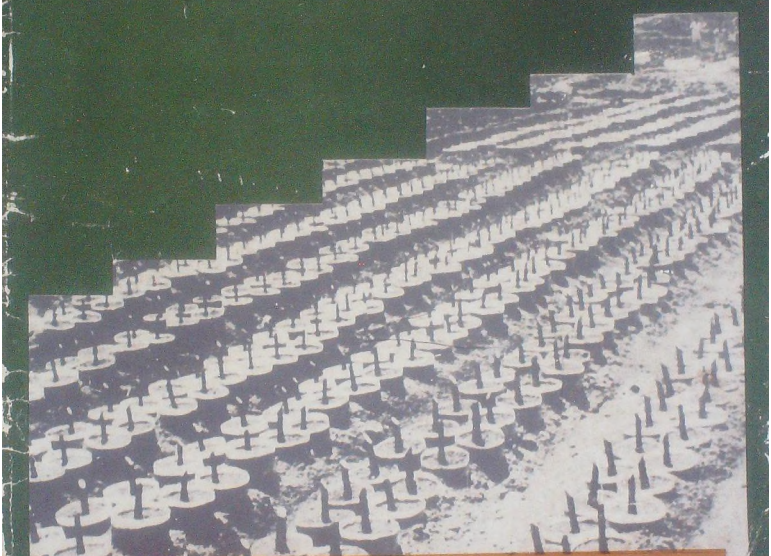

RUBBER RESEARCH INSTITUTE
OF INDIA

ANNUAL REPORT
1986-87

THE RUBBER RESEARCH INSTITUTE OF INDIA
KOTTAYAM-686 009, KERALA, INDIA.

Published by

M. R. SETHURAJ,
DIRECTOR,
RUBBER RESEARCH INSTITUTE OF INDIA,
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KERALA, INDIA.

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DECEMBER 1987

CONTENTS

THE RUBBER BOARD

The Indian Rubber Board was constituted under the Rubber (Production and Marketing) Act, 1947. This Act was passed on the recommendation of an ad-hoc committee appointed by the Government of India in 1945, and came into force on 19th April, 1947. The Rubber Production and Marketing (Amendment) Act of 1954 made certain changes in the constitution of the Board and shortened its name to the Rubber Board. This Act came into force on 1st August, 1955. The Rubber Act of 1947 was further amended by the Rubber Amendment Act 1960 which made certain alterations in the rate and procedure of collection of cess on rubber. The Act was again amended by the Rubber (Amendment) Act, 1982.

Organisation

The Chairman is the principal executive officer and he exercises control over all departments of the Board. There are five main departments, viz. Administration, Rubber Production, Research, Rubber Processing and Finance & Accounts.

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11. Dr. S. P. Raychoudhuri, A-61, Alakananda, Kalkaji, New Delhi - 110019.
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14. Dr. D. Joseph Francis, Professor & Head, Dept. of Polymer Science & Rubber Technology, Cochin University, Cochin - 682 022.

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Jiban Chakrabarti M.Com.	:	Junior Accountant

The total staff of the Institute is 332, which include 126 scientists and 206 supporting personnel in the scientific, technical and administrative wings.

Director's Report

The Rubber Research Institute - the Research Department of the Rubber Board - was established in 1955. With a modest beginning, the Institute has registered a gradual growth and has now become one of the Internationally recognised centres of research. The half yearly and the annual reports of the Institute used to form a part of the respective reports of the Board. The Board has now decided to start publication of the Institute's own annual reports for the benefit of the scientific community as well as the plantation and manufacturing sectors.

This being the first volume of the annual report of the Institute, it may be appropriate to briefly describe the structure and the functions of the Institute. The head office of the RRII is situated in a hillock, eight km east of Kottayam town in Kerala. The major research divisions of the Institute are Agricultural Economics, Agronomy & Soils, Biotechnology, Botany, Mycology & Plant Pathology, Plant Physiology & Exploitation and Rubber Chemistry, Physics & Technology. The Institute also has technical supporting sections like Library & Documentation, Instrumentation and Art & Photography. There are two experiment stations in Kerala attached to the Institute, one, of 33 ha in extent, at the HQ, and the other, Central Experiment Station, 258 ha in extent, at Chethackal 50 km from Kottayam. The Institute has established a Regional Research Complex in North-East India, with Research Stations in Agartala (Tripura), Guwahati (Assam), Tura and Darachikgre (Meghalaya) and Kolasib (Mizoram). The Institute also has Regional Stations in Dapchari (Maharashtra) and Kamakhyanagar (Orissa). For the specific function of plant breeding and initial evaluation, the Institute has established Breeding Stations in Paraliar (Tamil Nadu) and in Subramanya (Karnataka). Regional Analytical Laboratories have also been established in Thodupuzha, Calicut and Nagercoil for soil and leaf analysis for advisory purposes, with a mobile laboratory attached to each.

Thrust areas of Research

The consumption of natural rubber in India during 1986-87 was 0.26 million tonnes against a production of 0.22 million tonnes. The gap between demand and supply shows a widening trend and with the new industrial policies and expected spurt in industrial growth in India, this gap is likely to widen unless adequate and immediate action is taken to increase internal production of natural rubber. There are many limitations in achieving this. In the traditional rubber growing areas in the southern parts of India the scope for further expansion is extremely limited. A conservative estimate of the demand of natural rubber in 2000 AD is 5,00,000 tonnes and by 2010 AD, it may further increase to 7,00,000 tonnes. Even to achieve a target of production of 5,00,000 tonnes by 2000 AD, the area under rubber should be 5,00,000 ha, of which 4,00,000 ha would be yielding. This calculation is based on an assumption that the average national productivity can be raised to a level of 1250 (kg / ha) by 2000 AD. In order to achieve this primary objective, a massive programme of cultivating rubber in non-traditional areas with many agro-climatic constraints should be attempted. Clones should be bred and selected for different agro-climatic situations and additional agro-management inputs and techniques will have to be devised to suit local conditions. The need for studies to elucidate the clone-cum-environment interactions to guide future selections is also recognised. Another aspect deserving attention is perfection of exploitation systems for different clones grown under different climatic conditions. Introduction of a new crop, like rubber, in areas where tribal social customs predominate, presents

another dimension of constraints and makes it necessary to evolve rubber based agricultural systems wherein the element of intercrop and social forestry aspects will also have to be considered.

A constant watch on new diseases and pests in non-traditional areas becomes imperative. The variability in soil characteristics and nutrient status, topography and other agronomic aspects in different new areas necessitate extensive agronomic trials to assess nutrient requirements to make fertiliser recommendations. This applies to other agro-management techniques as well. When new agro-management practices are found necessary in a new area, economic evaluation of such systems becomes necessary. Integration of all new management techniques to reduce the cost of production will have to be attempted judiciously.

Attempts have already been concentrated on evolving modern agrotechnology with a view to reducing the prolonged pre-bearing stage of seven or more years. Breeding and clone evaluation in rubber takes over thirty years and to evolve early detection parameters a multidisciplinary approach from the morphological, anatomical, physiological and biochemical considerations is also under way.

In the field of processing and technology, the thrust area is based on the recognition that India will continue to be a major importing country for many more years and our priorities should be to optimise natural rubber use by achieving longer service characteristics of the products. Another area is chemical modification of natural rubber with the objective of replacing certain speciality synthetic rubbers which the country now imports. New methods to reduce the cost of processing are also under study.

Besides its major research functions, the Institute also gives advisory and consultancy service to plantations and small scale industries. The Institute conducts training courses for the plantation managers. In the academic scene, the Institute collaborates with Cochin University and Kerala Agricultural University in conducting a post-graduate B. Tech. course in Polymer Science & Rubber Technology and a post-graduate Diploma course in Natural Rubber Production, respectively. The Institute has established research linkages with National Chemical Laboratory, Pune; Indian Institute of Science, Bangalore; Kerala Agricultural University, Trichur and IIT, Kharagpur. Banaras Hindu University, Kerala Agricultural University, University of Kerala and Cochin University have recognised the Institute as a Centre of learning for Ph.D. work. This Institute has also been recognised by the International Rubber Research & Development Board (IRRDB) as a Centre of Excellence for training in the field of Plant Physiology and has also been charged with the responsibility of organising an international reserach project on Production and Stress Physiology. Being an active member of the IRRDB, the Institute has been associated with UNIDO projects on Composite Rubbers at MRPRA, UK and Liquid Rubber in Ivory Coast. Many International Fellows have been trained by this Institute in various disciplines. Two trainees from the Peoples Republic of China, one from Indonesia, two from Thailand and one from Malaysia have been trained in the field of Physiology. One Scientist from Malaysia was attached to this Institute for a short period in the Pathology Division. Three trainees from Vietnam were attached to the Institute for one year, for advanced training, one each in Agronomy, Plant Physiology and Rubber Technology.

Major Activities

Breeding

Breeding for higher yield and stress tolerance continue to be a priority area of our activities. During 1986 season, 12899 pollinations involving 56 cross combinations were attempted. An initial screening was made from the resultant seedlings and the selected progenies were planted to assess familywise performance. Studies on the factors affecting nursery yield (in test tapping) revealed that the number of latex vessel rows forms the predominent character influencing nursery yield.

Ortet selection

The Institute has also launched an intensive programme of ortet selection from polyclonal and monoclonal seedling populations in plantations. All reports of high yielding trees and disease tolerant trees are followed up.

Early prediction of yield

Decades of research efforts to evolve a method for early prediction of yield has not produced any reliable and dependable methods. The reason seems to be the fact that except for certain anatomical traits affecting yield, the other physiological characters determining yield are not reflected at early stage and cannot also be experimentally simulated. After a thorough analysis of the early work, a multi-disciplinary study, based on a conceptual analysis of yield components, to evolve methods for early prediction of both yield and stress tolerance has now been initiated.

Mutation Breeding

A few selections from irradiated materials recorded higher vigour compared to RRII 105. The Institute maintains many tetraploids and a triploid which are being evaluated for various characters.

Clone trials

Large scale evaluation of clones, evolved at RRII, ortet selections and imported promising materials was continued at different locations. A list of 30 promising experimental clones (including some of the imported clones)was prepared and a comprehensive programme for large scale evaluation in different agro-climatic regions has been drawn up. Most promising clones in small scale trials are tested for block-wise performance concurrently with statistically laid out large scale trials. This is done with an objective of reducing the time required for recommendation of new clones. Block trails are mostly conducted as on-farm trials with coded numbers.

New germplasm

The Institute has already acquired 800 genotypes of germplasm collection from Brazil under the auspices of International Rubber Research & Development Board. It is expected that by the end of 1987 we would be in possession of 10,125 genotypes from the germplasm bank. A phased programme has been prepared for evaluation of these materials.

Cytogenetical studies

The Cytogenetics Group could identify a natural triploid from among the stock of ortet selections. This appears to be the first report of occurrence of natural triploidy in *Hevea*.

Anatomical investigations

Anatomical investigation on clonal variation in stomatal features revealed that leaf fall due to *Phytophthora* was correlated to stomatal frequency, length of stomata and aperture index. It was also observed that laticifer area index of bark had a positive relation with yield while the density and width of phloic ray had a negative relationship.

Tissue Culture

There has been widespread interest among rubber producing countries to develop a tissue culture system for the propagation of rubber clones. Recently RRII upgraded its small tissue culture laboratory as a Division of Biotechnology. A significant achievement

within a short period of its functioning has been the development of a successful *in vitro* propagation system utilising shoot tips. Development of the shoot and tap root is attained within weeks and the rate of success and repeatability are extremely encouraging. Rooted plants had successfully undergone "hardening" and have been trasplanted in soil in polybags. Field planting will be undertaken during the next planting season.

Investigations on several tissue culture systems with the ultimate goal of *Hevea* improvement have been initiated.

Biochemical and Physiological basis of yield variation and stress tolerance

This Institute has pioneered in yield component analysis and presently is concentrating on sub-components of the major yield components already identified.

Results of investigations on the variations in the sub-components of yield between high yielding and low yielding clones have revealed that while plugging index and bursting index were low in high yielders, proteins, surgars and lipids tended to be high.

Tne studies on response of different clones to severe drought situations indicated extremely low values of afternoon water potential in all clones. However, drought susceptible clones gave lower values of water potential compared to comparatively drought tolerant clones. From the data on soil moisture depletion, it became evident that rubber trees draw water from soil layers beyond 90 cm depth. RRII 105 has higher rates of water uptake and transpiration during periods of extreme drought, probably indicating better root proliferation and root depth in the stock facilitating more effficient water uptake.

It was also observed that in clones considered drought tolerant the osmoregulatory mechanism was more pronounced.

A method was standardised to measure the thermostability of membranes of leaf tissues of *Hevea* clones.

A regression formula was also deduced to establish the relativity between water potential values obtained by pressure chamber and psychrometric method.

Lipid composition of leaves

Clonal variation was evident in the levels of glycolipids, triglycerides and sterols between a drought tolerant (in terms of latex yield) clone, RRII 105, and drought susceptible clone, Tjir 1. All the three components were significantly higher in RRII 105. Association of latex lipids with drought tolerance has already been reported from this Institute. This trend was evident in a Chinese cold tolerant clone as well.

Partitioning of assimilates

Labelled carbon was fed to the leaves of plants grown in polybags and the translocation of photosynthates and the rate of conversion to rubber in the bark were monitored. One interesting indication was the effect of girdling: rate of conversion to rubber in the shoot portion over the girdle was enhanced. This suggests the possibility of an effect of precursor concentration on rubber biosynthesis.

Constraint analysis of yield variation

The constraint analysis of yield variation between locations for the same clone of same age has yielded interesting results. The method is to check the major yield components and identify the causative factor for yield reduction in a partuicular situation, based on the differences recorded for these components. The factor of girth could be eliminated as there was no significant difference in this character between locations. Ultimately the yield difference

could be associated with difference in plugging index. A systematic analysis of the internal and external factors related to plugging index variation would reveal the reasons for yield variation among the locations studied.

HMG CoA reductase activity in latex

Estimation of HMG CoA reductase activity in bark in the drainage area at six hourly intervels during the interval between two successive tappings revealed that this enzyme exhibits strong diurnal variation in activity, activity being higher during the night hours. In general, the activity was found to be higher in the first 24 hours after tapping compared to the activity in the subsequent 24 hours.

In order to initiate studies on the physiology of nutrient uptake, water uptake, effect of moisture stress, etc, it was considered that use of solution culture might be of advantage. A simple method was standardised to grow young *Hevea* in soltuion culture.

Ecophysiology

Of the many clones tested at different locations representing different stress situations such as high altitude (Mudigere and Wynad), higher latitude with low winter temperature and prolonged dorught (Agartala) and high summer temperatures combined with low humidity and soil drought (Dapchari), RRIM 600 performed well under different stress situations. RRII 300, RRII 118 and RRIM 703 also performed well under stress situations. The physiological basis of stress tolerance of these clones is under detailed investigations.

Exploitation

There were many reports of comparatively high incidence of brown bast in RRII 105, which has become the most popular clone among the plantations. A tapping experiment with three systems; ½S d/2, ½S d/3 and ½S d/2 (t, t), was started to make detailed assessment of the susceptibility of this clone to brown bast. During the first year, yield reduction in d/3 system as compared to d/2 was only 17%. Lowest incidence of brown bast was recorded in ½S d/3 system.

Exploitation system for BI–2 stage

The usual practice of adopting ½S d/2 system of tapping till the BI–2 panel is completely consumed need revision as most of the plantations now at this stage of exploitation are planted with old materials and the average yield obtained really justify earlier replanting with modern high yielding materials than the conventionally followed schedule of replanting. Therefore different intensive tapping systems were studied.

Of the six tapping systems tried in a block-wise trial, S × ½S d/1 (t,t) system increased the yield level by 100%, while S × ½S d/2 increased the yield by about 80%. Incidence of dryness under different systems is being regularly assessed.

Studies on Nutritional Requirements

In order to get information on clonal variation in nutrient requirement and the regional effects many nutritional experiments were laid out, both for young and mature rubber. The data generated can be used to refine the present criteria fixed for discriminatory fertiliser recommendation based on leaf and soil analysis. Clone- specific and region-specific recommendations can be evolved. Follow-up studies were conducted in selected estates to evaluate the field results of discriminatory fertiliser recommendations given by the Institutes with a view to improving the diagnostic system.

Results of experiments revealed that a good legume cover during the first 3-4 years would result in a lot of fertiliser savings during the initial years after tapping.

Drip Irrigation

Drip irrigation experiments revealed that at an irrigation level of 10 l t^{-1} day^{-1} during summer, the yield depression could be reduced slightly (12%) as compared to the control (without irrigation). Further studies are necessary to evaluate the benefit of irrigation, if any, in mature phase. On the other hand, very promising results were obtained when young plants were irrigated . Girth increment could be significantly enhanced by drip irrigation indicating the possibility of reducing the immaturity period. Economic analysis is necessary before any recommendation is given.

Weed management

Studies on weed management systems yielded some useful results. It was demonstrated that Controlled Droplet Applications (CDA) could be profitably used to apply the herbicide 'glyphosphate'. The spray volume could be reduced to one twentieth the volume required under conventional methods. The potential of using the larvae of *Parechaetus pseudoinsulata* for the biological control of the weed *Cromolina oderata* was evident.

Intercrops

With the extension of area under rubber to higher altitudes and beyond the traditional latitudes, there are socio-economic compulsions for having intercrops. In this context new experiments have been initiated to assess the suitability of different intercrops such as coffee, pepper, cocao and cardamom among rubber under different spacings.

Diseases

Efforts to identify cheaper and more effective plant protection measures were continued. The Institute routinely tests new formulations of fungicides and oil samples before according approval for use by the farmers. Among different fungicides tested Dithane M-45 was found to be most effective against bark rot disease. The apprehension that weekly application of Dithane in panel may affect the PRI, Po values and Mn content of latex was found to be baseless. In another study it was observed that prophylactic treatment of fungicides against pink disease is not as effective as the conventional method of detection and treatment. In recent years the incidence of powdery mildew has been on the increase, causing concern. Of the many fungicides tested Calixin 1.5% was found to be superior in effect compared to conventional sulphur dust.

The results of studies to assess the yield loss due to abnormal leaf fall disease indicate that the loss ranges from 9% to 15.75%. Different experiments on the effect of *Oidium* on yield presented conflicting results. While in RRIM 600, the yield loss was found to be nil, in PB 86, in another location, the yield loss was as high as 17.34%.

Cover crop

The superiority of *Mucuna* over *Pueraria* has been further established in terms of microbiological studies. Competition, if any by *Mucuna* with young rubber plants is being assessed.

Pest control

Phorate 10G and Sevidol 4:4G were found to be very effective against white grubs attacking rubber. In slug control, Landrin and Zectran were found to be comparable with Temik in efficacy. Studies on rat control revealed that Brodifacoum at 0.005% was highly effective.

Agricultural Economics

The Economics Section of the Board was elevated to the status of a Division of Agricultural Economics under RRII. Presently the Division is collecting information on ancillary income from rubber plantations. A survey indicated that 85000m^3 of rubber wood is annually consumed in the sectors of plywood, veneers and splints. The annual production of rubber seed oil is estimated to be of the order of 4000 tonnes.

Another study initiated is on cost of production in small holdings with different input levels, farm gate price and economics of many of the recommendations on cultural practices.

Agro-meteorology

Considering the importance of agro-meteorology in efforts to extend rubber cultivation to non-traditional areas beyond the traditional latitudes and altitudes, a new section of agro-meteorology was established and a specialist is in position. Efforts are under way for agro-meteorological characterisation of new areas in North-East, Maharashtra and Orissa.

Studies on the relationship of meteorological factors controlling the onset of abnormal leaf fall disease reveal that an out-break invariably follows a five-day spell of rain with an overcast day. An epidemic can be expected within 9-15 days after the first overcast day. Wind rose diagrams prepared for Agartala indicate that south-east winds are predominant in the region.

Rubber Chemistry and Technology

Recognising the fact that India is still a net importer of NR, priority is fixed on product improvement with a view to prolonging the service life. Another task is to attempt chemical modification of NR to replace some of the imported synthetic rubbers. The fundamental profile of the investigations includes primary processing of rubber, chemical modification, reclamation and technology including engineering applications of rubber.

De-polymerised NR

An equipment has been designed for the preparation of de-polymerised rubber (DPR) and a few batches of DPR have already been prepared. However, the viscosity of the product was found to vary widely and further modification of the equipment to control the temperature conditions more precisely is being attempted. The possibility of using DPR as a vulcanisable plasticiser in Nitrile rubber composition is being explored.

Epoxidised NR

A method has been identified for epoxidisation of NR in the laboratory. Further studies are under way in formulating the conditions for making epoxidised rubber of various levels of expoxidisation.

Graft co-polymerisation of vinyl monomers on NR

Acrylonitrile graft NR was prepared using gamma radiation. It was seen that as the radiation dose is increased to 0.45 MR, the amount of graft rubber formed is also increased. As the acrylonitrile content is increased, oil and solvent resistance of NR is increased. However, other properties such as tensile strength, elongation at break, compression set resistance etc. were found to decrease with increasing content of acrylonitrile. Further improvement in the formulation is being attempted.

Reclamation

A process was developed to reclaim rubber from waste latex products. The physical properties of rubber compound containing this reclaimed rubber (WLR) were found to be better than those containing whole tyre reclaim (WTR). Service performance of the tyre retreads made from WLR was found to be better than that made with WTR.

Technology

The major areas of research in Technology are:

(a) development of chemical resistant NR compounds, (b) studies on compression set of NR vulcanizates, (c) NR/1,2 poly-butadiene blends, and (d) studies on ozone resistance of NR/EPDM blends. It was found that ageing of NR vulcanizates under distilled water

causes more deterioration than in acid or alkali solutions. Volume swell was also found to be more in samples immersed in distilled water. Blending of 1,2 poly-butadiene with NR was found to improve the ageing and ozone resistance of the latter. It was also observed that ozone resistance of NR could be improved remarkably by blending 20 to 30 parts of either ethylene/propoylene rubber or ethylene/propoylene/diene rubber.

North-East Research Complex

There are five Regional Research Stations in the North-East India, with a co-ordinating centre in Guwahati. The total area covered under various experiments in the Agartala centre is about 35 ha. In the other stations only multi-disciplinary evaluation of clones have been initiated. The most important information gathered from various experiments in these regions is that rubber can be successfully cultivated in various parts of North-East, though under the different situations of stresses additional agro-management inputs would become necessary. In Agartala, clones RRII 105, RRII 118 and PB 235 recorded better growth compared to other clones tested. In another clone trial RRIM 600 and RRII 300 also recorded good growth. Three clones which generally perform well under different stress situations in North-East, Mizoram, Meghalaya and Assam are RRIM 600, RRII 118 and PB 235. RRII 118 showed remarkable tolerance to stress situations in the high altitude region of Meghalaya. Physiological investigations to relate the clonal variation in performance to various physiological parameters are in progress. Clonal variations in stomata, leaf water potential, rate of transpiration, etc. were confirmed from these investigations. Another useful information emerged from these studies was the unusual closure of stomata in response to low temperature, which may be one of the reasons for low growth of plants during this period.

Regional Research Station, Dapchari

Data on clone evaluation trials indicated that even under drought situations RRIIM 600 grows well as compared to other clones tested. The plants have responded well to summer irrigation and efforts are under way to evaluate clonal variations in this regard. Different methods of irrigation are being tried to select a cheap and efficient system of irrigation during summer months. Other dry farming techiniques are also under evaluation.

Agronomy / Soils Division

The thrust areas of research in the Agronomy/Soils Division are investigations on nutritional requirements of different clones in different regions, studies on discriminatory fertiliser recommendations, agro-management practices including irrigation, intercropping and weed control. In order to strengthen the discriminatory fertilizer recommendation system,three Regional Laboratories were established with mobile soil and tissue testing vans attached to each.

1. NUTRITIONAL STUDIES (IMMATURE PHASE)

Nutritional requirements of different clones in different agro-climatic zones

This project aims at finding out the nutritional requirements of various high yielding clones of rubber during the immature phase in different agro-climatic regions of South India, with a view to reducing the immaturity period. Five field experiments are already in progress.

Out of the five experiments, two were laid out during the current year. Imposition of fertiliser treatments, collection of soil samples and recording of growth measurements were undertaken.

2. NUTRITIONAL STUDIES - (MATURE PHASE)

Differential response in yield to fertiliser application between areas which had either cover crop or natural cover was studied during the mature phase. The effect of leguminous cover on reducing the nitrogen demand during the first few years of tapping was established. The results obtained are given below:

(a) Rubber in association with legume cover

First year of tapping

Results indicate that the manured plots recorded significantly higher yield compared to the unmanured control plots. There was no advantage in increasing the dose of N from 20 kg to 40 kg/ha. There was response to application of P at 20 kg P_2O_5/ha. Increasing the dose of K_2O from 16 kg to 32 kg/ha significantly increased the yield.

Table - Ag. 1. *Effect of fertilisers on yield (first year of tapping)*

Levels of Nutrients	*Mean yield g tree^{-1} tapping^{-1}* S1		S2
N_1-20 kg N ha^{-1}	26.0		26.0
N_2-40 kg N ha^{-1}	26.3		26.6
P_0-No P_2O_5	25.5		25.7
P_1-20 kg P_2O_5 ha^{-1}	26.8		26.8
K_1-16 kg K_2O ha^{-1}	25.2		25.7
K_2-32 kg K_2O ha^{-1}	27.2		26.8
General mean		26.2	

C. D. for comparison between manured and unmanured : 1.68
C. D. for comparison between levels of P and K : 1.10

(S1 and S2 are two sequences of starting the manurial treatments during the immature phase).

Second year of tapping

The average effect of Mg application was significant and positive. But a closer examination of the data (Table-Ag. (2) indicates that there is response to Mg only in the absence of P. There was no difference between manured and unmanured plots.

Table - Ag. 2. *Effect of P and Mg on yield (second year of tapping)*

Treatments	*Mean yield g tree⁻¹ tapping⁻¹* No MgO	6kg MgO/ha	Mean
No P_2O_5	39.52	45.70	42.61
P_2O_5-20 kg ha⁻¹	44.77	43.93	44.35
Mean	42.15	44.82	43.48
S.E : 0.89			
C.D : 2.56			
For means in the body of the table	SE : 1.25		
	CD : 3.59		

Third year of tapping

Neither the average effect of manuring nor the simple effect of any of the nutrients was significant.

Fourth year of tapping

None of the main effects nor any of the interactions was significant.

Fifth year of tapping

The interaction NPMg was significant (Table - Ag. 3).

Table - Ag. 3. *Effect of NPMg on yield*

	Mean yield g tree⁻¹ tapping⁻¹ No MgO		6 kg MgO⁻¹ha		Mean
	No P_2O_5	20 kg P_2O_5 ha⁻¹	No P_2O_5	20kg P_2O_5 ha⁻¹	
20 kg N ha⁻¹	50.81	50.44	51.00	56.88	52.28
40 kg N ha⁻¹	47.18	53.19	50.73	49.24	50.09
Mean	49.00	51.81	50.86	53.06	51.18
For means in the body of the table	SE : 2.35				
	CD : 6.75				

The results reveal that when 40 kg N was applied in the presence of P and Mg, there was significant yield drop compared to the yield at 20 kg N level. Similarly, the higher level of N also depressed yield in the absence of P and Mg in comparison to the lower level of N in the presence of P and Mg.

(b) **Rubber in association with natural cover**

First year of tapping

The manured plots recorded significantly higher yield compared to the unmanured control (Table - Ag. 4). The effect of individual nutrients was not significant. The effect of N just missed the level of significance, but showed a positive trend.

Table - Ag. 4. *Effect of fertiliser application on yield*

Treatment	Mean yield g tree^{-1} tapping^{-1}	
Unmanured control	20.7	
Manured	25.5	CD : 3.5

Second year of tapping

The manured plots gave significantly higher yield compared to unmanured plots. Nitrogen application at 80 kg/ha was significantly superior to 40kg/ha in terms of yield (Table - Ag. 5).

Table - Ag. 5. *Effect of manuring in general and N application on yield* (g)

Unmanured control	Manured	Mean	40 kg N/ha	80 kg N/ha	Mean
33.07	37.62	37.12*	35.85	39.39	37.62
SE : 1.84				0.92	
CD : 3.96				2.64	

*Weighted Mean

Third year of tapping

Nitrogen application at 80 kg/ha significantly increased the yield over the 40 kg level (Table - Ag. 6).

Table - Ag.6. *Effect of N on yield*

Mean yield g tree^{-1} tapping^{-1}		
40 kg N ha^{-1}	80 kg N ha^{-1}	Mean
38.57	41.59	40.08
		S.E. 1.03
		C.D. 2.96

Fourth year of tapping

Nitrogen at 80 kg/ha was superior to 40 kg/ha level. It was also observed that Mg application increased yield (Table - Ag. 7).

Table - Ag.7. *Effect of N and Mg on yield*

Mean yield g tree^{-1} tapping^{-1}					
40 kg N ha^{-1}	80 kg N ha^{-1}	Mean	No MgO	6 kg MgO ha^{-1}	Mean
45.16	49.25	47.22	45.35	49.06	47.21
S E. :	0.99		0.99		
C.D. :	2.84		2.84		

Fifth year of tapping

The application of Mg significantly increase yield (Table - Ag.8).

Table - Ag. 8 *Effect of Mg on yield*

Mean yield g tree^{-1} tapping^{-1}		
No MgO	6 kg MgO ha^{-1}	Mean
49.89	56.87	52.88

S.E : 1.39
C.D : 3.99

Comparison of mean yield in legume and natural cover areas

During the first three years of tapping, the mean annual yield per hectare was higher in the legume cover area and a cumulative yield increase of 446 kg/ha was obtained in three years time. This trend was reversed in later years (Table - Ag. 9).

Table - Ag. 9. *Mean yield per annum in the two areas (kg ha^{-1}).*

Year	Legume cover	Natural cover	± in legume cover
1980	1175	1145	± 2.62
1981	1948	1685	± 15.60
1982	1949	1796	+ 8.52
1983	2010	2115	— 4.97
1984	2293	2369	— 3.21
Cumulative yield - 1980 to 1982	5072	4626	+ 9.64 (446 kg)

Based on the above results, the following conclusions could be drawn.

1. While making fertiliser recommendations, due consideration has to be given to the history of ground cover maintenance in the plantation.
2. When legume cover is not established, application of higher doses of N during the initial years of tapping is warranted to obtain a higher yield.
3. In legume maintained areas, there is scope for saving nitrogenous fertilisers during the initial years of tapping.

3. NUTRITIONAL REQUIREMENTS OF MODERN HIGH YIELDING CLONES (MATURE PHASE)

The object of this project is to find out the nutritional requirements of modern high yielding clones of rubber during the mature phase in different agroclimatic regions in South India with a view to achieveing higher yields by proper manuring. Nine field experiments are in progress, using three clones.

Of the nine experiments, three were initiated during the year under report. Imposition of the fertiliser treatments, collection of soil and leaf samples and recording of growth and yield of trees have been carried out.

4. EFFECT OF DENSITY OF PLANTING OF RUBBER ON GROWTH AND YIELD

This project aims at finding out the optimum desnsity of planting for early maturity and for higher yields at two levels of fertiliser application.

Imposition of fertiliser treatments and recording of growth measurements were undertaken. It is now too early to obtain any result from this experiment since plant competition which is expected in this study will set in only when the plants are at least four years old.

5. IRRIGATION AND SOIL MOISTURE MANAGEMENT

Drought is a major constraint that prolongs the immaturity period and reduces yield of rubber. The objective of this project is to find out how far this constraint can be countered by summer irrigation. Water is a scarce commodity in the rubber growing areas during summer and therefore water saving drip irrigation methods were used. Two field experiments and one observational field trial are in progress. One field experiment which was started in 1985 is on mature rubber and the second one was started on immature rubber during the current year. The observational trial also is on immature rubber.

Irrigation treatments were imposed during the summer season in all the three experiments. Recording of growth and yield data was also carried out. The preliminary results obtained during the first year from two of the trails are presented below.

Experiment on soil moisture management during mature phase

Irrigation treatments were imposed from December 1985 and monthly yield recording of sample trees was initiated from November 1985 (pre-treatment) onwards. The effect of irrigation on the latex yield was tabulated from the yield data during the period November 1985 to February 1986 (Table - Ag. 10).

Table - Ag. 10. *Effect of irrigation on yield*

Treatments	*Mean yield (g tree^{-1} tap^{-1})* Nov. 85 (pre-treatment)	Dec. 85 to Feb. 86 (Post-treatment)	%reduction in yield
No irrigation	36.67	19.22	47.58
5 l^{-1} tree^{-1} day	30 21	16.59	45.08
10 l^{-1} tree^{-1} day	30.80	19.88	35.45
15 l^{-1} tree^{-1} day	28.88	17.29	40.13
20 l^{-1} tree^{-1} day	31.73	19.08	40.31

The percentage yield reduction during summer months could be reduced to some extent by different levels of irrigation. The cumulative effect of irrigation over a number of years is to be studied.

Observational trial on irrigation during immature phase.

The irrigation treatments were commenced in February 1986 and continued till the onset of rainy season. The mean increase in diameter of plants, in one year, is as shown in Table Ag. 11.

Table - Ag. 11. *Mean diameter increment from* 5. 2. 1986 *to* 13.1.1987

Treatment	Mean diameter increment (mm)
Control (no irrigation)	12.65
Irrigated (10 l plant^{-1} day^{-1})	20.98

The effect of irrigation is encouraging.

6. WEED MANAGEMENT SYSTEMS

The objective of this project is to identify suitable herbicides, herbicide-combinations and applicatos for effective and economic weed control in rubber plantations right from seedling nursery to the mature stage. Methods include biological control also.

A total of 10 short-term field experiments were in progress. Four of them were completed during the early part of the year and the field work of the remaining five were completed towards the close of the period under report. One project on biological control is being continued.

Imposition of herbicide treatments and recording of observations were undertaken. The results obtained from the four experiments completed are summarised below.

1. Controlled Droplet Applicators (CDA) are economical and effective with the herbicide 'Glyphosphate'. The spray volume could be reduced to 15-30 *l* ha^{-1} from 600 *l* ha^{-1} for conventicnal sprayers.
2. For contact herbicides like 'Gramoxone', conventional high volume sprayers are better.
3. Useful microflora of soil is not adversely affected by application of ordinary herbicides on a short term basis.
4. A new herbicide 'Banvel' at 2 *l* ha^{-1} was observed to give good control of broad-leaved weeds.
5. A combination of 4 *l* ha^{-1} of Dowco 453 ME and 2 *l* ha^{-1} of Dowco 433 gave effective overall control of weeds.

Preliminary results of the investigation on the biological control of the weed *Cromolina oderata* using larvae of *Parechaetus pseudoinsulata* indicate success in rubber plantations. This study is being continued.

7. STUDIES ON INTERCROPPING IN RUBBER

This study was taken up to find out shade tolerant intercrops that can be grown during immature and mature phases of the rubber plantation both in the plains and at high elevations. Three field experiments are in progress under this project.

One experiment, where annual intercrops were grown during the immature phase, has now reached the fourth year of yielding. Recording of yield and growth measurements were carried out in the experimental area and are under statistical analysis.

The other two experiments were started during the period under report. The obective is to find out suitable shade tolerant perennial tree intercrops that can thrive throughout the life period of the rubber trees. One experiment is in the plains and intercrops such as coffee, cocoa and pepper will be grown with rubber. The other experiment which is located in high altitude has intercrops like coffee, cardamom and pepper. The planting materials of the intercrops were procured and raised in polybags for field planting in 1987 season.

8. FORMS OF FERTILISERS AND METHODS OF APPLICATION

The objectives of the experiments currently under this project are evaluation of different forms of fertilisers in the field, glass house and laboratory to find out their uptake, losses and mineralisation pattern. Six experiments of which two are field trials, three trials are in glass house with polybag plants and one a laboratory study are in progress.

The imposition of treatments, recording of observations, collection of soil and leaf samples and laboratory analyses were undertaken based on the requirement in each of the six experiments. Preliminary results are available from all the experiments.

(a) **Experiments on forms of phosphatic fertilisers**

The study on one year old budded rubber plants in glass house using different proportions of water soluble and water insoluble phosphatic fertilisers, indicated that the mean height, diameter and total dry weight of plants increase when higher proportions of water soluble phosphates were given.

The mean dry weight of the cover crop, *Pueraria phaseoloides*., grown in polybags for one year under different levels and forms of phosphate are given in Table - Ag. 12.

Table - Ag. 12. *Mean dry weight of cover crop*

Treatments	Mean dry weight (g)
Super phosphate @ 30 kg P_2O_5 ha^{-1}	37.37
Super phosphate @ 45 kg ,,	82.28
Mussorie rock phosphate @ 30 kg P_2O_5 ha^{-1}	27.14
Mussorie rock phosphate @ 45 kg ,,	27.16
Bowl sludge @ 30 kg P_2O_5 ha^{-1}	55.08
Bowl sludge @ 45 kg ,,	68.13
No phosphate (control)	16.02

It is seen that application of phosphate increased the dry weight of the cover crop. Both at 30 and 45 kg ha^{-1} levels, the soluble sources of P gave higher mean dry weights. Again, the soluble forms performed better at 45 kg level compared to 30 kg level.

(b) **Experiments on forms of nitrogenous fertilisers**

It is observed that the nitrogenous fertilisers–Urea, Ammonium Sulphate and Ammophos did not make appreciable differences in the mean height and diameter of seedlings in this nursery trial.

(c) **Experiment on mineralisation of nitrogen**

Soil and leaf samples collected from an existing NPK experiment on mature rubber, with clone RRIM 600, were utilised for this study. Plots receiving 0, 30 and 60 kg N ha^{-1} were selected. Samples taken at 7 days, 15 days, one month and two months after fertiliser application were analysed.

Soil nitrification began from the 7th day, reached maximum on the 15th day and slowly declined after 30 days. The ammoniacal N content sharply increased from the 7th day and declined after the 30th day.

The total N content of leaf increased from the 7th day onwards and declined slowly after the 40th day. Nitrate accumulation in leaf began from 15th day and reached maximum between 30 to 40 days.

(d) **Volatalization loss of Urea**

The gaseous loss of ammonia from 25 g of urea applied to 2 kg of surface soil kept in sealed containers and maintained at field capacity and at half field capacity was assessed after 72 and 144 hours. The loss taken place in terms of mg of N under the above conditions are given below.

Table - Ag. 13. *Loss of Nitrogen*

Period	Mositure content	Nitrogen loss (mg)
72 hours	Field capacity	28.0
144 hours	Field capacity	53.0
72 hours	Half field capacity	4.2
144 hours	Half field capacity	22.4

It is observed that volatalization loss of N from Urea is more rapid at field capacity than at half field capacity. Also the total volatalization loss increased with time.

Plate : 1 Mobile Soil and Tissue Testing Laboratory

9. PHYSICO-CHEMICAL AND MINERALOGICAL CHARACTERISTICS OF RUBBER GROWING SOILS

The objective of this experiment is to characterise the physical, chemical and mineralogical properties of rubber growing soils in different regions with a view to gaining possible clues for region wise fertiliser experiments aimed at offering region-wise fertiliser recommendations.

Three experiments were in progress which included pot culture and laboratory incubation studies and analytical work. The study included the assessment of manganese status of soil in a few regions and analysis of different fractions of soil P and K using different extractants.

Collection of soil samples, application of treatments in pot culture studies and analytical work were undertaken. The following results are available from the above studies.

1. The manganese status of soil in terms of exchangeable and total, varied among the regions Kanyakumari, Calicut, Kottayam and Dapchari. There was also considerable variation among samples within each region. The status was higher for Dapchari compared to the other three regions.

2. There was variation in the status of different fractions of K and total K from soils of Kanyakumari, Mundakayam, Trichur and Calicut regions.

10. POST RECOMMENDATION EVALUATION OF DISCRIMINATORY FERTILISER APPLICATION

The aim of the project is to evaluate the correctness of discriminatory fertiliser recommendation and the possible increase in yield and saving in cost of fertilisers as compared to fertiliser application based on general recommendations.

This study was being carried out in nine large private estates and later extended to six more estates. Two adjacent blocks in the same field were selected. In one block, discriminatory fertiliser application based on soil and leaf analysis was done and in the other, general fertiliser recommendation was followed. Yield data were collected from the estates and the costs of fertilisers applied were ascertained.

In two estates an yield increase of 20 to 25 kg ha^{-1} of dry rubber per annum and a saving of fertiliser cost ranging from Rs. 90/- to Rs. 170/- per ha per annum were noticed. The study is being pursued.

Biotechnology Division

There has been widespread interest among the rubber producing countries to develop a tissue culture system for propagation of the rubber tree. To meet the challenge, the tissue culture laboratory attached to the Plant Physiology Division of the Institute has been recently upgraded as a fullfledged research division. Additional personnel required urgently have been appointed and are in position. *In vitro* propagation system has been developed by utilising some of the commercially successful clones. Shoot tips were harvested from clonal populations and grown in tissue culture medium where the shoot and tap root development was completed within weeks' time. The rooted plants have successfully undergone the process of hardening and they have been transferred into polybags containing soil. (Plate 1) The plants look phenotically similar to their respective parent clone of origin.

Several tissue culture systems are being experimented upon with the ultimate goal of crop improvement. Biochiemical characterisation of the tissue culture derived plants and their respective original clones, somatic embryogenesis, organogenesis, meristem, shoot tip and the anther culture etc. are programmed.

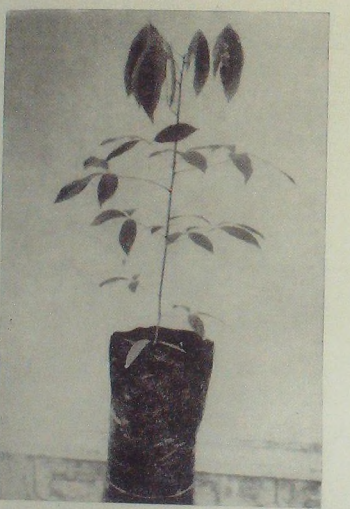

Plate 1: Polybag plant raised by shoot tip culture Technique.

Botany Division

The Botany Division concentrates on tree improvement, propagation techniques, cytogenetics, anatomy and germplasm collection and conservation. The major areas of research activities include breeding, ortet selection, mutation and polyploidy breeding, clone evaluation, cytogenetics, bark and wood anatomy, propagation techniques, horticultural manipulations, genetic studies, floral biology, introduction/collection and conservation of germplasm and identification of early selection parameters.

1. Hybridisation and Selection

The conventional method of hybridisation and selection is an accepted method of tree improvement in *Hevea brasiliensis*. This has brought about significant achievements in improving the quality of planting materials and thereby boosting the production potential.

During 1986 flowering season, a total number of 12899 hand pollinations were attempted, from which 4.14% fruit set was obtained. The resultant seedlings (1394 numbers) belonging to 56 cross combinations were established in a seedling nursery at RRII. A selection of progenies from these seedlings have been planted with suitable lay out for nursery observations on the familywise performance.

Regular yield recordings for the clone trials under tapping and annual girth recordings were continued. In 1956 HP trials, (in panel D) RRII 300 continued to be the highest yielder with an average yield of 151.91 g tree^{-1} tap^{-1} during the year.

Based on yield data, five second selections were made from the 1954 H. P. series. Table 1 gives the yield data of these selections.

Table Bot. 1 *Mean yield (g tree^{-1} tap^{-1}) of the second selections*

Code	5 years	10 years	15 years	20 years
HP 185	49.67	89.73	102.30	100.04
HP 187	48.22	71.89	85.71	91.06
HP 204	42.73	114.49	115.16	94.91
HP 223	48.90	84.26	94.20	96.35
HP 372	50.98	73.76	91.69	104.27

Seven second selections were also made from 1971 HP series based on yield and ten second selections from 1970 HP series were identified based on tolerance to abnormal leaf fall disease.

Statistical analysis on simple, partial and multiple correlations of nursery yield with related characters such as height, girth, number of latex vessel rows and bark thickness was carried out using data from clones resultant of 1982 HP series. The results show that nursery yield on test tapping was positively correlated with all other characters.

Table Bot. 2. *Simple correlations of nursery yield with related characters*

	X2	X3	X4	X5 (Bark thickness)
Yield (X1)	0.5179**	0.4880**	0.3577**	0.3835*
Height (X2)		0.8431**	–0.0345	0.2313
Girth (X3)			–0.0090	0.2922*
No. of latex vessel rows (X4)				0.3703**

*P ∠0.05 ** P ∠0.01

Studies on partial correlations revealed that among the characters studied, the number of latex vessel rows is the most important character influencing nursery yield. The characters studied could account for 43% of yield variability.

Table Bot. 3. *Partial correlations of nursery yield with related characters*

	X2	X3	X4	X5 (Bark thickness)
Yield (X1)	0.2773*	0.7580	0.3647**	0.1603
Girth (X2)		0.7747**	–0.1387	–0.0545
Height (X3)			–0.0634	0.1709
No. of latex vessel rows (X4)				0.2992*

*P ∠0.05 **P ∠0.01 Multiple correlation: 0.6566**

An attempt was made to improve the method of test tapping by taking into consideration girth and yield at different growth phases of the tree. The data on immature and mature yield and girth of 1970 H. P. seedlings were satistically analysed and the results are given in Table 4.

Table Bot. 4. *Correlations among girth and yield factors at immature and mature phases*

	Yield				*Girth*		
	Test tapping						
	I	II	III	Mean	At test tapping	At regular opening	Girth increment on tapping
Yield at first year of regular tapping	0.4313**	0.5287**	0.5343**	0.5456**	0.1869*	0.2248**	—
Mean yield over five years of regular tapping	0.2037*	0.2702**	0.3309**	0.2931**	0.0800	0.1832*	—
Mean yield of test tappings	—	—	—	—	0.4630**	—	—
Yield increment on tapping	—	—	—	—	—	—	0.7023**

**P ∠0.01 *P ∠0.05

Table Bot. 5. *Correlations among the girth characters*

	Girth at regular opening	Girth at fifth year of tapping
Girth at test tapping	0.7939**	0.6097**
Girth at regular opening	—	0.8683**

**P ∠0.01

These results reveal the influence of girth increment on tapping on yield and the relationship among the characters. The drop in the degree of relationship between the test tap yield and mature yield after a few years of tapping can be attributed to the high influence of girth increment on tapping on the yield increase on tapping.

2. **Ortet Selection**

Ortet selection is one of the earliest methods, still being continued, for tree improvement in *Hevea*. Large population of seedling genotypes are screened for desirable characteristics and the ones which are selected based on preliminary observations are subjected to rigorous observations and final selections made. These are multiplied and tested in the field in different phases. This approach has resulted in the development of the primary clones, some of which are popular even today.

Forty three ortet clones collected from various small holdings and the CES, Chethackal were vegetatively multiplied. The budded stumps were planted in polybags at the *Hevea* breeding sub-station, Nettana (Karnataka), for laying out small scale trial during 1987 planting season. The source bush budwood plants were properly maintained at the RRII nursery. Seven ortet clones maintained at the RRII nursery were test tapped and yield for five cycles of test tapping (10 test tappings each) were recorded and the data are summarised in Table 6.

Table Bot. 6. *Girth and yield of ortets, test tapped in the nursery*

Code	Girth at opening (cm)	Yield (g tree^{-1} tap^{-10})					
		Jan	April	June	Sept	Oct	Mean
C 70	16.00	7.88	9.52	24.50	27.83	44.17	22.78
C 140	17.33	7.69	12.45	27.27	47.26	61.67	31.27
T 1	16.71	7.64	12.07	8.43	23.57	31.43	16.63
T 2	16.50	7.82	13.98	18.75	20.00	28.75	17.86
P 0	15.22	3.64	3.30	9.17	9.00	17.22	8.47
C 150	14.60	3.19	5.38	12.20	15.40	28.00	12.83
$C\frac{1}{2}$	15.40	6.40	8.71	9.20	8.80	19.00	10.31

From a large estate an area of 176.09 ha comprising 44364 seedling genotypes were systematically screened and 211 potential mother trees were identified. The yield of these trees was recorded for one year (four different seasons). Seventy one high yielding mother trees were selected and branches were cut back for production of budwood. Forty six clones from these selections were budgrafted and attempts are under way to establish all the available plants in source budwood nursery for further multiplication and laying out field trials during 1988 planting season. Bark samples of all the selections were sectioned and studied for anatomical characters.

From another large estate, an area of 106.75 ha comprising 33222 seedling genotypes were screened and 213 potential mother trees were identified. Yield of these selections were recorded during five different seasons. Of the trees, 7.65 per cent were discarded due to brown bast and 1.88 per cent were lost due to wind damages.

Yield of a reported high yielding ortet from a small holding was recorded from January to December, along with other clones like RRII 105 and RRII 118. DRC samples were also collected.

3. **Special Techniques in Breeding**

The genetic base in *Hevea* being narrow, the object of the project is to broaden the genetic base by employing chemical and physical mutagenic agents, select desirable genotypes and evaluate their performance in field trials.

Girth measurements at the time of opening was recorded in the 1977 trial laid out with clones developed from irradiated materials. The data collected indicated that four of the clones show more vigour at opening compared to the control clone, RRII 105. A summary is given in Table 7.

Table Bot. 7. *Vigour at opening of clones raised from irradiated materials*

Code	Vigour at opening in cm.
6	57.65
7	64.33
15	60.00
19	59.97
21	57.67
32	62.67
42	59.94
43	64.11
45	58.23
RRII 105 (control)	57.64

Monthly yield recordings had been carried out in the 1976 and 1977 trials of irradiated population. Gap filling was carried out in the 1985 trial of selections from irradiated population. VM 4 plants resultant of Colchicine application are showing morphological variation. Tetraploidy was induced in five clones and these are showing true polyploid nature, the chromosome complement being $2n = 72$.

4. **Evaluation of Clones**

Tree improvement research in *Hevea brasiliensis* has led to the development of a number of modern clones, some of which are outstanding yielders and very popular. However, much more remains to be achieved and therefore the activities have to be continued every year. Improvement is attempted through breeding and selection, ortet selection and a large number of genotypes have been evolved. The new genetic materials have to be tested in the field and selections made based on the small scale trials. The materials thus selected have to be tested further. The project envisages to test the selections under large scale trials and in blockwise trials.

The various field trials of indigenous and introduced clones, including the block trials of modern clones were maintained well and the growth was recorded. Regular yield recordings of the trials under tapping were carried out.

Data on yield, girth and virgin bark thickness from a twelve clone trial in an estate were summarised and the results are given in Table 8.

Table Bot. 8. *Mean yield, girth and virgin bark thickness of twelve clones*

Clone	Mean yield over four years g tree^{-1} tap^{-1}	Girth at opening (cm)	Virgin bark thickness (mm)
RRII 5	57.46	63.80	9.84
RRII 104	46.75	54.90	10.94
RRII 116	52.14	62.30	9.66
RRIM 513	47.73	56.30	8.55
RRIM 519	46.02	56.79	10.10
RRIM 600	49.05	59.64	9.17
RRIM 628	58.33	54.21	8.85
PB 206	49.12	56.20	8.88
PB 213	42.28	52.89	9.44
PB 217	40.07	58.42	9.47
PB 5/76	38.90	59.02	9.43
Tjir 1 (control)	44.44	59.44	10.16
S.E	4.04	2.09	0.32
C.D	11.85	6.12	0.94

Among the clones tried RRIM 628 and RRII 5 recorded the highest yield.

Data on yield and girth of 1966 clone trial consisting of seven selections of RRII 100 series clones with Tjir 1 as control over ten years of tapping is given in Table 9.

Table Bot. 9. *Mean yield and girth of RRII clones in large scale trial over ten years*

Clone	Parentage	Yield g tree^{-1} tap^{-1}	Girth (cm)	Brown bast (%)
RRII 101	Tjir 1 × AVROS 255	16.85	68.67	11.11
RRII 102	Tjir 1 × Gl 1	24.89	65.69	3.45
RRII 105	Tjir 1 × Gl 1	66.71	74.54	8.57
RRII 106	Tjir 1 × Mil 3/2	20.92	74.98	8.82
RRII 109	Tjir 1 × Mil 3/2	39.93	92.98	8.57
RRII 110	Tjir 1 × Hil 28	37.95	90.80	5.26
RRII 111	Tjir 1 × Hil 28	39.53	100.91	5.41
Tjir 1 (control)	Primary clone	31.08	82.03	8.82

Out of the nine RRII 200 series clones (1973 trial) with PR 107 as control in a large scale trial, RRII 206, 208 and 203 were the top yielders (Table 10).

Table Bot. 10. *Mean annual yield of RRII 200 series selections*

Clone	Parentage	Mean yield at 5th year of tapping (g tree^{-1} tap^{-1})
RRII 201	Tjir 1 × PB 25	58.79
RRII 202	PB 86 × Mil 3/2	58.51
RRII 203	PB 86 × Mil 3/2	60.03
RRII 204	PB 86 × Mil 3/2	55.57
RRII 205	PB 86 × BD 10	41.90
RRII 206	Mil 3/2 × AVROS 255	63.56
RRII 207	Mil 3/2 × AVROS 255	47.33
RRII 208	Mil 3/2 × AVROS 255	61.08
RRII 209	Mil 3/2 × BD 10	50.06
PR 107 (control)	Primary clone	41.35

Among the ten clones in another large scale clone trial, RRIM 703, Harbel 1 and RRIM 701 were the highest yielders with an average annual yield of 52.18, 50.98 and 49.28, as respectively during the seventh year of tapping. The control GT 1 recorded an average annual yield of 40.38 above.

In the Sri Lanka clone trial seven clones recorded better yields than the control GT 1 during third year of tapping. (Table 11).

Table Bot. 11. *Average annual yield of RRIC clones*

Clones	Yield (g tree^{-1} tap^{-1})
RRIC 36	46.80
RRIC 102	46.75
Nab 17	46.45
RRIC 100	46.27
RRIC 104	42.65
RRIC 7	37.12
RRIC 45	36.31
GT 1 (control)	33.69

A large scale trial of indigenous clones planted in 1978 was opened for tapping in 1986 and regular yield recordings were carried out. A block trial of eight clones was taken up in an estate during 1986.

The vacancies in 1985 clone trial at Dapchari were filled with polybag plants. In 1986, three large scale trials of ten modern clones were taken up, one at Guwahati and the other two at Meghalaya. Of these, one trial at Meghalaya is intended for testing d/2 and d/3 systems of tapping.

Nucleus materials of selected experimental clones were supplied to two estates for multiplication and subsequent block planting.

5. **Estimation of Genetic Parameters in *Hevea***

Selection of appropriate parents for crossings constitutes one of the important problems in tree breeding. The long duration of breeding cycle in *Hevea* remains a hindrance to genetic studies and possible genetic advancement of the crop. In this context, it is of paramount importance to have an investigation into the genetic parameters for specific

characters of selected clones. With a view to studying the genetic parameters for characters of breeding value and to assess their possible use as parents in breeding programmes, work on this line was initiated during 1986.

Open pollinated progenies of three clones viz. GT 1, Tjir 1 and RRIM 600 were field planted during 1986 planting season. Open pollinated progenies of ten clones were raised in the nursery as family blocks for field planting during 1987 season. Genetic parameters such as heritability, variance components, genetic gain, genetic diversity, parent offspring regression, heterosis etc. are intended to be investigated.

6. **Introduction, Collection and Conservation of Germplasm**

Crop improvement programme should necessarily have a broad genetic base and this is more vital in perennial crops with long breeding cycles. Considering the importance of conserving the available germplasm, attempts have been taken to establish a germplasm nursery. Recognising the significance of broadening the genetic base, the International Rubber Research and Development Board (IRRDB) launched an expedition to the Amazon, the centre of origin of *Hevea*, and collected wild genotypes. The genotypes were multiplied and are now being distributed to member institutes.

Activities were continued for the introduction of wild Brazilian germplasm from the Malaysian source bush nursery. Six hundred genotypes were introduced and transferred to the North East. Genotypes already received in the previous two consignments have been maintained well. Gap filling has been done and the nurseries were maintained properly.

The clone museum at RRII was maintained properly. Gap filling was carried out using polybag plants belonging to 111 genotypes. Investigations on minor laticiferous plants are being initiated.

Indigenous and exotic genotypes, comprising of old popular clones, modern clones, ortets and experimental clones, collected and conserved so far, and maintained in the RRII gene banks are as follows.

Table Bot. 12. *Genotypes conserved*

Origin	Genotypes conserved
Malaysia	77
Indonesia	10
Sri Lanka	14
South America	5
Liberia	1
Thailand	3
China	3
India	103
Wild Brazilian collection	638

7. **Evaluation of Germplasm**

With a view to evaluating the characters of the genotypes which were available indigenously and already conserved, three germplasm gardens were established during 1977-81. These germplasm materials were under observations. Two hundred genotypes from the Brazilian collection were established in source bush nursery.

The first germplasm garden at the Central Experiment Station of the RRII was opened for tapping and regular recordings were carried out. Bark samples were collected for anatomical studies. Observations on wintering and flowering, wind-damage, pink disease etc.,

Fig. 1

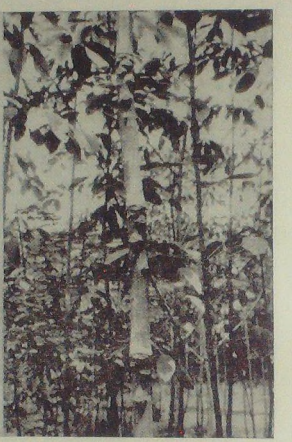

Fig. 2

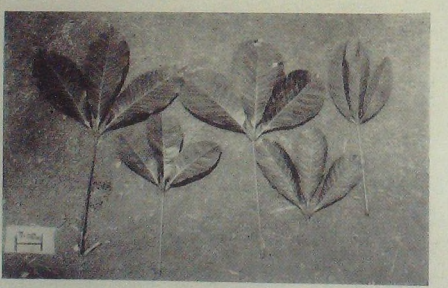

Fig. 3

Fig: Bot. 1. A genotype with wavy margined leaves; Fig: Bot. 2. very prominent leaf scars on certain genotypes; Fig: Bot. 3. variation in size and shape of leaflets in a genotype.

of the component clones in all the three replications were recorded. Annual girth measurements were done in all the gardens.

One series of test tapping was carried out on 100 genotypes arrived in the first consignment of Brazilian germplasm. These genotypes were screened for various morphological characters also (Fig. Bot. 1-3). Scion height, basal diameter, number of flushes etc. were also recorded. The stem portion at a height of 9 cm was prick tapped and the latex drops were collected and quantified after drying. The data is summarised in Table 13.

Table Bot. 13. *Growth parameters (mean) and dry weight of rubber of the 100 genotypes from Brazil*

Source	Scion height (cm) ±SD	Scion diameter at base (mm) ±SD	No. of flushes ±SD	Total No. of leaves ±SD	No.of leaves in 3rd flush ±SD	Length of third flush ±SD	Weight of latex (g)± SD
RO/J/05	134.11± 22.3	13.72± 2.7	3.80± 0.62	34.27± 6.40	11.69± 1.82	11.50± 3.78	0.021± 0.027
RO/JP/3	118.88± 23.62	12.18± 1.51	3.53± 0.51	27.70± 5.18	9.65± 1.77	10.29± 1.99	0.011± 0.008
MT/IT/14	121.74± 23.05	12.64± 2.35	4.14± 0.59	36.81± 8.7	10.81± 1.36	11.74± 2.44	0.022± 0.014
Gen. mean	125.71± 23.54	12.95± 2.63	3.92± 0.68	34.35± 8.07	10.94± 1.75	11.42± 2.96	0.017± 0.009
Control	89.88± 16.92	10.20± 1.30	3.60± 0.55	25.44± 5.37	10.20± 1.92	10.40± 2.79	0.038± 0.022

The genotypes exhibited wide variability with respect to all the characters studied. The average dry weight of rubber in the latex was 0.017 g in comparison to 0.038 g in the control.

The genotypes in general seem to be more vigorous than the control. Visual observations for certain common diseases indicated that the clone MT/IT/14/30/108 is susceptible to shoot rot caused by *Phytophthora* spp. and MT/IT/14/30/1, 30/6, 30/12 etc. are susceptible to *Gloeosporium* spp.

8. **Cytogenetical Investigations**

Cytogenetical studies are necessary for thorough understanding of the genetic system of the species and are expected to throw light on the segregation of heritable variations and the behaviour of chromosomes in somatic and meiotic cell divisions. Investigations on the meiotic system of polyploids, identification of male sterile clones and possibility of evolving a semidwarf clone have been taken up.

A natural triploid was identified and is the first report in *H. brasiliensis*. Meiotic studies have confirmed that this is a true triploid with a chromosome compliment of 2n = 54.

Detailed studies on the meiotic behaviour of induced tetraploid of RRII 105 were carried out. The meiotic data from 50 pollen mother cells were recorded in comparison with those of diploid RRII 105. Meiosis in the diploid *Hevea* was normal with the formation of 18 bivalents at metaphase 1. However, the stickiness of chromosome is a common feature. Details of chromosome associations at metaphase I in the induced polyploid are given in Table 14.

Table Bot. 14. *Chromosome associations in induced polyploid*

Associations	Total No. of cells analysed	Range	Mean
Univalents	50	1–9	5.9 ± 0.38
Bivalents	50	21–32	26.5 ± 0.46
Trivalents	50	0–4	1.7 ± 0.21
Quadrivalents	50	0–4	2.0 ± 0.18

The induced polyploid showed the formation of a large number of bivalents and a few univalents and multivalents.

Studies on the progenies of a natural mutant have shown four segregating types. The growth attributes of these progenies were studied and the intermediate type showed more vigour. For the dwarf, the number of leaves were more, where as the petiole length and interwhorl length were less compared to those of other types and the control.

9. **Floral Biology and Fruitset in** *Hevea brasiliensis*

Fruitset in *Hevea brasiliensis* is low, both in the case of hand pollination and under natural conditions. Two experiments were intitiated with the objective of improving the fruitset, one in the case of hand pollination and the other under natural conditions following open pollination.

The first experiment was taken up to try different treatments for improving the fruitset following artificial hybridisation. About 200 hand pollinations were carried under each of the treatments. Fruit counts were recorded 2 weeks, 4 weeks, 8 weeks and 12 weeks after pollination. Timely plant protection operations were carried out. Hand pollinated flowers were collected at different intervals following pollination and observed for pollen tube growth using a fluorescence microscope.

Statistical analysis of the data on fruitset have shown significant differences among the treatments for initial fruitset. Among the treatments tried, the following were found to be superior to the rest with respect to initial fruitset.

Treatment :	*Initial fruitset*
1. GA 3 sprays after pollination	57.01%
2. Nutrient medium application on the stigma prior to pollination	56.69%
3. Covering the inflorescences with a butter paper cover after pollination instead of plugging individual flowers to avoid mechanical injury.	37.99%
4. Control-Conventional method	16.14%

The second experiment was taken up with a view to finding means of combating the low fruitset under open pollination. An RBD was employed for imposing nine treatments comprising of nutrients and growth regulators on selected trees. Three rounds of treatment sprays were given at fortnightly intervals following refoliation. Observations on fruitset were recorded from selected branches, the mean values of which are given in the following table.

Table Bot. 15. *Fruit counts at three intervals after cessation of flowering (mean no. of fruits/ branches).*

Sl. No.	Treatment	1 month	2 months	4 months
1.	No spray	45.33	30.33	28.33
2.	Water spray	57.33	48.00	42.00
3.	Borax	63.67	58.00	58.33
4.	GA 3	73.33	71.67	78.00
5.	Urea	49.00	42.33	44.33
6.	Orthophosphoric acid	76.00	63.67	62.33
7.	Urea + Orthophosphoric acid	68.33	64.00	50.67
8.	Urea + GA 3	78.33	70.33	65.33
9.	Urea + Borax	56.33	44.00	41.67

Statistical analysis yielded no significant effects due to treatments with respect to fruitset and fruit retention. An assessment of the incidence of powdery mildew was made for the trees subjected to different treatments and no significant differences among treatments were found.

10. **Anatomical (General) Investigations**

Detailed studies on the anatomical factors of the species, excluding bark anatomy and wood anatomy, are programmed in this project, with a view to ascertaining interclonal variability of general structure, tissue orientation, stomatal features, cambial activity and the occurrence of intraxylary phloem.

The periodicity of cambial activity and latex vessel formation varied from season to season and a positive correlation between cambial activity and latex vessel formation was observed in one clone studied. The yield also showed a positive relationship with the number of latex vessel rows and the number of cambial layers except during the drought period. Based on these observations studies are being extended to eight clones and samples were collected for processing. Observations are being recorded.

The occurrence of intraxylary phloem was observed. Observations on one year old twigs, collected from eight clones, indicated a positive relation between the number of protoxylem groups, number of intraxylary pholem groups and the rate of girth increment on tapping.

Clonal differences were observed with regard to stomatal features and organographic variation was also noted. Differences were noted in the frequency and aperture size of petiolar stomata between clones tolerant and susceptible to abnormal leaf fall disease. Further studies revealed that leaf retention percentage had negative correlation with stomatal frequency (P 0.01), length of stomatal aperture (P 0.05) and the aperture index (P 0.01).

Leaf and twig samples were collected from ten clones for detailed study. The samples are under preparation and observation. Samples were also collected for detailed structural studies of buds and the materials are being processed for microscopical observations.

11. **Bark Anatomical Investigations**

The project was taken up with a view to making detailed studies on the quantity distribution and orientation of laticifers, size and distribution of phloic rays, interrelationship among structural features and also the influence of structural variabilities on yield and secondary characteristics.

Detailed studies have been made on the structure of the bark of ten clones and the clonal variabilities with regard to the density and size of ray groups, density of laticifers per row per unit circumference of the tree, diameter of laticifers and the extent of anastomoses between laticifers. Clonal variability was highly significant with regard to the density of ray groups, ray height, ray width in the laticiferous layer and laticifer characters. Laticifer area index had a positive relationship and the density and width of phloici rays a negative relationship with yield. It was indicated that the laticifer area index and the orientation of laticifers influence yield of different clones.

Bark samples were collected from eight year old trees belonging to ten clones and were studied. Observations were taken on the total number of functional laticifers. Clonal differences were noted in the mean number of laticifers and a summary is given in table 16.

Table Bot. 16: *Number of laticifers in virgin bark*

Sl. No.	Clone	Mean no. of laticifer rows
1	RRIC 7	12.06
2	RRIC 36	14.35
3	RRIC 45	9.09
4	RRIC 52	6.45
5	RRIC 100	11.42
6	RRIC 102	12.02
7	RRIC 104	11.35
8	RRIC 105	7.48
9	Nab 17	13.98
10	GT 1	10.56

Secondary characteristics of these clones as well as yield were recorded and further work is in progress.

Samples of virgin bark and renewed bark collected from ten clones, of different origin, were observed and the results are being collected.

Samples of bark collected from 1966 trial, belonging to eight clones are under observation. Samples of bark were collected from clones laid out in three trials for detailed studies on bark structure.

12. **Wood Anatomy of** *Hevea*

Increase in the demand of timber and shortage of wood necessitates exploration of available sources. Rubber wood is a light hardwood and can be used for various purposes after appropriate treatments. Although much work has been done on the treatment aspects, information on the basic structure of rubber wood is meagre. Studies have therefore been taken up on rubber wood, which is available in the country in substantial quantity.

Wood samples were collected from 36 year old trees of one clone and wood discs were prepared at 60, 210 and 360 cm heights from the ground level. Tension wood zones were traced and the area occupied was calculated using ACD.

Cubic blocks of wood of each wood disc were prepared and were fixed in FAA for further studies. Diamensional studies of wood fibres were made using macerated and stained preparations.

The wood discs showed prominent growth eccentricity. Freshly sawn and unpolished discs showed a broad lustrous and wooly tension wood zone in contrast to the remaining dull normal wood zone. Tension wood was mostly compact (Fig-Bot: 4) but diffused gelatinous fibres were also seen. The tension wood (tension arcs) were mostly concentrated towards the central zone surrounding the pith. Table 17 illustrates the comparative analysis of the area occupied by tension wood and normal wood.

Table Bot. 17: *Area occupied by tension wood and normal wood (cm²) and their percentage*

Sampling height (cm)	Surface area of wood disc	Area of pith	Area occupied by tension wood (TW)	% of TW	Area occupied by normal wood (NW)	% of NW
360	706.86	0.95	251.97	35.64	454.89	64.36
210	774.43	0.46	227.46	29.37	546.97	70.63
60	1182.07	0.45	99.87	8.45	1082.20	91.55

The proportion of tension wood was more with increase in height from the base.

The dimensional characters of the wood fibres of the normal wood zone and of the tension wood zone were studied from adequate number of fibres after macerating the wood and staining the fibres. The data are being summarised. It was found that the fibres of normal wood were longer and narrower than those of the tension wood.

13. **Propagation Techniques**

Studies on different aspects of propagation methods have been taken up to perfect them under the climatic conditions prevailing in nontraditional tracts. Attempts are also being made to improve upon the methods popularly used at present as well as to develop novel methods of propagation and planting.

A budding experiment was taken up in 1985 at the Regional Research Station, Tripura, to ascertain the optimum season for carrying out budgrafting. Data collected on budding success and meteorological factors were summarised. Green budding gave more success (above 80%) during the period January to July. In the case of brown budding, success was better (above 70%) during April, May and September. The trial was repeated during the year under report. But unfortunately it had to be abandoned due to the severe damage caused to the stock seedlings and budwood plants due to a heavy hailstorm in April.

A trial was laid out and planted in an estate for assessing the effect of height of budding and depth of planting on plant establishment and growth. One month after planting sprouting of buds was noted, a summary of which is given in Table 18.

Table Bot. 18: *Sprouting of buds*

Sl. No.	Treatment	Sprouts (%)
1	Normal budding; 60 cm taproot	81
2	Budding 15 cm above collar	32
3	Budding 30 cm above collar	49
4	Budding 45 cm above collar	52
5	Normal budding; 45 cm taproot	91

Six months after planting, height of the scion of all the plants were recorded and the data is being summarised.

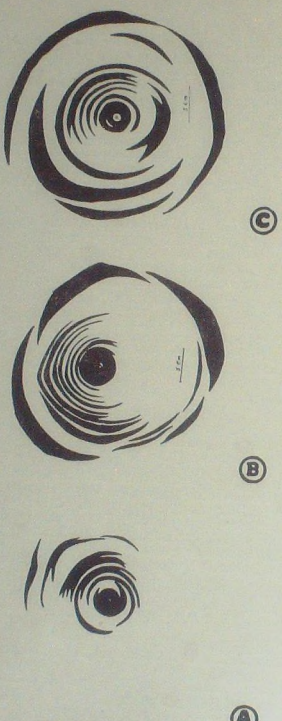

Fig: Bot. 4. Wood Discs Showing tension wood (shaded) and normal wood (unshaded) zones.
A–Disc at 60 cm. height
B–Disc at 210 cm. height
C–Disc at 360 cm. height

A preliminary trial was conducted with a view to developing a proper methodology for benchrgrafting in rubber. Five clones were taken for the study and the budding success is given in table 19.

Table Bot. 19: *Budding success*

Sl. No.		Percentage success	
		Bench grafting	Nursery grafting
1.	RRII 105	71	94
2.	RRII 118	85	97
3.	RRII 203	97	100
4.	RRII 208	97	100
5.	GT1	97	100
	Mean	89	98

The plants are being maintained in bags for further observations.

14. Genetic Basis of Stock Scion Relationship

Utilisation of the appropriate stock for budgrafting is important for maintaining the full potentialities of clones and it had been observed that the root stock influence the performance of the scion.

A field trial was laid out with fourteen treatments in 1984 to assess the genetic basis of stock scion relationship. The trial was maintained well and cultural operations are being carried out timely. Preliminary observations were taken on growth parameters.

15. Horticultural Manipulations

Horticultural manipulations in *Hevea* involves primarily crown modification with a view to establishing a tolerant crown on a high yielding trunk so that costly plant protection operations can be eliminated and high yield assured. It can also aid modification of the root system with a view to establishing good anchorage and enhancing girth rate. Induction of branching and development of a balanced branch system can also be attained through appropriate techniques.

Budded stumps of RRII 105 were raised in polybags of size 75cm × 35 cm, 500G. for future crown budding. The plants are being maintained by proper cultural operations. Budding will be carried out when the plants attain the required height. It is proposed to develop a suitable method for producing crown budded three part plants in polybags for subsequent establishment in the field. The present method of crown budding field plants is expensive and cumbersome and does not give fully satisfactory results.

16. Studies on Early Evaluation in *Hevea*

Development of a modern planting material in *Hevea* for commercial use requires over thirty years as there are no reliable juvenile parameters which will indicate the performance of the clones in the mature phase. Rubber cultivation in the country is being extended to non-traditional areas where the problems and climatic conditions are different compared to those in the conventional belt. As it is necessary to develop appropriate planting materials as quickly as possible, it is important to identify juvenile parameters to avoid the delay involved in developing planting materials under the conventional methods.

Two field experiments, one on early evaluation for yield and the other on early evaluation for drought, laid out during 1985, were properly maintained and the gaps filled using one year old polybag plants. For studies on early evaluation on yield, 13 clones were planted with 35 replications on single tree single plot basis at an espacement of 2 x 2 m. Similarly for studies on early evaluation for drought ten clones were planted on a completely randomised, single tree single plot design as above with 40 replications. A set of growth parameters were recorded twice (at six months and one year age). Work has already been initiated to identify various morphological, physiological and biochemical parameters for early prediction of yield as well as tolerance to drought.

Mycology/Plant Pathology Division

Pathology Division consists of Plant Pathology, Mycology, Entomology, Microbiology and Meteorology Sections. The main activity of the Division is crop protection. The Microbiology Section is engaged in the work of improving soil fertility through microbes and also pollution control with microbes. Regional meteorological stations in traditional and non-traditional rubber growing belts are being established. The relation between various meteorological factors on growth and yield of rubber and also on disease incidences are being studied.

1. **Control of Abnormal Leaf Fall Disease of Rubber in India**

Abnormal leaf fall disease caused by *Phytophthora* spp is the most important leaf disease of rubber causing significant yield loss. The damage to the health of plants due to shoot rot and die back is also considerable. Various studies are being carried out to combat this disease economically.

(a) Comparison of the methodology of leaf retention in copper fungicide sprayed plots.

Comparison of two methods of leaf retention for the evaluation of spraying in rubber plantations was carried out during 1984 and 1985 seasons. The results are given in tables 1 and 2.

Table Path 1: *Percentage leaf retention* - 1984

Treatment	Conventional method	Basket method
T_0 (No spraying)	44.33	85.66
T_1 (COC 56% @ 8kg/ha)	80.00	82.33
T_2 (COC 56% @ 16 kg/ha)	90.00	77.33
T_3 (OBC 40% @ 6.2 l/ha)	82.33	75.33

Table Path 2: *Percentage leaf retention* - 1985

Treatment	Conventional method	Basket method
T_0 (No spraying)	8.66	27.72
T_1 (COC 56% @ 8kg/ha)	62.33	26.50
T_2 (COC 56% @ 16kg/ha)	87.66	43.71
T_3 (OBC 40% @ 6.2 l/ha)	63.00	45.46

The results clearly indicate that the conventional method (leaf counting and tagging the twig) is the reliable method for evaluation of spraying.

(b) **Defoliation experiment**

Cacodylic acid in 1:10 with water, gramaxone 0.2% dilution with water and diesel oil were sprayed on the twigs of budwood nursery plants. A defoliation of 95-100% was obtained in the case of cacodylic acid sprayed plants. The sprayed twigs remained leaf less for more than four months. The other two materials were not effective for defoliation.

(c) **Testing of new fungicides and spray oils**

Two new copper oxychloride formulations (40% oil based copper paste) manufactured by M/s Karnataka Chemical Indistrial Corporation (KCIC 40% OBC paste) and M/s Solar Syndicate Gujarat (SOLOCOP 40% OBC paste) were subjected to large scale field applications by aerial spraying after completing all preliminary screening tests. The percentage leaf retention is given in table below.

Table Path - 3: *Percentage leaf retention*

Sl. No.	Name of estates	KCIC 40%	SOLOCOP 40%	Chlorocop (control) 56%
1.	Koothatukulam	50.98	78.13	90.87
2.	Malankara	57.80	51.46	46.05
3.	Manikal	64.01	72.78	49.58
	Average	57.59	67.45	62.16

One new spray oil sample supplied by Indian Petrochemical Limited, Bangalore (IPCL-oil) was subjected to large scale field applications by aerial spraying. The result is given below as percentage leaf retention.

Table Path - 4: *Percentage leaf retention*

Sl.No.	Name of Estates	IPCL oil	IOC oil (Control)
1.	Koothattukulam	65.15	90.87
2.	Malankara	84.08	46.05
3.	Manikal	73.04	49.58
	Average	74.09	62.16

The RRII has given approval for these two copper oxychloride 40% paste formulations and IPCL Oil for use in rubber plantations.

2. **Studies on High Volume Spraying**

High volume spraying is done in nearly 65,000 ha, mostly small holding. The cost of spraying is almost double that of low volume spraying. Hence, methods of reducing cost have to be found out. The efficacy of high volume spraying compared to low volume has to be evaluated.

In a study on the spray fluid requirement in high volume spraying of rubber 3000 l of 1% Bordeaux mixture was found to give satisfactory leaf retention, provided the spraying is done as prescribed by RRII.

The new experiment, which was started in 1985 season, was continued for the second year. The mean leaf retention in different treatments is given below.

Treatment	*% leaf retention*
T_1 – Bordeaux mixture 1%	82.65
T_2 – Bordeaux mixture 0.5%	66.79
T_3 – Copper Oxychloride (COC) 40% paste with micron sprayer	66.06
T_4 – COC 56% powder	75.71
T_5 – COC 56% powder-aerial spraying	78.45
T_6 – Control - Unprotected	53.48

1% Bordeaux mixture and 56% COC by micron and aerial spraying gave satisfactory leaf retention. The leaf fall in 1986 was not severe due to failure of monsoon.

3. **Evaluation of Panel Protectants and wound Dressing Compounds**

Bark rot disease is not very serious in India. But when untreated it can cause serious damage to the bark in some areas. Moreover, the recommended organomercurial fungicide is likely to be banned in India due to health hazard reasons. Hence, an effective and economical substitute fungicide has to be found out.

(a) **Bark rot disease control experiment**

The experiment was conducted at Lahai Estate. 36 Blocks containing 175 trees each were selected in 1960 GG 1, GG 2 area for this experiment with 6 treatments with 6 replicates. Fungicide application was made on the same day of tapping on the lower cut at an interval of 7 days from June-August, 1986. At the end of the disease season the results were assessed by computing the average disease incidence in each treatment.

Table Path-5: *Average disease incidence*

Sl. No.	Treatment	Dose	No. of trees treated	No. of trees observed	Average disease incidence
1.	Oxadixyl 2 PA	Ready to use formulation	1050	210	11.50
2.	Oxadixyl 4 PA	,,	,,	,,	11.33
3.	Dithane M-45	0.75% (10g/l)	,,	,,	9.66
4.	Emisan	0.015% (2.5g/l)	,,	,,	18.66
5.	Emisan	0.03% (5g/l)	,,	,,	14.00
6.	Control	Untreated	,,	,,	21.16

It was observed that significantly highest disease control was obtained in Dithane M-45 treated blocks.

In order to ascertain whether the application of 0.75% Dithane M-45 on the tapping pannels at weekly intervals will affect the quality of latex by Mn contamination, weekly application of 0.75% Dithane M-45 was made on the pannels of some trees for 10 weeks and latex samples were analysed from these trees and from untreated control trees and observed that continuous application of this funngicide will not affect the P_0, PRI and Mn content of latex.

b) **Evaluation of wound dressing compounds**

ATLASOL - A petrolium jelly was recommended for use in rubber plantations. Two samples of Mahathotex wax were found phytotoxic after screening tests. One Sopkot sample was found non-phytotoxic after tests.

4. **Crown Budding of Susceptible High Yielding Clones with Disease Resistant/Tolerant Clones**

Crown budding is a novel technique to resist the attack of a disease occurring on leaf and twigs with a resistant crown. Eventhough some difficulties are to be encountered, this technique has to be exploited for control of major diseases.

Carried out over budding with resistant clones at Central Nursery, Karikkattor and Regional Nursery, Neriyamangalam for establishing a budwood nursery of RRII 33, F 4542 and FX 516 for new crown budding experiments. Established a budwood nursery of above clones at Malankara Estate for proposed crown budding experiments.

Carried out yield recording at three locations once in a month for seven months by cup coagulation method

Table Path - 6: *Yield in crown budded trials*

Crown clones	Dry rubber in g/tree/tap during 1986		
	Kaliar estate Panel clone RRIM 628	Shaliakary estate Panel clone RRIM 600	Kinalur estate Panel clone GT1
F 4545	40	46	16
FX 516	58	46	36
RRII 33	56	49	30
CONTROL	35	41	40

Leaf retention assessment of trial areas, against abnormal leaf fall disease was also carried out (Table 7)

Table Path 7: *Leaf retention in crown budded trials*

Crown clones	% of leaf retention during 1986		
	Kaliar estate Pannel clone RRIM 628	Shaliacary estate Panel clone RRIM 600	Kinalur estate Panel clone GT 1
F 4542	75	87	71
FX 516	83	100	86
RRII 33	95	91	95
CONTROL	65	70	80

In the preliminary crown budding trial, it was observed that yield increased in RRIM 600 and RRIM 628 crown budded plants and decreased in GT 1. But leaf retention against abnormal leaf fall was higher in crown budded plants than sprayed control plants.

5. **Chemical Fruit Thinning in Hevea**

Chemical fruit thinning is a new approach for reducing the intensity of infection due abnormal leaf fall disease, as pods are the single biggest source of inoculum.

A fruit thinning experiment was commenced at CES, Chethackal on RRIM 600. The treatments included:

1. Naphthalene acetic acid (NAA) 20 ppm
2. NAA 50 ppm
3. 2. chloroethyl phosphonic acid (ethephon) 100 ppm
4. Ethephon 300 ppm
5. Ethephon 600 ppm, and
6. Water spray (control)

There was only single spray for each treatment. Each dosage was sprayed either of the two stages i.e., one at full bloom stage and the next at 3 weeks after full bloom. Flower/ fruit count was carried out for assessing fruit thinning just before spraying and after. Adequate plant protection measures were taken to protect the leaves as well as flowers from Powdery mildew disease. The severity of powdery mildew was also assessed periodically. Weekly yield recording by cup coagulation was carried out to study the effect of this chemical on yield.

The average pod set was assessed from the experimental trees and is given below:

Chemical	*Pod Set (Mean %)*
1. At full bloom stage:	
NAA 20 ppm	2.56
NAA 50 ppm	3.74
Ethephon 100 ppm	1.84
Ethephon 300 ppm	3.56
Ethephon 600 ppm	2.04
Control—Water spray	4.72
2. At pod stage	
NAA 20 ppm	67.14
NAA 50 ppm	68.21
Ethephon 100 ppm	66.36
Ethephon 300 ppm	71.89
Ethephon 600 ppm	58.37
Control—Water spray	80.12

No significant trend could be noticed on yield.

6. **Pink Disease and its Control**

Pink disease is the most important stem disease of rubber during its growth period from third to twelfth year. It could be serious when the disease occurs at the for king region or trunk. The disease is widespread in high rainfall areas and in certain clones like RRII 105.

In the field experiment to evaluate the fungicides for the control of pink disease, propiconazole at a concentration of 1000 ppm incorporated in Pidivyl China Clay compound and applied after light scrapping of the bark, in the affected region was observed to be superior to other treatments. Thiride at a concentration of 7500 ppm also gave good performance. The results are presented below:

Table Path-8: *Treatment of pink disease with new fungicides*

Sl. No.	Treatments	No of trees treated	No of trees recorded	% recovery
1.	Propiconazole 1000 ppm	30	29	96.66
2.	Thiride 7500 ppm	30	28	93.33
3.	Thridemorph 10,000 ppm	30	27	90.00
4.	Bordeaux paste (Control)	30	27	90.00

An experiment was laid out for the comparison of prophylactic treatment against pink disease with the currently recommended practice of detection and treatment. The experiment was laid out in clone RRII 118 planted during 1985 at TR & T (Manickal) Estate Mundakayam. Prophylactic treated trees received bordeaux paste application both at the first forking region and at the top most point of brown bark. In the other plot diseased trees were detected and treated at an interval of 15 days to 1 month during disease season.

Observations recorded till December indicate that 16 trees were affected in the prophylactic treatment plot, out of the 151 trees. In the other plot 24 trees were detected as disease affected, out of the 146 trees and were treated. The results clearly indicate that the prophylactic treatment cannot ensure complete protection of the trees from pink disease.

In an observational trial on phytotoxicity of vegetable oils applied on the budwood trees, none of the oils were found to be toxic.

In the laboratory bioassay for screening an ayurvedic oil for the control of pink disease, growth of the fungus was noticed.

The results obtained in a clonal screening trial for susceptibility/tolerance/resistance to pink disease are presented below.

Table Path - 9: *Average mycelial growth (cms) of C. salmonicolour subsequent to artificial inoculation*

Clone	15 days	33 days	50 days
GT 1	2.55	5.14	12.58
RRIM 600	0.65	0.93	3.29
RRII 105	2.05	4.83	12.30
RRII 108	1.66	3.00	9.14
RRII 208	1.75	1.88	7.75
RRII 300	1.60	1.89	5.50
PB 5/51	0.95	1.06	10.10
PB 86	0.30	1.40	9.88

Note: The values are from eight replicates except in RRII 208 in which the number of replicates is four.

The results indicate that RRIM 600 was most tolerant andGT 1 most susceptible under artificial inoculation.

7. **Powdery Mildew Disease and its Control**

This disease caused by *Oidium hevea* is the second most important leaf disease of rubber. In recent years, it is occuring in severe form in areas where it was not at all a problem. Appreciable crop loss also was noticed in one experiment.

In order to find out a substitute to sulphur dust for the control of powdery mildew disease 1.5% Calixin was dusted in one haplot in the RRII Experiment station. Three rounds of dusting at an interval of 15 days were carried out. Sulphur dusted control was maintained. The result as percentage disease incidence, is given below.

Table Path - 10: *Percentage disease incidence*

Sl. No.	Treatment	% disease incidence
1.	Calixin 1.5% dust	40.83
2.	Sulphur dust	61.33

Calixin 1.5% dust was found superior to sulphur dust.

An experiment was laid out in Tropical Plantations Mundakayam to control powdery mildew disease infecting young plants of 1-3 years of age. For this, two year old RRII 105 plants were selected. Six treatments were given with four replicates each. The fungicide

were dispersed in water and sprayed using a mist blower sprayer. Four rounds of sprayings was given at an interval of 15 days each. The results were assessed by leaf grading method and percentage disease incidence was assessed (Table 11).

Table Path - 11: *Average disease incidence*

Sl. No.	Treatment	Fungicide Concentration		Average percentage disease incidence
1.	T0	No treatment		67.94
2.	T1	Calixin 80 EC	0.4%	52.50
3.	T2	Calixin 80 EC	0.2%	53.50
4.	T3	Bavistin 50 WP	0.2%	43.13
5.	T4	Topsin 70 WP	0.14%	49.13
6.	T5	Wettable sulphur (Sulfex FOWP)	0.72%	54.44

It was observed that Bavistin 0.2% a. i. is significantly superior to all other treatments, followed by Topsin 0.14% a. i. All other chemicals used are at par.

8. **Dry Rot Disease and its Control**

Dry rot disease caused by *Ustulina deusta* is next in importance to pink disease among the stem diseases of rubber. The incidence of this disease is on the increase in recent years. It is more difficult to control this disease than pink, because by the time it is detected the penetration of pathogen is deep. Copper fungicides are ineffective and hence control measures are costly.

Monthly observation was carried out on the disease severity in the experimental trees at Malankara Estate. This experiment was started in November 1985 and the treatments included the following:-

A – Emisan 0.015% + wound dressing compound
B – Bordeaux paste (10%) only
C – Calixin 80 EC (1%) + wound dressing compound
D – Thiride 75 WP (0.75%) + wound dressing compound
E – Plantvax 20 EC (0.5%) + wound dressing compound
F – Wound dressing compound only.

The data collected are being analysed.

A new field experiment for disease control was started at Malankara Estate in the RRIM 600 area of 1969 planting. The following fungicides were included in the trial.

A – DithaneM-45 – 0.75%
B – Topsin M-70 – 0.35%
C – Bavistin 50WP – 0.5%
D – Emisan – 0.03%
E – Tilt 25 EC – 0.20%
F – Calixin 80 EC – 1.0%

These fungicides were incorporated in Pidyvil-China clay compound before trunk application.

The same chemicals were incorporated with a blender into Sopkot and applied on another set of trees for testing the comparative efficacy of both carriers. The observations on disease severity is being recorded periodically.

9. **High Pressure Injection for Disease Control**

a) High pressure injection with streptomycin against diseases of the rubber tree.

Incidence of pink disease, abnormal leaf fall disease and bark rot disease were assessed during the last half year and it was observed that streptomycin is effective against all the three diseases. The data are subjected to statistical analysis.

(b) In vivo screening of systemic fungicides against diseases of the rubber tree:

It is seen that brush-on application of Bordeaux paste at the forks has produced the best leaf retention against abnormal leaf fall disease even after two years of application. Melalaxyl + ziram, Tilt and streptomycin have also produced very high percentage of leaf retention against the disease even after two years of injection.

(c) Efficacy against pink disease of rubber:

In order to assess the efficacy of the different treatments against pink disease of rubber observation on pink disease incidence in the different plots was assessed and the treatments were compared using injection index as parameter. It was observed that Tilt injection produced the best result with least infection index closely followed by Bordeaux brush on application). All other treatments are ineffective against the disease.

In this case also the efficacy shown is after two complete years of treatment application. The lasting effect of treatments are to be reconfirmed by repeating the experiments.

10. **Biological Treatment of Effluent from Rubber Processing Factories**

Effluent from rubber processing factories cause very serious water pollution problems. Hence the problem will have to be investigated in detail for evolving a suitable, simple, economic and efficient method for treating the effluent. The selection of a suitable microorganism for the effluent treatment and the evaluation of the present treatment systems are also included in the study.

A comparative study on different parameters of the effluents from crumb rubber processing factory and latex centrifuge factory was carried out. The pollution load in the latex centrifuge factory effluent was found significantly high.

Table Path – 12: *Comparative study of crumb rubber processing and latex centrifuge factory effluent*

Parameters	Crumb rubber factory effluent	Latex centrifuge factory effluent
pH	6.5	4.2
Total solids	1680 mg/l	8805 mg/l
Suspended solids	720 ,,	1925 ,,
Dissolved solids	960 ,,	6880 ,,
B O D	300 ,,	4200 ,,
COD	680 ,,	8520 ,,
Total Nitrogen	85 ,,	6570 ,,
Ammonia Nitrogen	15 ,,	5530 ,,
Chlorides	64 ,,	1120 ,,
Sulphates	285 ,,	8760 ,,
Phosphates	890 ,,	380 ,,

Crumb rubber factory effluent was inoculated with *Chlorella* sp and analysed for various parameters. Algal culturing with aeration was found to reduce the pollution load.

Effluent samples from latex centrifuge factory was collected and different dilutions were made and *Chlorella* sp. was inoculated and found that maximum growth was in 1:2 dilutions.

A comparative study of the pollution of four types of rubber processing factories was conducted. The results are given in table - 13.

Table Path - 13: *Comparative study of four types of rubber factory effluent*

Parameters	Ribbed sheet factory effluent	Crumb rubber factory effluent	Crepe factory effluent	Latex centrifuge factory effluent
pH	4.6	6.2	6.0	3.8
Total solids	4200 Mg/l	1670 Mg/l	1400 Mg/l	3800 Mg/l
Dissolved solids	3450 ,,	620 ,,	480 ,,	6880 ,,
Suspended solids	750 ,,	1050 ,,	925 ,,	1920 ,,
BOD	1400 ,,	310 ,,	340 ,,	3500 ,,
COD	3260 ,,	1200 ,,	1350 ,,	10500 ,,
Total Nitrogen	200 ,,	125 ,,	140 ,,	1860 ,,
Ammonia Nitrogen	—	—	—	1725 ,,
Phosphates	—	8.5 ,,	10.0 ,,	200 ,,
Sulphates	—	1186 ,,	950 ,,	4340 ,,
Chlorides	—	65 ,,	45 ,,	730 ,,

Total bacterial as well as the coliform counts were also made and the latex centrifuge factory effluent showed less population due to high acidity.

11. **Minor Leaf Spot Diseases and its Control**

Leaf spot diseases caused by *Corynespora cassicola* , *Drechslera heveae* and *Gleosporium alborubrum* are of minor importance, mostly confined to nursery plants. Occassionally these occur in mature trees in severe form. Damage to tender leaves often warrant regular spraying.

The field trial at Karikkattoor nursery to study the role of fertilizers on leafspot disease incidence was completed. The data for number of leafspots per unit area in the samples leaves, final average height and girth of the observational plants in each replication were prepared. The soil and leaf samples collected for initial and final fertility status are being analysed.

Calixin (50, 100, 250 & 500 ppm concentration) and Dithane M45 (50, 100, 250, 500 & 1000 ppm) were tested against the fungus *Gleosporium alborubrum* using poisoned food technique in the laboratory. The percentage of inhibition at each concentration is given below.

Table Path - 14: *Inhibition of Gleosporium alborubrum*

Fungicide	% inhibition under different concentrations				
	50ppm	100 ppm	250 ppm	500ppm	1000 ppm
Calixin	82.39	88.63	100	100	
Dithane M 45	17.39	17.61	21.47	22.16	31.7

12. **Studies on Residual Copper in Rubber Sprayed with Copper Fungicides**

Large quantity of copper fungicide is applied annually in rubber estates for the control of diseases. The problems due to copper residues have to be evaluated, as copper residues are known to affect soil structure and microflora.

Samples of soil, leaf and latex from the trial area. Spraying in the trial area during the 8th year with the following fungicide formulations, was done.

T 1	Copper oxychloride 56% (powder)	— 8 kg/ha
T 2	,, ,, (,,)	— 16 kg/ha
T 3	Copper oxychloride 40% (Paste)	— 6.2 l/ha
T 4	,, ,, (,,)	— 12.4 l/ha

During May, August and October soil, leaf and latex samples were collected for analysis of copper content.

Latex samples, collected during October, November and December 1983, were analysed for Copper (Table 15)

Table Path - 15: *Copper residue in latex samples*

Treatments	October 1983	November 1983	December 1983	
T_0	8.42	7.45	6.19	ppm of copper/g of dried latex.
T_1	8.07	8.17	8.90	
T_2	11.40	14.14	10.00	
T_3	5.52	8.58	5.89	
T_4	5.81	10.94	7.12	

T_0 : Unsprayed control

The soil samples collected during October 1986 were analysed for copper and also for microbial population.

Table Path - 16: *Copper residue and microbial count in soil sample*

Treatments	Copper/g of dried soil	Microbial count/g of dry soil				
		Bacteria eria	Fungi	Actino-mycetes	Phosphate solubilising	Non-symbiotic
T_0	53.2 ppm	21	13	11	8	Nil
T_1	76.98 ,,	21	5	7	4	,,
T_2	92.06 ,,	15	5	5	5	,,
T_3	73.69 ,,	20	4	7	4	,,
T_4	76.86 ,,	12	4	6	4	,,

T_0: Unsprayed control.

13. **Assessment of Yield Loss Due to Diseases**

Crop loss studies are essential to evaluate cost benefit ratio of control operations. Systematic studies on crop loss of diseases of rubber have not been conducted so far.

(a) Yield loss due to abnormal leaf fall disease

Considerable yield loss was recorded in the yield loss assessement trials located at Boyce Estate, Kumbazha Estate and at CES Chethackal. The loss was observed to be more

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at Boyce Estate where the experimental material is clone PB 86 under high level tapping. The data recorded for the tapping season 1985-86 is presented, along with the pretreatment data for comparison.

Table Path - 17: *Comparative statement of yield recorded in yield loss assessment trial, March /April 85-Feb/March 86*

Location, clone and year of planting	Treatments	Mean yield/ha		Yield/tap		%leaf retention	% yield loss over projects yield
		1984-85	1985-86	1984-85	1985-86		
Boyce Estate PB 86 1957	Unsprayed	1858.5	1272.13	14.08	9.20	5.44	15.75
	Sprayed	1868	1519.75	14.15	10.97	75.34	—
Kumbazha Estate	Unsprayed	2480.37	2074.63	16.97	16.63	3.46	9.57
	Sprayed	2182.50	2086.63	15.56	16.86	59.93	—

In the experiment located at CES on trees newly opened for tapping, comparative data on yield recorded by daily cup lump coagulation from ten sample trees are recorded from June-March.

Table Path - 18: *Yield loss assessment trial, CES*

Location Clone Year of planting	Treat ments	Yield of 10 trees (g) June-March		Tapping days June-March		Yield June-March		% leaf retention	% yield loses over projected yield
		84–85	85–86	84–85	85–86	84–85	85–86		
CES Chethackal RRIM 600 1976	Unsprayed	33.61	46.14	126	127.3	0.266	0.362	6.27	9.27
	Sprayed	34.73	51.14	127	124.7	0.273	0.410	71.10	--

The yield recording is continued in all the three locations. Spraying was carried out in unsprayed plots after the first year at Boyce Estate and Kumbazha Estate. Although the area at CES was retained to assess the cumulative effect of continuous non-protection, the control plot was accidently oversprayed.

(b) **Yield loss due to powdery mildew disease:**

No difference in yield was recorded in the experiment on assessment of yield loss due to powdery mildew disease laid out at Vaikuntam Estate. The data is presented below:

Table Path 19: *Comparative statement of yield recorded in yield loss assesment trial for powdery mildew disease Vaikuntam Estate (April - Feb)*

Clone & year of planting	Treatment	Mean yield/block		Mean yield /tap		%disease incidence	% yield loss
		1984–85	1985–86	1984–85	1985–86		
RRIM 600 1973	Undusted	1552.25	1665.25	15.94	15.84	48.91	Nil
	Dusted	1364.50	1233.0	13.87	13.70	35.70	

In the experiment located at Ramamangalam Estate, there was appreciable loss in yield in the undusted plot.

Table Path 20: *Comparative statement of yield recorded in yield loss assessment trial on powdery mildew disease - Ramamangalam Estate*

Clone		1983-84	1984-85 (post treatment)			1985-86 (post treatment)		
Year of Planting	Treatment	Pre treatment yield kg/block	Yield k/gblock	% disease incidence	% yield loss over projected yield	Yield kg/block	% disease incidence	% yield loss over projected yield
PB 86 1968	Undusted	1156.176	850.40	14.3333	27.29	823.67	26.44	17.34
	Dusted	1093.68	1106.40	6.59	–	959.52	14.61	–

The trials are being continued at both the locations, yield, disease incidence and growth of trees are being monitored.

14. Over Summering of Phytophthora

Studies on over summering of pathogens is an important supplementary study required for the control of diseases in the weakest point of its life cycle. A knowledge on this aspect can be used effectively to considerably reduce the inoculum potential.

The method of wet sieving was adopted for concentrating the *Phytophthora* spores in the soil. Most of the oospores were obtained in the residue collected between 53 um and 32 um sieves though few could be seen in 63, 45 um sieves and in the filtrate. Studies have shown that the oospores, besides lying free in the soil, also remain embedded in the organic matter particles in the soil. Such particles when floated in water produced sporangia.

Different specific media were repeatedly tried for isolating *Phytophthora* from soil. Though *Phytophthora* could be isolated on the gallic acid medium, macroscopic detection in the early stages was difficult and *Phytophthora* could not be obtained regularly. Further, fungi like *Fusarium* and *Cephalosporium* are not inhibited. In all the media tried *Phytophthora* grows normally when pure culture was inoculated. Among the media tried orig inal PVP medium was found to be best for isolating *Phytophthora* from soil.

15. Collection, Classification and Comparative Morphology of Regional Isolates

Pathogenicity studies were carried out with the 12 local isolates of *Phytophthora*, on the clone RRIM 701 and cent per cent infection was noticed in all cases.

16. Studies on Physiological Specialization of Phytophthora

Physiological specialisation of pathogens can cause considerable problems in control, specially with resistant varieties. Information on this aspect is essential in breeding for resistance.

Ten regional isolates of *Phytophthora* were sent to CMI for identification. Seven isolates were identified as *Phytophthora meadii*. All regional isolates of *Phytophthora* are being maintained by re-isolating and renewing by passing through the host tissue.

Four regional isolates were screened by detached leaf inoculation method. These isolates showed different degrees of infection to various resistant/susceptible clones viz., RRII 33, F 4545, F X 516, RRIM 600, RRIM 701 and PR 107. Detached petioles of these clones were kept paratially immersed in a spore suspension of *Phytophthora*

Table Path - 21: *Phytophthora infection on petioles*

Clones	Culture No. 5	Culture No. 6	Culture No. 7	Culture No.8
RRII 33	R	R	S	S
F 4542	R	R	S	S
FX 516	S	S	R	S
RRIM 600	R	S	R	S
RRIM 701	S	S	S	S
PR 107	S	S	S	S

R: No infection (resistant), S: infection (susceptible)

17. **Host Parasite Interrelationship**

Host parasite relationship is an important aspect of study in the biology of pathogens, which can reveal many clues to break this relationship for the control of pathogens.

Artificial inoculation of the fungus *Corticium salmonicolor* was carried out in the brown and green stem of RRIM—701 using seven day old culture bits and the pathogen established on sterilized brown wood pieces as inoculum was done to study the penetration of the fungus. The brown stem was found to take infection but the green stem did not show any symptoms of infection. The infected bark after 11 days and 1 month were taken and fixed in F. A. A. After embedding in paraffin wax microtome sections of the bark was taken and observed after staining.

18. **Epidemiology of Diseases of Rubber**

The initiation and spread of diseses are determined by various extraneous factors. Identification of these factors and information on the manner in which these factors help the spread of diseases can help in the forecast of diseases and timing the control measures to achieve best results.

Stevenson screens were installed inside, border and outside the rubber plantation and regular recording was done on temperature and humidity. There was no difference between the border and outside, but the inside temperature was slightly lower and humidity slightly higher. These variations gave no advantage for any disease. Sunshine was found to be an important factor in the triggering of abnormal leaf fall disease. A cloudy day with favourable temperature, humidity and wet condition was found essential for the initiation of the disease.

19. **Selection, Testing and Introduction of New Leguminous Cover Crops for Rubber**

Establishment and maintenance of leguminous cover crop in rubber plantation is an important cultural operation. The leguminous plants used at present have some undesirable characters like drying in summer and palatable to cattle. Hence, action was taken to find out a most suitable cover crop.

The field experiments started in 1982 and 1985 were continued. There is not much difference in girth of plants under *Mucuna* and *Pueraria*. Soil moisture level also did not vary in plots planted with these two cover crops. The soils under *Mucuna* contained more of total heterotrophic bacteria, non-symbiotic nitrogen fixing bacteria and phosphate solubilising bacteria, when compared to soil under *Pueraria*. There is not much variation in the population of fungi and actinomycets in the soils under these cover crops.

Table Path -22: *Microbial population in soils under Mucuna and Pueraria.*

Cover crop	Bacteria 10^4	Fungi 10^4	Actino-mycets 10^4	Beijerin-ckia 10^2	Phospho-bacteria 10^4
Mucuna	55	13	14	5.4	9
Pueraria	32	11	11	2.7	5.3

In summer at Palghat, *Puerarir* dried completely while *Mucuna* showed sparse green vegetation. At CES, Mucuna continued to grow well even after the closure of the canopy, while the *Pueraria* plants completely vanished. At Cheruvally estate the *Mucuna* plants covered the ground completely in the first year itself. But *Puerariu* did not cover the area leading to profuse weed growth especially *Mimosa pudica.*

Table Path - 23: *Nodulation and dry matter production by Pueraria inoculated with different isolates of rhizobia* (*wt. in g*)

Rhizobium isolate	shoot	root	nodule	nodule number
A	6.64	1.48	0.36	70
B	10.71	0.87	0.44	110
C	8.25	1.41	0.27	77
D	7.67	1.41	0.31	79
E	10.12	0.93	0.44	105
F	7.38	1.32	0.29	66
Control	6.72	1.49	0.23	59

The *Rhizobium* isolates B and E are found to enhance modulation and biomass production.

Sowing of *thizobium* treated *Pueraria* seeds in coconut husks resulted in thick roots and plenty of big nodules. The *Rhizobium* isolate from Chethelvetty, a location where this plant grows profusely, caused more nodulation and biomass production.

Formation of VA - mycorrhiza in *Mucuna* and *Pueraria* by the mycorrhizal fungal spores in rubber fields was tested. Golden coloured spores of *Glomus* sp infected both these cover crops. The plants inoculated with Rhizobium and Beijerinckia showed more growth and the experiment is in progress.

All the cover crop seeds inhibited the growth of Rhizobium. Both the seed coats and cotyledon contained the inhibiting compound.

Pachyrribizus erosus the tuber forming legume, *Sesbania prostrata* a stem nodule producing legume and an unidentified wild legume were collected and are being tested for their growth and survival in acid soils. With a view to identifying a legume which can provide either grains or vegetable during the immaturity period of rubber ten different grain legumes and fodder legumes were tested for their growth. None of them showed satisfactory growth.

Rooted cuttings of Mucuna and Rhizobium cultures were prepared and distributed to rubber growers.

20. Rhizosphere Studies of Rubber Plants

Root region of plants known as rhizosphere is the region of intensive microbial activity. Both associative and antagonistic activity among micro organisms and between plants and microbes are taking place in this region.

A study was conducted to enumerate the occurrence of phosphate solubilising micro-organisms in the rhizosphere of different clones of rubber viz., PR 107, RRIM 600, RRIM 701, F 4542 and FX 516 and different group of micro organisms present in them were estimated. The population of phosphate solubilising bacteria, fungus and actinomysetes are given in the table below:

Table Path - 24: *Microbial population in* 10^4*/gof dry soil*

Clone	total phosphate solubilisers	Bacteria	Fungus	Actino-mycetes
PR 107	103	81	7	14
RRIM 600	42	33	4	4
RRIM 701	100	62	12	25
F 4542	234	162	54	18
FX 516	100	75	12	12

Bacterial isolate No.3 and No.7 showed maximum rock phosphate solubilisation and isolate No. 1 solubilised more aluminuum phosphate and isolate No. 3 showed maximum ferrous phosphate solubilisation.

21. **Isolation and Testing Antagonistic Micro Organisms Against Plant Pathogens of Rubber**

So far no report on the occurrence of antagonistic actinomycete in rhizosphere of rubber plants as well their inhibitory activity against the pathogens of *Hevea* is available. Hence a study was carried out to isolate antagonistic actinomycetes in the rhizosphere soils of rubber and test them against major pathogens of rubber.

In general the antagonistic actinomycetes are more in the rhizosphere of *Hevea*. Actinomycetes inhibiting *Phytophthora* sp, *Poria* sp and *Corticium sp* upto 10 mm are more. More population of antagonistic actinomycete having inhibitory zone over 10 mm were recorded in the rhizosphere of clones FX 516 and PR 107.

22. **Studies on the Non-Symbiotic Nitrogen fixing Microorganisms of Rubber Growing Soils**

Biological fixation of molecular nitrogen can be performed by a number of prokaryotic microorganisms. The free living nitrogen fixing microorganisms of rubber growing solis were studied giving special importance to *Azotobacter, Beijerenckia, Derxia* and *Azospirillum* and to find out their use in rubber plantation to maximise the yield at less cost without any pollution.

Growth characteristics of *Beijerenckia* sp and *Azotobacter* sp isolated from rubber growing soils were examined under different pH in the laboratory conditions and found that a pH of 6-9 was favourable for *Azotobacter* sp and 4-8 for *Beijerenckia* sp.

Beijerenckia sp and *Azotobacter* sp. individually or in combination, with and without nitrogenous fertilizer, was applied in the rhizosphere of rubber seedlings. *Beijerenckia* sp. along with half dose of recommended nitrogen showed favourable response in attaining girth of seedlings. Although the inhibitory effect of *Beijerenckia* sp was tested against *Phytophthora* sp. there was no positive results.

An experiment was carried out to study the effect of Dalapon, Fernoxone, Glycel, Gramaxone and Diuron on soil micro organisms like *Rhizobium, Beijerenckia, Bacillus, Aspergillus* and *Streptomyces*. It was found that all herbicides at higher doses inhibit the growth of these organisms in the artificial media. The effect was also studied in soil conditions and it was found that Gramaxone even at recommended field dose inhibit the organisms (Table 25).

Table Path–25 : *Effect of herbicides on soil micro organisms in soil (expressed in % of inhibition)*

Micro organisms tested	Gramaxone*				Glycel*				Fernoxone*				Dalapon*				Diuron*			
	208	104+	52	26	320	160	80	+40	332	166	+83	42	1233	616	+308	154	456	228	+114	57
Bacillus sp.	92	76	68	51	38	70	62	35	38	32	22	23	86	26	11	10	46	36	24	11
Beijerenckia sp.	75	64	51	40	67	56	48	23	42	51	37	23	51	37	27	10	97	92	75	0
Rhizobium sp.	96	93	69	38	88	85	69	54	92	35	29	14	23	4	2	0	62	18	14	12
Aspergillus sp.	86	62	60	28	74	50	40	20	50	18	14	0	68	30	20	0	62	40	32	25
Streptomyces sp.	74	42	36	27	29	24	18	16	92	86	64	48	80	32	30	12	84	67	56	48

*Concentration in ppm; +Recommended field dose.

Azospirillum sp was isolated from the rubber roots. The quantity of nitrogen fixed by these organisms should be estimated. The dual inoculation of *Beijerenckia* sp and *Rhizobium* sp has showed an increase in biomass production and nodulation in *Pueraria phaseoloids*. The biological process behind this is to be studied.

23. **White Grubs Attacking Rubber**

White grubs are serious pests of agricultural crops. The damaging stage survives in soil and hence control of the pest is difficult.

Mean percentage survival of the plants in treated plots of white grub control experiment was evaluated on the basis of reduction in the number of plants damaged by white grubs and render them unfit for transplanting. The data obtained were subjected to statistical analysis and the mean percentage survival of plants is presented in table 26.

Table Path 26: *Comparative evaluation of different insecticidal formulations for the control of H. serrata F.*

Treatments	Dose (kg ha^{-1})	Mean percentage survival of plants /plot*	
Carbofuran 3G	25	68.20 (55.67)	b
Phorate 10G	25	88.80 (70.45)	a
Carbaryl 5D	100	30.90 (33.77)	c
BHC 10D	100	14.40 (22.30)	d
Carbaryl 4G	25	57.90 (49.55)	b
Phosplone 4D	100	34.50 (35.97)	c
Sevidol 4:4G	25	88.10 (69.82)	a
Control		2.40 (8.91)	e
F test		Significant	
S. E. of X		2.08	

*Mean of four replications

Figures in parentheses are values

Mean values followed by the same letter do not differ significantly (P = 0.05) as per Duncan's multiple range test.

The results revealed that all the insecticidal treatments were found significantly superior to control in protecting rubber seedlings from white grubs. The application of Phorate 10G gave 88.80% protection and did not differ significantly to that of sevidol 4: 4G in its effectiveness. However, both were significantly superior to other treatments. The next effective treatment was carbofuron 3G followed by carbaryl 4G which are on par. The minimum survival of seedlings was noticed in the plots broadcast with BHC 10D.

Population sampling data revealed high grub population in June ie., 1 grub per cubic foot and 2 grub per cubic foot at the Central Nursery, Karikattoor and Regional Nursery, Neriamangalam respectively.

Studies on the entomogenous fungi, *Beauveria brongniarti* and *Beauveria bassiana* in relation to white grubs and the possibilities of their use in the management of white grubs are in progress.

24. Control of Termites Infesting Rubber

Termite infestation on young and old rubber trees is rather a menace to growers than damage. The gallary formation on the tree trunk upto a height of 2m is common. The mud contaminates the latex. Termites damage the shade baskets, mulch, cupholding ropes etc.

An experiment has been planned to evaluate the effect of new termiticides. As a part of the trial the pre-treatment observations were recorded during 1986-87. The incidence generally starts from November and continued upto March. The height and width of gallary was measured. The observations indicated that 16% of the trees were infested.

25. Studies on Bark Feeding Caterpillars of Rubber

The bark feeding caterpillar, *Atherastis circulata* is becoming more and more serious in low rainfall rubber growing belt of Kanyakumari, Trivandrum and Pathanamthitta districts. Oozing of latex in considerable quantity from some points of attack and secondary fungal infection at such points result in rotting and snapping of branches.

Severe attack of the pest was noticed in Ayiranallur Estate of Rehabilitation Plantation and Shaliakary Estate. A search for parasites of this pest indicate that only a species of chalcid attack the larva and its population is very low.

26. Studies on Slugs and Snails Attacking Rubber

Slugs damage young rubber plants of one to two year age at several places. The damage is not well understood by planters as the slug and snails appear only in the night. Due to this 6–12 months growth of plants is lost. Slugs and snails also feed on latex from tapped trees, resulting in contamiation and loss of latex.

Severe damage was seen at Muthiramala and at RRII (Field–4). The percentage of attack was 80% at the former area and 40% at the latter area. The field population was quiet high. An experiment was conducted on methods of control of slugs in field. The results indicated that painting the trunk portion at a height of 30 cm from bottom with a mixture of 0.1—0.2% Temik, maida and water to be effective.

Maida itself adhered well with the bark so stickers are not necessary. This method of treatment is cheaper and more effective than broadcasting granules (3g/tree) around the base of the plant. The effect of treatment lasted for 35 days by giving decreasing number of mortalities day by day. A second field trial was conducted to evaluate the effect of carbaryl, sevidol, carbofuran, landrin and zectran along with Temik applied in the same manner as before ie., painted with a slurry of maida in water. The results revealed that Landrin and Zectran were comparable with Temik.

27. Nematodes Infesting Rubber and Associated Cover Crops

Plant parasitic nematodes are pernicious parasites. Their occurrence starts much earlier than the symptoms of damage. In rubber, the cover crop *Pueraria* is severely attacked by root knot nematode and a few plant parasitic nematodes were isolated from rubber soils. Hence, a watch on the population and attack of nematodes is essential

Frequency of occurrence and population of plant parasitic nematodes associated with different nursery soils was evaluated. It was found to vary in different nurseries. Neriamangalam nursery showed the peak population with 100% frequency of occurrence which is followed by Kadackamon nursery Karikkattoor, CES Chethackal, RRII, Pandalam, Alacode, Mancheri and Thonnackal in descending order of population and frequency of occurrence.

28. Vertebrate and Non-Insect Pests of Rubber

Vertebrate pests like rats, porcupines, sambar and elephants cause considerable damage to rubber, especially plantations adjacent to virgin forests. Specialised control measures are to be adopted for these pests.

Bordifacoum baits at 0.005% (50 ppm) concentration were evaluated against three rat spp. viz., *Bandicota bengalensis, Bandicota indica* and *Rattus meltada* damaging rubber at the Central Rubber Nursery, Karikattoor. The data are presented in table 27 and 28.

Table Path-27 : *Efficacy of Brodifacoum in controlling rodent pests in rubber nursery*

Rodenticide	Burrow counting period	Total burrows	*No. of burrows ha*$^{-1}$ Rattus meltada	Bandicota bengalensis	Bandicota indica
Broadifacoum at 0.005%	Pre-control census	54	16	20	18
	Post-control census	3	2	0	1
	Control success (%)	94.44	87.50	100.00	94.44

The success in rubber nursery was 94.44% on the basis of burrow count. Post-control census revealed 100% kill of *B. bengalensis*, 94.44% kill of *B. indica* and 87.50% kill of *R. meltada* At 3, 6 and 9 months' stages in the growth of nursery rubber seedlings, the pre and post-control damages to the rubber were evaluated by studying hundred 1x1 m^2 plots. At every stage in the growth of rubber seedlings. significant reductions (P 0.001) in the rodent damages were obtained with Brodifacoum baits (table 27).

Table Path - 28: *Reduction in per cent rodent damage to the nursery rubber plants at various stages of growth after controlling rodents with Brodifacoum treatments.*

Rodenticide	Per cent rodent danage	*Stages of nursery rubber seedling* 3 months	6 months	9 months
Brodifacoum	Pre-control	20.54 ± 4.73	10.33 ± 2.34	29.55 ± 8.93
baits (0.005%)	Post-control	2.77 ± 0.52	1.25 ± 0.13	2.53 ± 0.63
	*probability level	0.001	0.001	0.001
	Reduction(%)	86.51	87.90	91.44

*Student 't' test

29 Bee-Keeping in Rubber Plantations

Bee keeping is a profitable ancillary industry in rubber plantations. This is a gain to the planters without much additional input.

In addition to the establishment of 25 plants of *Antigonon leptopus* Hook. & Arn. and 10 plants of *Callistemon lanceolatus* DC, 25 poly bag-raised seedlings of *Pongamia glabra* Vent at the RRII farm, 20 cuttings of *Manihot glaziovi* Muell. Arg. were also successfully established as off-seasonal bee forage plants at the CES. These plants are proved to be best suited for off-seasonal bee management in rubber plantation-based apiaries.

Further studies on the identification and establishment of additional bee flora are in progress. Among the predators of *Apis cerana indica F., Vespa* spp. were identified as potential bee hunters of honey bee. Studies on the parasites of bee are in progress. Studies on the effect of environmental factors on the foraging rhythm of *A. C. indica* are also in progress.

Plant Physiology and Exploitation

Introduction

The thrust areas of the Phyiology Division are yield component analysis at whole tree level, physiology and biochemistry of latex production and flow, development of physiological and biochemical methods for early prediction of yield potential and stress tolerance, a comprehensive analysis of brown bast syndrome and investigations on impact of different stress situations and to develop methods to counter these effects. Another important area of work is on the exploitation systems including chemical stimulation for modern clones. Physiological aspects in relation to water management and dry farming techniques also from another area of study.

1. **Studies on the Physiological and biochemical sub-components of major yield components of Hevea**

Though the contributions of major yield components towards dry rubber yield in *Hevea* are well established and quantified, knowledge regarding the nature and relative significances of the sub-components is limited. Comparisons of biochemical parameters of different clones with contrasting yielding characters are likely to be useful in identifying the biochemical sub-components.

Clones RRII 105 (high yielder), RRII 102 (medium yielder) and HP-20 (low yielder) were selected for the present study. The trees selected were under $\frac{1}{2}$S d/2 system of tapping in BI2 panel and were located in the RRII Experiment Station.

Total volume, plugging index, bursting index, osmotic potentials and proteins of B and C-serum, sugars in latex, triglycerides in rubber cream and phospholipids in the bottom fraction were observed. The data collected are presented in Tables 1 and 2.

Table Phy-1: *Latex volume, plugging index, bursting index and solute potentials of latex.*

Clone	Latex volume ml tree^{-1} tap^{-1}	Plugging index	Bursting index	Solute Potential Bars	
				C.serum	B-serum
RRII 105	221.89	3.50	10.64	–10.4	–11.5
RRII 102	49.08	6.89	29.32	–12.9	–11.0
HP 20	23.55	13.33	35.56	– 8.6	–10.8

Table Phy–2: *Contents of protein, sugars, triglycerides and phospholipids in latex fractions*

Clone	Protein (mg/100 ml)			Sugars (mg/100ml)		Triglycerides, (mg glycerol/ 100 mg)	Phospholipids mg/100g BF
	C-serum	B-serum	Total	Reducing	Non-reducing		
RRII 105	11.44	14.29	279.0	52.46	226.54	8.53	198.98
RRII 102	10.25	13.71	191.0	34.62	156.33	5.38	126.68
HP 20	8.43	9.84	177.3	30.57	146.73	4.08	67.24

The data shows that high latex yield of RRII 105 is associated with low plugging index, low bursting index and high contents of proteins, sugars and lipids. On the other hand the low latex yield of HP 20 is associated with high values of plugging and bursting indices and low contents of proteins, sugars and lipids. In the case of the medium yielder, the above parameters showed intermediate values. The solute potentials of the serum fraction did not show any consistent pattern though the values were high for the low yielder HP 20. It is too early to arrive at any definite conclusion based on the present data. Further studies are in progress.

2. **Biochemical basis of clonal variations in *Hevea*-Lipid composition of leaves**

Many of the physiological and genetic variations in *Hevea* clones are related to biochemical differences among clones. Establishment of definite relationships between these biochemical differences will be useful in crop improvement programmes. Earlier studies conducted in the Institute have established that clonal differences in the lipid composition of latex particles are associated with differences in plugging index, yield, drought susceptibility etc. Seasonal changes in the lipid composition of latex particles have also been observed particularly with reference to drought.

A study has been undertaken to see whether clonal variations exist in the leaf lipid composition also and if so, whether such differences can be correlated to physiological differences. Such studies would be useful in early identification of yield characteristics as well as stress tolerance.

Leaf samples of three clones, RRII 105 (drought resistant in terms of latex yield), Tjir 1 (drought susceptible in terms of latex yield) and SCATC 93-114 (cold tolerant) were collected from bud wood nursery and the contents of different lipid components were estimated. The data are given in Table.3

Table Phy-3: *Lipid composition in the leaves of three clones of Hevea (mg g^{-1} dry wt.)*

Clone	Glycolipids**	Triglycerides**	Sterols**	Phospholipids
Tjir 1	62.05 a	10.35 a	17.14 a	7.38
RRII 105	71.12 b	11.28 b	23.22 b	6.14
SCATC 93-114	74.58 b	11.47 b	23.39 b	7.65
CD 0.05	4.65	0.60	1.14	

**Significant at 1% error (figures followed by same letter are not significantly different from each other).

The data shows that the contents of glycolipids, triglycerides and sterols are significantly low in Tjir 1 compared to the levels in the clones RRII 105 and SCATC 93-114. However, there is no differences between these two clones in terms of the contents of these lipids in their leaves. There was no significant difference in the levels of phospholipids in the leaves of all the three clones. The studies indicate that lipid fraction in the leaf might be an indictaion of drought resistance. Further studies are in progress.

3. **Yield constraint analysis of *Hevea* in different agroclimatic zones of the traditional area**

Within the rubber growing areas, there are many distinct agroclimatic zones with marked differences which influence growth and yield of *Hevea*. However, these yield variations are yet to be quantified and correlated with the agroclimatic variables. A study was undertaken at five estates located in different agroclimatic zones.

Uniformity was maintained in the selection of clone (GT 1), year of planting (1977) and the cultural operations. The recording of girth and yield components were made at bimonthly intervals. At all locations, one block each was selected and 25 trees at random were selected for the experimental analysis. Girth, length of tapping cut, plugging index, initial flow rate, total volume and dry rubber content were recorded.

From the estate records, data on rubber yield(kg tap^{-1})of the selected block for 1985-86 and 1986-87, daily rainfall for 86-87 (Fig 1) and monthly rainfall for the past twenty years were collected.

In the month of September 1986 soil and leaf samples were collected and analysed to determine nutrient status.

Dry rubber yield/block at each location is presented in Fig 1. Mean rubber yield tree^{-1} tap^{-1} for the three distinct seasons are given in Table 4. During April-May, the dry rubber yield was highest at New Ambadi, while it was lower at Malankara and Kinalur. Yield obtained at Perinaad is higher than that in Kinalur, but lower than that in New Ambadi. Statistical analysis of the data have shown that the yield difference observed between New Ambadi and Malankara, New Ambadi and Kinalur, Perinaad and Malankara are significant. For the season June-August, the highest yield was recorded at New Ambadi, while the lowest was observed at Kinalur. Yields obtained from Malankara, Kundai and Perinaad were medium and these did not differ significantly.

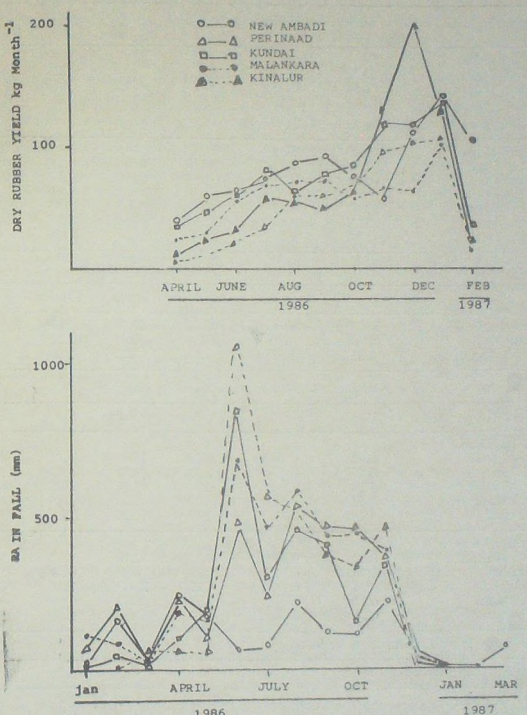
For September-December, the highest yields were recorded at Perinaad and New Ambadi. The lowest yield was obtained at Kundai and medium yields were recorded at Kinalur and Malankara.

On further analysis of yield components, it was observed that the tree girths in different locations were not significantly different from each other (Table 5.) High yield obtained at New Ambadi was associated with high latex volume and a low plugging index. The lower yields at Malankara and Kinalur were associated with low latex volume and high plugging index. These values were statistically significant. The same trend was maintained during the season June-August in these estates with regard to plugging index and latex volume. In September-December, the lower yields at Kinalur and Malankara were associated with high plugging index and latex volume. However, at Malakara, the low latex volume was somewhat compensated by a slightly higher dry rubber content (Table 4).

The data indicate that the growth of trees are not affected differently by the agroclimates studied. However, the agroclimatic components influence plugging index and hence the latex volume. Plugging index can be influenced by soil moisture conditions, nutritional status and probably the mircoclimates in the estates. The soil and leaf analysis data could not be related to the observed difference in plugging index and total volume.(Table 6,7). The important factor which may be affecting plugging index is the seasonal variation in soil moisture which are now being monitored.

Table Phy 4. *Seasonal variations in initial flow rate, total volume, plugging index and yield of dry rubber per tree per tap.*

Season	New Ambadi	Perinaad	Malankara	Kundai	Kinalur	LSD at .05
Plugging index						
April-May	5.0	8.78	9.47	–	6.39	1.79
June-August	2.52	4.15	3.69	4.32	5.16	0.99
September-December	2.33	2.65	3/16	2.88	3.82	0.51



Phy. Fig. 1. Monthly Rubber Yield and Rainfall at various experimental locations in GTI during 1986-87 (New Ambadi, Kanyakumari District, Kinalur-Calicut District)

Season	New Ambadi	Perinaad	Malankara	Kundai	Kinalur	LSD at 0.05
Total Volume						
April-May	55.57	36.83	21.3	—	31.4	40.69
June-August	92.53	93.75	74.53	60.2	48.6	22.65
Sept.-Dec.	122.63	123.03	93.25	93.31	111.5	16.26
Initial flow rate/cm of tapping cut/min (ml)						
April-May	0.081	0.079	0.057	—	0.060	0.034
June-August	0.068	0.097	0.075	0.070	0.073	0.027
Sept.-Dec.	0.092	0.021	0.084	0.084	0.1	0.014
Yield/tree/tap (g)						
April-May	23.03	16.48	7.24	—	13.45	6.6
June-August	37.8	33.46	22.33	27.99	20.02	10.62
Sept.-Dec.	45.74	49.27	38.76	31.23	40.75	6.53

Table Phy-5. *Girth and yearly girth increment (cm) in different estates.*

	New Ambadi	Perinaad	Malankara	Kundai	Kinalur
Initial girth	58.64	56.66	56.76	57.78	60.22
Final firth	61.09	61.30	58.74	60.6	62.22
Girth increment	2.45	4.64	1.98	2.82	2.00

Table Phy-6 *Soil nutrient status in the different estates (mg/100 g)*

Estate	%O.C	P	K	Ca	Mg	pH
At 0 to 30 cm						
New Ambadi	0.92	0.20	1.94	16.81	9.12	4.95
Kinalur	0.76	0.26	2.55	8.37	5.48	5.06
Kundai	1.20	1.70	5.97	11.85	6.28	4·68
Malankara	0.77	0.59	3.30	5.28	5.45	4.91
Perinaad	1.14	0.22	3.13	10.29	7.6	5.18
At 30 to 60 cm						
New Ambadi	0.58	0.10	1.38	22.10	9.67	5.13
Kinalur	0.50	0.22	2.03	8.29	4.58	5.16
Kundai	0.90	0.78	6.25	23.43	7.22	4.88
Malankara	0.33	0.24	2.80	3.65	6.56	4.19
Perinaad	0.96	0.24	3.12	17.46	8.54	5.16

Table Phy-7: *Nutrient* status of leaves (%)

Estate	N	P	K	Ca	Mg
New Ambadi	3.39	0.23	1.41	1.25	0.43
Kinalur	3.80	0.26	1.48	0.84	0.23
Kundai	3.41	0.30	1.71	0.80	0.20
Malankara	3.51	0.27	1.35	1.17	0.43
Perinaad	3.55	0.29	1.56	1.16	0.38

4. **Photosynthesis and partitioning of assimilates.**

One year old rubber plants of clone RRIM 623 were used in this study. Fully mature leaves were fed with $^{14}CO_2$ for 30 min. on a clear sunny day in a closed system (Fig. 2). The plants were sampled at different intervals on the day of feeding (0) and subsequently 1, 5, 20, 30, 45 and 60 days after feeding and fractionated into fed leaf, leaves, bark, wood and root. The samples were extracted sequentially in 80% ethanol, water, Benzene-TCA and PCA soluble compounds. Girdling near the bud union was also carried out to check the movement pattern of photosynthetically assimilated carbon and its conversion to rubber hydrocarbon in bark and roots as a function of precursor availability.

Results indicate that the radioactivity from the fed leaves moved into roots within six hours. By twenty four hours the label reappeared in petioles, bark and wood. The level of ^{14}C in Benzene-TCA extracts was maximum on the 45th and 60th day in leaves and on the 30th day in bark. Majority of the Benzene-TCA extractable radioactivity was recovered from bark and roots. However, a remarkable increase in the appearance of label in rubber fraction was noticed in fed leaf on the 5th day.

Girdling experiments indicate maximum occurrence of label in the shoot (leaves and bark), suggesting the downward translocation of photosynthates to roots. Girdling resulted in maximum occurrence of label in bark on the 1st day after feeding, indicating a faster rate of conversion of photosynthates into rubber hydrocarbon which is otherwise slow in leaves. (Fig 3).

5. **Diurinal variation in the activity of 3 -Hydroxy 3-methyl glutaryl Coenzyme-A reductase in the drainage area of the bark of *Hevea* under 1/2 S d/2 system of tapping.**

3-hydroxy-3-methyl glutaryl coenzyme-A (HMG-CoA: EC. 1.1.1.34) catalyzes the reduction of HMG-CoA to mevalonate. Mevalonate is then further converted to isopentanyl pyrophosphate which is the building unit for rubber biosynthesis. HMG-CoA reductase is considered to be a rate limiting enzyme in the biosynthesis of rubber as it has the lowest activity compared to other enzymes in the path way. Hence it can be assumed that variations in the activity of HMG-CoA reductase may be related with variations in rates of rubber biosynthesis.

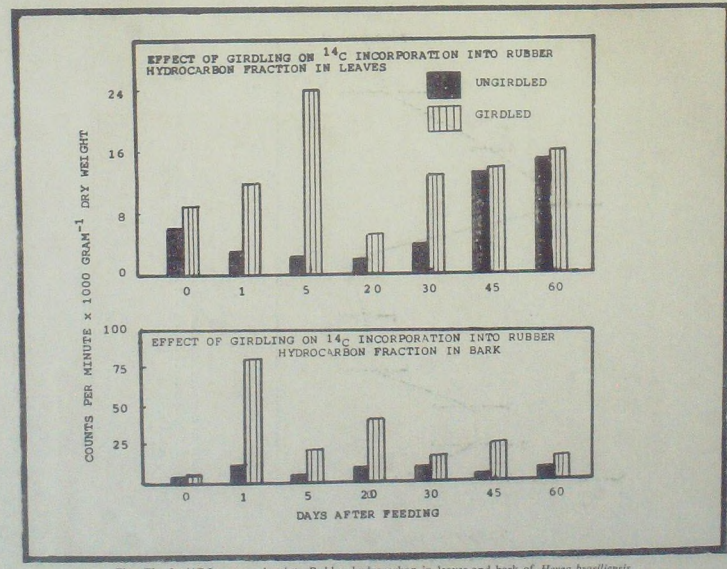
Reports on the biosynthetic rates of rubber in the bark during the period between tapping are scanty. A study was undertaken to estimate the HMG-CoA reductase activity in the bark in the drainage area at six hourly intervals during the period between two successive tappings (1/2 S d/2). The clone chosen was Gl 1 under tapping in BI2 panel. The bark samples were collected from drainage area in the vicinity of cut ends. The first sampling was done at 06.00 hours, just before tapping and further samplings were done at six hourly intervals for 48 hours with the last sampling done just before the subsequent tapping. The enzyme activity was estimated by analysing the levels of HMG-CoA and mevalonate. The activity of the enzyme is expressed as the ratio between HMG-CoA and mevalonate.

From the data (Fig. 4) it is seen that there is diurinal variation in the activity of HMG-CoA reductase. The activity is high during night hours and low during day time. In general, the activity of the enzyme was higher in the first 24 hours after tapping compared to the activity in the subsequent 24 hour period. Further studies are in progress.

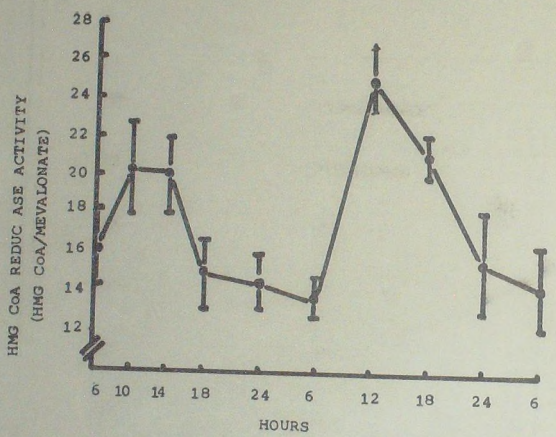
6. **Physiological evaluation of *Hevea* clones in different agro-climatic zones.**

In non-traditional areas, many of the environmental conditions reach stress levels for *Hevea* growth. Due to the lack of data on growth and on clonal variations in the non-traditional areas, a multi-location trial involving four regions and 12 clones was started in 1982. The regions are North Konkan region (Dapchari, Maharashtra) with high temperature and prolonged drought; North-East region (Agartala, Tripura) with low temperature in winter

Phy. Fig. 2. Incorporation of $^{14}CO_2$ into Rubber leaves in a closed system.



Phy. Fig. 3 ^{14}C Incorporation into Rubber hydrocarbon in leaves and bark of *Hevea brasiliensis*.



Phy. Fig. 4. Diurnal variations in HMG CoA reductase activity in the drainage area of the bark of *Hevea* tree under 1/2 S d/2 system of tapping (clone Gl 1), higher ratio of HMG CoA/mevalonate indicates lower enzyme activity.

and drought in summer; high elevation (Mudigere, Karnataka) with high wind velocity and low temperature and traditional region (Central Experiment Station, RRII). The clones included in the trial are listed in Table 8. At Dapchari life saving irrigations (15 *l plant*$^{-1}$ *week*$^{-1}$) were provided to the plants during extreme drought periods. The growth of the plants were monitered in terms of girth increments and the data are presented in table 8. Routine meteorological parameters were also recorded.

The data, though not statistically analysed, indicate that in comparison to the girth attained in the traditional area, the girth attained is 16% less at Dapchari, 20% less at Agartala and 39% less at Mudigere. It was evident that high elevation has the maximum inhibitory effect on growth. (Table 8)

Clonal variation, however, was observed in the degrees of inhibition of growth caused by the different agroclimatic factors. Thus, contrary to the general trend, PR 107 showed 19% extra growth at Dapchari as compared to its growth at Central Experiment Station (CES). At Dapchari maximum girth was attained by RRIM 600 (19.5 cm) followed by PR 107 and RRII 300 (17.7 cm). Though the general inhibition was 16% at Dapchari in clones Gl 1 and GT 1 the girth attained was only 6% less compared to that of the respective clones at the CES. The growth inhibitions of RRII 300, RRIM 612 and RRIM 600 were between 9 to 12%. Of all the clones, RRIM 600 showed maximum girth at Dapchari.

At Agartala, maximum girth was attained by RRII 118 (21 cm) followed by RRII 300 (18.9 cm) and RRIM 600 (17.8 cm). The girth attained by RRII 118 was comparable to that at CES. Girth of RRII 300 was only 3% lower. GT1 and PR 107 showed 13% inhibition in girthing.

At Mudigere, though the growth was poor, in general, clones RRIM 600, RRIM 703, GT 1, RRII 300 and PB 235 were comparatively better.

It was also noticed that plants grown at the higher elevation showed very high stomatal resistance during January, 1987 (Table 9). This could be due to the low temperature in winter. Plants grown in this region also showed reduced growth rates during winter period which could be due to lowered photosynthesis resulting from high stomatal resistance. Among all the clones, RRIM 600 and RRIM 703 maintained low stomatal resistance during winter. These two clones also show comparatively better growth performance.

Table phy. 8: *Mean girths (cm) attained by different Hevea clones at traditional and non-traditional zones* (1986).

Clone	Location			
	CES	Dapchari	Agartala	Mudigere
RRII 300	19.4±0.08	17.7±0.08	18.9±0.18	12.3±0.12
PB 235	21.9±0.11	15.9±0.08	15.0±0.07	12.2±0.06
GT 1	17.8±0.09	16.8±0.04	15.4±0.07	12.9±0.09
RRIM 612	18.5±0.09	16.4±0.14	14.4±0.08	12.0±0.09
RRII 118	21.1±0.09	16.9±0.05	21.0±0.09	10.7±0.10
RRIM 703	21.7±0.09	13.7±0.12	16.8±0.07	13.4±0.11
Tjir 1	21.8±0.11	15.7±0.05	15.0±0.07	12.3±0.11
RRII 105	18.8±0.12	12.9±0.12	11.6±0.11	11.9±0.07
RRIM 600	22.1±0.07	19.5±0.07	17.8±0.05	13.1±0.10
RRIM 501	15.3±0.09	15.5±0.18	12.9±0.08	10.9±0.13
PR 107	14.9±0.12	17.7±0.07	12.9±0.06	9.5±0.09
Gl 1	17.1±0.06	16.0±0.06	13.2±0.05	9.9±0.08

Table Phy. 9. *Stomatal resistance (s cm^{-1}) of leaves of Hevea grown at high elevation (Mudigere) and in plain (Chethackal) during January* 1987.

Clone	Mudigere.	Chethackal.
RRII 300	33.15	4.96
PB 235	25.15	5.06
GT 1	48.60	4.69
RRIM 612	43.19	5.51
RRII 118	15.68	2.91
RRIM 703	10.47	5.53
Tjir 1	29.06	3.77
RRII 105	14.07	3.24
RRIM 600	10.15	3.37
RRIM 501	11.23	2.29
PR 107	18.35	5.05
Gl 1	15.82	4.17

7. **Performance of Rubber Under High Elevation Situations**

Considerable area which can be classified as marginally suitable are available between altitudes of 450 m and 900 m from the MSL in Idukki and Wynad districts. Experiments were undertaken to study the effects of high altitude on growth and yield in rubber and to find out whether rubber can be grown economically at higher elevations as well as to identify suitable clones which can withstand the environmental constraints at high elevations.

Sixteen popular clones were planted in 1981 at Mullenkolly in Wynad (840 m from MSL) with a control in the plains (Poonoor Estate). The growth performances of clones in both locations are given in Table 10.

In the Wynad region, RRIM 600 showed maximum girth (20.2 cm) followed by RRII 203, RRIM 612 and RRII 118, where as in the plains RRII 118 followed by RRII 203 performed better than other clones.

Clones Gl 1, GT 1, Tjir 1 and PB 28/59 recorded 19–20% growth inhibition in high altitude compared to the growth in plains. The inhibition of growth was more pronounced (above 30%) in other clones. The studies indicate that clones RRII 203, RRIM 612 and RRIM 600 might perform better at higher elevations.

Table Phys - 10. *Growth of Hevea clones in Poonoor and Wynad (girth in cm)*

Clone	Wynad	Poonoor	%inhibition
PB 28/59	18.3	23.6	22.3
RRII 203	19.3	30.2	36.1
PB 6/9	10.1	20.2	49.9
RRII 105	16.6	27.8	40.2
RRIM 612	19.3	27.5	29.7
RRIM 501	15.6	26.4	41.0
RRIM 605	15.8	23.5	32.9
Gl 1	17.2	21.3	19.2
PB 5/51	14.8	22.1	32.9
PR 107	13.6	20.2	32.7
GT 1	16.6	28.3	41.4
RRIM 600	20.2	25.5	20.7
RRIM 623	18.4	27.6	33.5
Tjir 1	16.8	20.9	19.5
LCB 1320	15.0	27.4	45.2
RRII 118	18.9	33.0	42.5

8. **Leaf water potential and its components**

Leaf water potential, solute potential and pressure potential during pre-dawn and after-noon conditions were measured in budwood nursery plants of clones RRII 105, Gl 1, Tjir 1 and RRIM 701, representing varying degrees of drought tolerance, the former two being fairly drought tolerant than the latter two. Results indicate that there is significant clonal variation in pre-dawn water potential and pre-dawn and after-noon pressure potential.

While the drought tolerant clones RRII 105 and Gl 1 showed little variation in the parameters studied, clones Tjir 1 and RRIM 701 showed greater degree of variation. (Table 11). The presence of osmotic adjustment with the falling water potential is clear in tolerant clone like Gl 1. The fall in water potential itself is less during after-noon in Gl 1 than in other clones. The higher after-noon water potentials observed in all the clones might be because of the higher root shoot ratios of the budwood plants.

The ability in osmotic adjustment in leaves influences the sensitivity of clones to drought/summer periods.

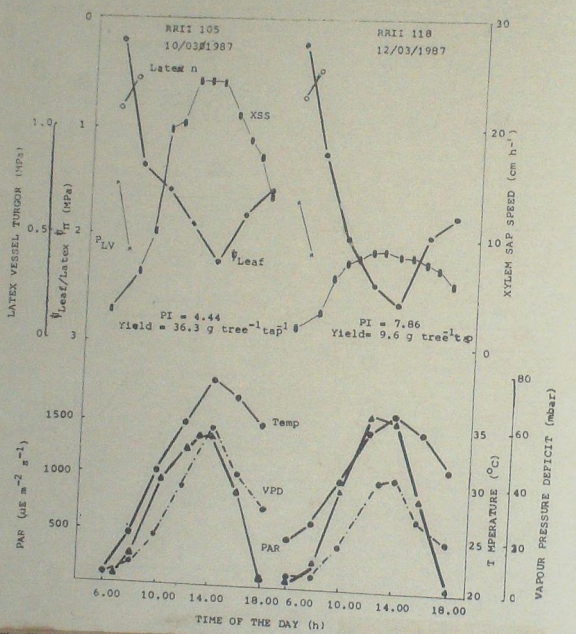
Table Phys 11. *Pre-dawn and after-noon leaf water potential, solute potential and pressure potential*

	Leaf water potential		Solute potential		Pressure potential	
Clone	Pre-dawn (-MPa)	After-noon (-MPa)	Pre-dawn (-MPa)	After-noon (-MPa)	Pre-dawn (MPa)	After-noon (MPa)
RRII 105	0.316	0.446	0.966	0.994	0.652	0.589
Gl 1	0.392	0.429	0.953	0.975	0.567	0.554
Tjir 1	0.407	0.598	1.134	1.237	0.731	0.640
RRIM 701	0.502	0.619	1.102	1.168	0.602	0.553
Mean	0.404	0.523	1.039	1.094	0.638	0.589
S. E.	0.0503	0.0772	0.0650	0.0980	0.0570	0.060
C. D. 0.05	0.046	0.070	0.059	0.089	0.052	0.054

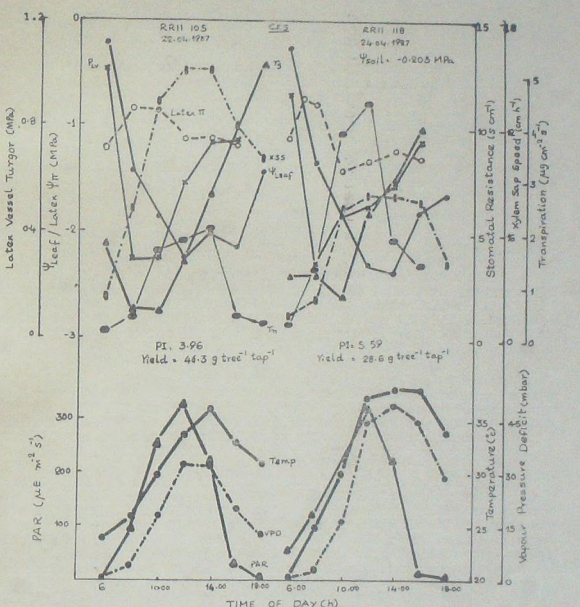
9. **Water Relations of trees under tapping**

In the traditional rubber growing tracts, a definite drought period exists from December to April. In certain years the moisture stress becomes more severe due to early cessation of North-East monsoon and/or due to failure of pre-monsoon showers. Normally the average yield decline in summer ranges from 20-50 per cent compared to the peak yield periods depending on the clone. In clones like RRII 105 and Gl 1, yield depression is less compared to clones like Tjir 1 where the yield depression is very high. Though latex yield is highly correlated with soil plant water relations, information on the changes in the water status of different plant parts of the tree, water uptake and transpiration rates and on the influence of environmental parameters on these are inadequate to explain the observed clonal variations as well as the seasonal variations in latex flow characteristics.

Various components of soil plant atmosphere system were studied in four clones, RRII 105, RRII 118 (9 years old) at RRII Central Experiment Station and in Gl 1 and Tjir 1 (25 years old) at Malankara Estate. Soil water potential, plant factors (leaf water potential, stomatal resistance, transpiration rates, xylem sap flow, latex vessel turgor, latex solute potential, leaf temperature and yield and yield components like girth, initial flow rate, drc and plugging index and the atmospheric/environmental variables, ambient temperature, relative humudity, vapour pressure deficit and total radiation/PAR) were considered for the study. Semidiurnal variations in the plant and atmospheric factors were monitored in the summer period of 1987. The diurnal patterns of two typical clones RRII 105 with a minimum yield depression in summer and RRII 118 with high yield depression are given as observed in March & April 1987 (Fig. 5 and 6)



Phy. Fig. 5. Semi-diurnal changes in leaf water potential (Ψ leaf), xylem sap speed (XSS), Vapour pressure deficit (VPD), Temperature (Temp) and PAR in RRII 105 and RRII 118 during March, 1987.



Phy. Fig. 6. Semi-diurnal changes in components of Soil-Hevea-atmosphere system in RRII 105 and RRII 118 during April, 1987.

Observed pre-dawn turgor of latex vessels was almost near the calculated values derived from the observations on pre-dawn leaf xylem potential and pre-dawn latex solute potential indicating uniform water potentials throughout the plant system which is probably in equilibrium with soil water potential at the root surface. Under similar soil moisture situations the pre-dawn latex vessel turgor (prior to tapping) was slightly higher in RRII 105. Leaf water potentials were also similar in these two clones under these conditions. Tapping had resulted in a sudden drop in turgor which continued for about 90 min. and increased gradually thereafter. Rebuilt-up of turgor coincided with the cessation of latex flow. The drop in latex vessel turgor was also less in RRII 105.

RRII 105 was found to maintain higher leaf water potentials as compared to RRII 118. The transpiration rates were higher in RRII 118 while RRII 105 showed lower water loss. Very high rates of xylem sap flow were noticed in RRII 105. It is seen that lower leaf water potentials in RRII 118 is due to lowered water uptake as well as high transpiration rates. High rates of water uptake even when transpiration is low in RRII 105 indicate quick recoupment of lost water in the plant system.

10. Impact of unusual drought on *Hevea* clones

The traditional rubber growing areas in the West Coast experienced an unusual and severe drought during 1986-1987 because of the failure of North-East monsoon and post-monsoon rains. The symptoms of the severe drought were severe yield decline, branch drying, and in certain cases complete tree drying. A study was undertaken to evaluate the effects on drought on soil moisture, yield, and after-noon leaf water potentials in certain clones in four different locations. The clones observed were RRII 105, Gl 1, Tjir 1, RRIM 600, RRIM 501, PB 235, GT 1 and RRII 118. The data collected on soil moisture levels at four depths (0-15 cm; 15-30 cm; 30-60 cm and 60-90 cm) and the after -noon leaf water potentials of the sun leaves of the trees of different clones are presented in Table 12.

In majority of the locations, soil water potential was found to be below the wilting point in the feeder root zone (0-30 cm). Even at 60-90 cm depth, the available soil moisture was very low. No live feeder roots were seen in the active root zone. Though the drought situation was severe in all the locations, it was comparatively less in the RRII Experiment Station. In all the locations the trees showed wintering and refoliation as usual. Though the drought was very severe, the trees did not show any symptom of wilting.

Though the normal drop in the after-noon leaf water potentials is about -10.0 bars under good soil moisture conditions, the severe drought conditions resulted in the drop of after-noon leaf water potential values ranging from -20.0 to -34.0 bars. Though RRII 105 showed drying of lower branches, the leaves were found to maintain higher water potentials compared to those of other clones. The range was from -23.0 to -24.8 bars in RRII 105. The water potentials in clone Gl 1, which is known to be drought tolerant, were between –24.4 to –25.3 bars. The maximum drop of leaf water potential was recorded in Tjir 1, which is a drought susceptible clone (-26.2 to -34.9 bars). The water potential of RRIM 600 ranged from -20.2 to –29.1 bars. The values were –25.3, –27.5, –27.7 and –29.6 bars for clones RRIM 501, PB 235, GT 1 and RRII 118, respectively.

Present study shows that *Hevea* trees draw water from the soil layers well below 90 cm depth. In another study conducted during the same season, it was observed that RRII 105 has higher rates of water uptake and low transpiration compared to other clones. It is probable that RRII 105 scion induces better root density or lower root resistance which results in higher water uptake. The study also shows that variations in drought injury to shoot are associated with variations in sensitivities of the plants to drops in plant water potentials. Yield drops and recovery rates are being studied.

Table Phys-12. *Soil moisture percentage and soil water potentials (bar) in Hevea plantations*

Soil	RRII	MALANKARA		CES			CHERUVALLY	
Depth (cm)	Gl 1, Tjir 1 RRIM 501	RRIM 600	RRII 105	Gl 1 Tjir 1	RRII 105 RRII 118	PB 235	RRII 105 GT 1	RRIM 600
0-15	15.80 (<–15.0)	12.57 (<–15.0)	12.50 (<–15.0)	12.45 (<–15.0)	12.46 (<–15.0)	13.30 (<–15.0)	12.25 (<–15.0)	12.36 (<–15.0)
15-30	16.30 (–14.0)	14.13 (<–15.0)	14.85 (<–15.0)	14.42 (<–15.0)	14.41 (<–15.0)	15.78 (<–15.0)	13.21 (<–15.0)	12.98 (<–15.0)
30-60	17.60 (–8.9)	18.03 (–8.0)	16.87 (–11.6)	16.17 (–15.0)	16.18 (–16.0)	16.04 (–15.0)	14.90 (<–15.0)	13.74 (<–15.0)
60-90	19.48 (–2.7)	18.42 (–6.6)	17.49 (–9.8)	17.55 (–8.2)	16.44 (–13.2)	16.92 (–11.3)	15.24 (<–15.0)	14.94 (<–15.0)

Figures in the parenthesis are the soil water potentials in bars

11. **Comparative evaluation of Basin and Drip irrigations on the establishment and growth of immature *Hevea* plants under Dapchari conditions**

Due to the prolonged dry periods experienced in Konkan region, the possibility of irrigating *Hevea*, at least during the immature phase, is under consideration.

A new trial was initiated in 1986 to evaluate the water requirements under basin and drip irrigation systems.

12. **Development of dry farming techniques**

An experiment was laid out at Regional Research Station, Dapachari in 1986 to evaluate the effects of dry farming techniques on mitigating stress effects in immature *Hevea* plants. The treatments selected are limited deep irrigation, pitcher irrigation, dew catching with coarse sand or granite chips and contact shading with reflectants. The trial is in progress.

13. **Adaptive trials on contact shading in young rubber plants as a measure to substitute conventional shading**

In the North Konkan region, even field planted polybag plants require artificial shading during summer season. A trial has been initiated in 1986 to see if use of reflectants (contact shading) can eliminate the use of conventional shading which is expensive.

METHODOLOGY

14. **Thermostability of membranes of leaf tissues of *Hevea brasiliensis***

Field observations in non-traditional and traditional areas indicate variation among clones in their sensitivity to heat injury. As there is no quick method for assessing temperature sensitivity in *Hevea*, the suitability of the electrolyte leaching technique developed by Sullivan for determining temperature sensitivities in soyabean genotypes was assessed. This test is based on the onbservation that when leaf tissue is injured by exposure to high temperatures, cellular membrane permeability is increased and electrolytes diffuse out of the cells. If the tissue is subsequently bathed in deionized water for a specified period after the application of heat stress, the amount of electrolyte leakage can be evaluated by electrical conductance measurements.

Hevea has two types of functional leaves (sun leaves and shade leaves) and a study was made to see if the thermostabilities of these leaves were different. Range of critical temperature, which causes 50 percent injury when exposed for 15 minutes, was also assessed.

The data are given in table 13.

Table Phys. 13. *Per cent of injury to sun and shade leaf tissues of* RRII 105 *by temperature shocks*

Temperature°C	40	45	50	55	60	70	75	80	Mean
Sun leaf	4.1	2.8	5.7	28.1	35.5	68.8	73.6	79.6	37.0
Shade leaf	1.6	7.0	4.4	26.1	29.8	67.6	73.6	79.7	36.2
Mean	2.9	4.9	5.1	27.1	32.7	68.2	73.6	78.7	36.6

Though sun leaves showed slightly higher injury compared to shade leaves the difference was statistically not significant. Since sun leaves are exposed to direct heat radiation better thermostability of the membranes in the cells of these leaves compared to that of the shade leaves is likely to be expected. The lack of such difference in the present study might be because of sampling during the monsoon period. It is likely that samples collected during early summer may show the expected differences.

Since there was no significant difference between sun and shade leaves in the percentage of membrane damage caused by temperature shocks, a common response curve was prepared (Fig. 7). The response is sigmodal and it is found that 50 per cent injury is caused by a shock of 63.5°C for 15 minutes. Further studies on clonal variations in thermostability of the membranes of leaf tissues are in progress.

15. **Comparison of thermocouple psychrometre and pressure chamber methods for measuring leaf water potentials**

For studies on leaf water potentials in rubber, a comparison was made between the pressure chamber technique and thermocouple psychrometry. In *Hevea*, exudation of latex from the severed ends of the petioles causes problems in the use of Scholander pressure chamber for measuring leaf water potentials. A study was undertaken to compare the values of water potentials of the same leaves measured by pressure chamber and psychrometer methods and also to find out the feasibility of interconverting the values obtained. Clones RRII 105, Gl 1 and Tjir 1 were chosen for the study.

Values of leaf water potentials obtained by psychrometric and pressure chamber methods are shown in table 14. In general the values obtained by pressure chamber methods were slightly higher than the values obtained by psychrometric method. The lower observed values in psychrometric method is due to the presence of cut ends in the periphery of the discs used.

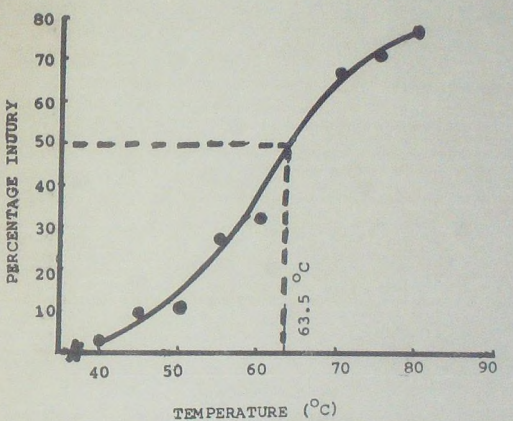
In all the three clones, the data showed highly significant correlations between the values obtained by the two and suitable regression equations could be developed to convert psychrometric valves into pressure chamber values (Table 14). Analysis of the data showed that regression co-efficients of pressure chamber values on psychrometric values obtained for the individual clones are not different from each other. Accordingly values obtained from the three clones were pooled separately and a common regression equation was developed to estimate pressure chamber value of leaf water potential from observed psychrometric value. The equation thus developed is

$$Y = 0.9195X - 0.0201.$$ (Fig. 8)

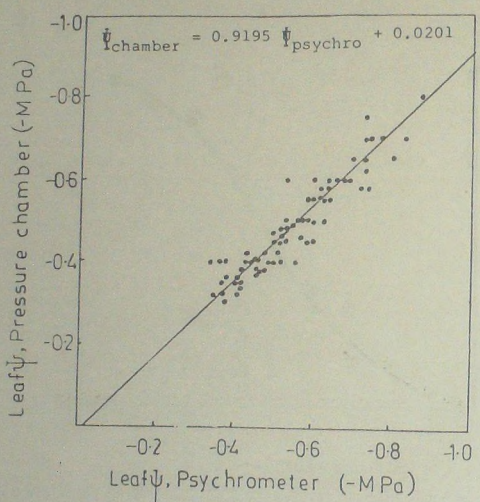
Where Y = Calculated pressure chamber value of ψ leaf

X = Observed psychrometric value of ψ leaf

The co-efficient of correlation between the pooled pressure chamber and psychrometric values of ψ leaf is 0.921 which is significant at one per cent error.



Phy. Fig. 7. Effects of different temperatures on the percentages of injury in the leaf discs of *Hevea brasiliensis*.



Phy. Fig. 8. Relation between the water potential (Ψ) of the same leaf measured by Pressure chamber and Psychrometer (Pooled data)

It can be concluded that when comparing data of Ψ leaf obtained by pressure chamber method with the data of ψ leaf obtained by psychrometric method, the later value can be converted into the former using the above equation. Moreover, it will be always better to transform the psychrometric value of ψ leaf into pressure chamber value as the later is close to the actual situation in plants.

Table Phy-14: *Leaf water potentials as measured by Pressure Chamber and Psychrometer.*

Clone	Instrument	Sample Mean ± SE (leaf Ψ Mpa.)	Variance	r	No. of observations
RRII 105	Psychrometer	0.604 ± 0.026	0.0193	0.914**	29
	Pressure Chamber	0.541 ± 0.024	0.0167		29
Gl 1	Psychrometer	0.510 ± 0.020	0.0120	0.945*	30
	Pressure Chamber	0.446 ± 0.019	0.0102		30
Tjir 1	Psychrometer	0.535 ± 0.016	0.0077		30
	Pressure Chamber	0.468 ± 0.015	0.0063	0.930**	30

16. **An easy method to estimate leaf area**

Estimation of leaf area becomes essential for studies connected with crop physiology. Use of leaf area meter for non-destructive measurements becomes tedious at times when the smaple size is large. Under such occasions measurements of leaflet lengths and breadths are useful to compute the leaf area using regression equations. Since the sizes of the individual leaflets of a leaf are also correlated, observations were made to see if length and breadth measurements of middle leaflet alone can be used to work out the area of whole leaf without much error.

Leaves were collected from the mature trees of clones RRII 105, Gl 1, RRIM 501, RRIM 623 and Tjir 1. Actual area of individual leaflets was measured using LI-3000 area meter. Lengths (L) and maximum breadths (B) were measured. Total leaf area (actual) was regressed on the product of length x breadth as given below.

1. Area of all the leaflets *Vs* L × B
2. Area of whole leaf *Vs* L × B of middle leaflet

The regression equations developed for computing areas of individual leaflets from its length and breadth measurements as well as for computing areas of whole leaves from the products of length and breadth of middle leaflets alone are given in Table 15. The test of significance of correlation coefficients has shown that a separate equation has to be used for the individual clones tested. The data also shows that the whole leaf area can be estimated by using the data on length and breadth of middle leaflet with more than 96 per cent accuracy.

Table Phy. 15. *Regression equations and correlation co-efficients of Leaf area vs length* x *breadth in a few clones of Hevea*

Clone	Middle leaflet	All leaflets
RRII 105	Y = 1.563X + 16.095 (r = 0.962)	Y = 0.597X + 1.321 (r = 0.986)
Gl 1	Y = 17.66X + 7.318 (r = 0.974)	Y = 0.616X + 0.587 (r = 0.997)
RRIM 501	Y = 1.678X + 10.955 (r = 0.974)	Y = 0.610X + 0.938 (r = 0.996)
RRIM 623	Y = 1.871X + 5.007 (r = 0.987)	Y = 0.673X — 0.694 (r = 0.993)
Tjir 1	Y = 1.736X + 8.841 (r = 0.986)	Y = 0.694X — 0.971 (r = 0.990)

Y = Actual Leaf area (cm^2)
X = Product of length x breadth

17. **Solution culture of young *Hevea* plants**

Solution culture method was tried to study root growth, nutrient uptake, water uptake and water stress in young plants.

Six month old young seedlings were uprooted with minimum damage to roots. Soil particles were washed off and the root portions were inserted into glass bottles (3 l) containing 1/4 strength Hoagland culture solution adjusted to pH 6.00. The solutions were aerated daily and changed once in a week. Micro nutrients were added twice in a week. The plants started showing root growth and shoot growth in around three weeks time. The strength of the culture solution was made to full at the time of initiation of fresh growth. Fresh growth of shoot and roots were observed up to five months before termination of the experiment. Similar experiments were also conducted with rooted budded stumps with one whorl of leaves and with freshly prepared budded stumps (Fig. 9A–9D). The method was found successful in these cases also. The method is now being used for simulating water stress using carbowax. Studies on photosynthesis in these plants have been initiated (Fig. 10).

18. **Effects of different exploitation systems on the yields of modern *Hevea* clones**

Clone RRII 105 is a high yielding clone (2000 kg year^{-1}ha^{-1}) which has become very popular among growers and substantial area has come under this clone. In this clone, the tapping system generally followed is 1/2 S d/2. However, higher incidence of brown bast is being reported by some growers. It is probable that the incidence of brown bast might be reduced by changing the exploitation system without much reduction in net profit. Adoption of the less intensive system of 1/2 S d/3 is one such possibility.

In the absence of sufficient data, a study was taken up at CES in 1985 to evaluate the effects of different tapping intensities on the yield and incidence of brown bast in clone RRII 105 (1975 planting BO 1 panel). The tapping systems imposed were 1/2 S d/2, 1/2 S d/3 and 1/4 S ↓ ↑ d/2 (tt) and the statistical lay out, was completely randomised design with 30 trees under observation in each plot, with four replications per treatment.

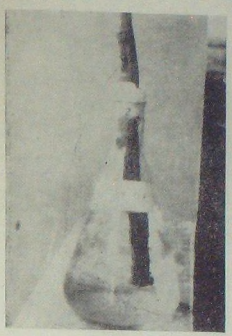
Mean values of dry rubber yield, latex volume, dry rubber content and per cent of brown bast trees were worked out from the data collected in the first nine months and are given in Table 16. During the initial nine months of tapping highest yield is obtained from trees under 1/2 S d/2 system of tapping. Under 1/2 S d/3 system the yield is 17.3 per cent lower and under 1/4 S ↑ ↓ d/2(tt), it is 31.4 per cent lower. The volume of latex per tree per tap is only 6.8 per cent more in trees under 1/2 S d/3 system as compared to the volume obtained from trees under 1/2 S d/2 system. However, the volume is very low from trees under 1/4 S ↑ ↓ d/2 (tt) system.

Table Phys. 16. *Effects of different tapping systems on dry rubber yield, latex volume, dry rubber percentage and incidence of brown bast in clone RRII 105**

Tapping System	Dry rubber yield** (kg/ha/9months)	Volume of latex tree/tapp**	Dry rubber content (%)	%of brown bast trees
1/2 S d/2	1027.25	153.2	33.46	10.8
1/2 S d/3	845.50	163.6	35.84	3.3
1/4 S↑ ↓d/2 (tt)	704.25	105.2	35.37	6.7
S D (0.05)	11.90	15.34	1.29	NS

*The data given is for the period from July 1985 to March 1986 and per hectare yield is yield/300 trees.

**Significant at 0.05 % error.



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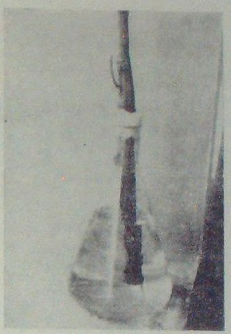

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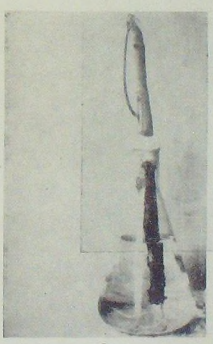

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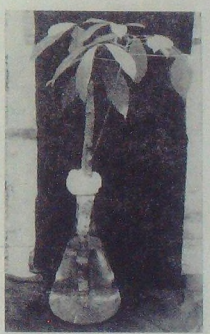
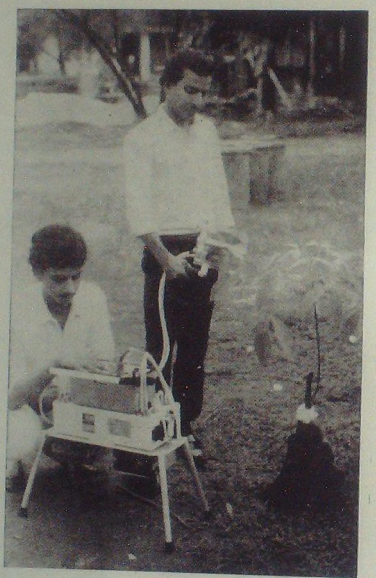


D

Phy. Fig. 9. (A–D) Solution culture of freshly prepared budded stumps of clone RRIM 600—Growth Stages. (A. Sprouting of bud; B & C. growing scion; D. with one whorl of leaves).



Phy. Fig. 10. Measurement of photosynthesis using LI-6200 Portable photosynthesis system.

The dry rubber content was around 2% more in the latex samples obtained from trees under 1/2 S d/3 and 1/4 S ↑ ↓ d/2 (tt) systems of tapping compared to that in the samples from trees under 1/2 S d/2 system. Though statistically not significant, the incidence of brown bast was highest in the plots under 1/2 S d/2 system of tapping and lowest in the plots under 1/2 S d/3 system of tapping. The trial is in progress.

A new project on physiological evaluation of tapping systems on modern *Hevea* clones was initiated at *Hevea* Breeding Station, Karnataka.

19. **Development of more efficient exploitation system after BI 2 stage**

A large proportion of our present plantation in BI 2 stage are low yielders and intensive exploitation is therefore called for. A trial was laid out at Pullangode Estate in 1985, with the following treatments on (Tjir 1) seedling trees of 1963 planting.

T1 = 2 x 1/2S ↑ ↓ d/1 (tt) T4 = 1/4 S ↑ +1/2 S ↓ d/1

T2 = 1/4 S ↑ +1/2 S ↓ d/2 (tt) T5 = 2 x 1/2 S ↑ ↓ d/2

T3 = 2 x 1/2 S ↑ ↓ d/2 (tt) T6 = 1/4 S ↑ +1/2 S ↓ d/2

Block yields per tap was collected regularly and the yield data are presented in (Fig.11) The double cut exploitation system, 2 x 1/2 S ↑ ↓ d/1 (tt) gave yield of around 2000 kg dry rubber per block per year. This is much higher than the average yield of 1000 kg with (normal) system of tapping. The system 2 x 1/2 S ↑ ↓ d/2 also has recorded an yield of 1600 kg/block/year. (Fig. 11)

20. **Studies on the effect of stimulants on girth increment**

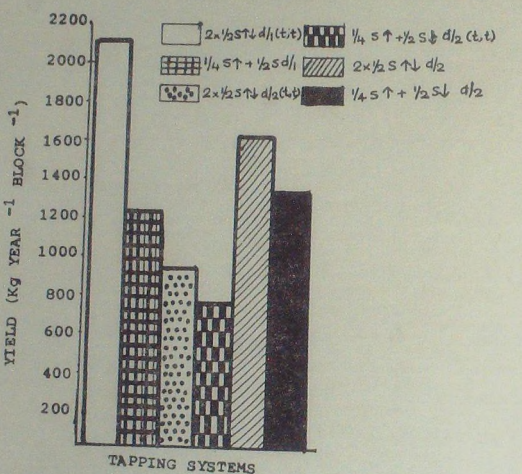
There are some reports that puncture tapping results in higher girth increment as against the normal cut tapping. In order to assess the possibility of the stimulants used in puncture tapping having any effect of girth increment, a trial was initiated to find out if application of stimulants at pre-tapping stage would enhance the girth rate. The results indicate no such effect. In another trial on puncture tapping, no significant difference in girth increment was obtained between puncture tapped trees and trees under normal tapping.

Other new projects initiated in exploitation are

— Effects of different exploitation systems on 'k' and 'c' factors.

— Effects of different rest periods on the yield performances and girth increments during B0 1 and B0 2 stages.

— Effect of an ayurvedic (indigenous) oil on the prevention of brown bast incidence.



Phy. Fig. 11. Effects of different tapping systems on the annual yields of rubber (Tjir 1, clonal material) in BI-2 stage. (45 per cent and 52 per cent tappings days were lost due to labour problem in treatments 2×1/2 S ↑ ↓ d/2 (t, t) and 1/4 S ↑ + 1/2 S ↓ d/2 (t, t) respectively).

Rubber Chemistry, Physics and Technology Division

The Division concentrates on improving the quality of raw natural rubber and products made therefrom. The thrust areas of research include

1. primary processing of NR
2. chemical modification
3. reclamation
4. rubber technology

1. Preparation and application of depolymerised natural rubber

Rubber in liquid form is suitable for various special applications. Though liquid synthetic rubber can easily be produced by suitably modifying the reaction conditions, production of liquid NR needs depolymerisation. The project was taken up to standardise a process for thermal depolymerisation of NR.

An equipment was fabricated for preparing depolymerised NR. Ten trials were conducted to assess the performance of the equipment. During the initial trials, the time taken for attaining 200°C was 2 hrs. This was rectified and it is possible to get 200°C by 30-40' heating time. However, it was observed that control of temperature in the desired level is difficult and the equipment gave an accuracy of ± 17°C only.

The following trials were again done to study the effect of heating time on viscosity of the product, effect of peptiser on viscosity and to check the consistency of the product obtained at a particular condition. Results are given in Table 1.

Table - Chem. 1. *Effect of heating time and peptiser on viscosity*

Expt. No.	Material used	Heating time (hr)	Temperature (C°)	Brookfield viscosity RVT, spindle7 5 RPM, 38°C (CPS)
I	NR	2	220°C	8,00,000
II	NR	3	220°C	1,32,000
III	NR	4	220°C	1,04,000
IV	NR + 0°2 phr Renacit 7	2	220°C	1,38,000
V	,,	4	220°C	32,000
VI	,,	4	220°C	40,800
VII	,,	4	220°C	27,200

It was observed that addition of peptiser and increase in heating time decrease the viscosity of liquid rubber. But on repeating the experiment at a particular set of conditions, liquid rubber samples of consistent viscosity was not obtained.

2. Graft co-polymerisation of vinyl monomers on Natural Rubber

The main objective of this project is to modify natural rubber by grafting other polymers on it. Grafting of polyacrylonitrile is expected to improve the oil resistance of NR, such that the modified rubber could be used as a substitute for nitrile rubbers.

The conditions were standardised for preparing acrylonitrile graft NR using gamma radiation. The graft NR, of varying acrylonitrile content, was prepared using the standardised method. The percentage of graft rubber and free polyacrylonitrile present in the rubber obtained were determined (Table 2). The technological properties of these graft rubbers were ascertained in comparison with those of nitrile rubber (Table 3).

Table - Chem. 2. *Characterisation of the graft co-polymer*

Radiation dose (MR)	NR-AN ratio	Free NR (%)	Free poly AN (%)	Graft rubber (%)
0.075	60:40	46.2	9.8	43.9
0.15	60:40	39.3	12.9	47.8
0.30	60:40	21.2	18.3	60.5
0.45	60:40	12.7	18.9	68.4
0.60	60:40	8.6	19.5	71.9
0.75	60:40	7.4	19.9	72.7
0.90	60:40	4.9	20:99	74.1
0.45	80:20	17.7	10.9	72.0
0.45	70:30	13.9	17.2	68.9
0.45	60:40	11.1	21.7	67.2
0.45	50:50	7.2	28.4	64.4

It was seen that as the radiation dose is increased the amount of graft rubber formed is also increased. However as the dose was increased above 0.45 MR, the increase in the amount of graft rubber was not much appreciable, indicating that the dose of 0.45 MRis optimum.

Table - Chem. 3. *Technological properties of graft NR*

Properties	NR:AN 80:20	NR:AN 70:30	NR:AN 60:40	NR:AN 50:50	NR alone	Nitrile Rubber
1. Modulus at 300% elongation	64	87	102	..	45	31
r.a.a. at 70°C for 96 hrs (%)	118	114	103	..	104	110
2. Tensile strength (Kg/Cm^2)	178	148	106	89	243	94
r.a.a.at 70°C for 96 hrs (%)	97	97	99	108	93	105
3. Elongation at break (%)	503	383	220	65	746	538
r.a.a. at 70°C for 96 hrs (%)	92	89	93	55	83	98
4. Tear strength (Kg/Cm)	60	68	59	42	74	49
5. Hardness (Shore A)	64	74	86	96	51	54
6. Compression set (%)	23.5	29.8	47.3	57.7	17.8	28.4
7. Heat build up 50°C ($\triangle$T°C)	34	46	62	68	21	73
8. Swelling in petrol after 70 hrs (%)	84.75	76.3	54	38.5	122.5	11
9. Swelling in hydraulic oil after 70 hrs (%)	23.6	16	9.6	6.0	32.2	0.005
10. Resilience (%)	56	43	40	35	61	39

As the acrylonitrile content is increased, oil and solvent resistance of NR is increased. But the increase in oil and solvent resistance is not upto that of nitrile rubber. Other properties such as tensile strength, elongation at break and compression set resistance are decreased as the acrylonitrile content is increased.

3. Utilisation of waste material from latex goods manufacturing industry

Latex based rubber products manufacturing industry wastes 10-15% of the rubber consumed. No attempt was hitherto made to reclaim this rubber rich waste.

A method for reclaiming waste from latex goods manufacturing industry was standardised. The reclaimed rubber so obtained was characterised. Effect of incorporation of different levels of reclaim on the processing and physical properties of NR compounds was also studied. Jeep and car tyre treads were made using this reclaimed rubber and the service properties were evaluated.

It was found that the waste latex products, after powdering by milling on hot mill and treating with activated pentacholoro thiophenol (Renacit VII) at 140°C for 30 minutes, yielded a reclaimed rubber suitable for compounding with normal grades of rubber. Vulcanisates containing equivalent quantities of the new reclaim were found to have better overall properties than those containing whole tyre reclaim.

4. Development of chemical resistant natural rubber compound

The aim of this project is to develop suitable heat and chemical resistant natural rubber compounds. Natural rubber is a known acid and alkali resistant polymer except at very high concentrations and very high temperatures. Fundamental study involved in this project is the nature of failure of the vulcanisates in these media.

Ageing of six natural rubber gum compounds at 70°C for 166 hours with three different systems of cure (conventional, semi EV and EV system), with and without antioxidants, was studied. The media used were 10% H_2SO_4, 10% NaOH, distilled water and air. A similar ageing study was conducted at 90°C for 166 hr. Ageing of SBR gum compound at 90°C for 166 hr and ageing of natural rubber gum compounds (conventional system) for varying periods were also studied.

The results revealed that the properties of the aged vulcanisates depend on the temperature of ageing and period of ageing. Vulcanisate properties were found to depend on the type of curing system, semi EV and EV systems showed better retention of properties after ageing. The properties of the vulcanisates were not found deteriorating markedly by ageing at 90°C for 166 hours in acid and alkali media. Properties of the vulcanisates after ageing at 90°C for 166 hr, however, were found to have deteriorated.

5. Studies on blooming

The project was started with a view to minimise the blooming of chemicals (accelerators, antioxidants, sulphur etc.) on the surface of finished rubber articles like hot water bottles. The migration of chemicals to the surface of the vulcanised rubber goods diminishes the appearance and causes fading of coloured ones.

Coloured sheets with the following recipe, incorporating 5, 10 & 15 pphr of LDPE were prepared.

	I	II	III	IV
Natural rubber	100	95	90	85
Low density polyethylene	..	5	10	15
Zinc oxide	4	4	4	4
Stearic acid	1.5	1.5	1.5	1.5
Antioxidant SP	1.0	1.0	1.0	1.0
MBTS ..	0.7	0.7	0.7	0.7
TMT ..	0.1	0.1	0.1	0.1
Sulphur ..	2.5	2.5	2.5	2.5
Benzoquinone	1.0	1.0	1.0	1.0
Titanium dioxide	5	5	5	5
Colour (blue)	0.2	0.2	0.2	0.2

In order to understand the effect of cure time on blooming, the vulcanisation was done to different states of cure.

For understanding the effect of cure temperature, these compounds were vulcanised at 140°C, 150°C and 160°C. Blending of LDPE with NR was carried out in laboratory intermix at 40 RPM and at temperature 75-80°C.

Another trial was to note the effect of antioxidants. In this case one compound was prepared with antioxidant and one without antioxidant. The third trial was to minimise the level of activators (stearic acid/zinc oxide). In this case 0.5 phr lauric acid/2 phr ZnO system was used. Yet another study was conducted to find out the effect of mould release agent, cooling water, air and light. Samples were vulcanised without mould release agent, without cooling after vulcanisation and keeping the vulcanised sheets covered in polythene. Conventional cure systems were used in all the above cases.

Blooming was observed in all cases, irrespective of the state of cure or the temperature. No effect of antioxidant was observed ie; in both cases there occured blooming. Decreasing the levels of activators had no effect in reducing the bloom. When the samples were enclosed in polythene covers and observed, there was no tendency for blooming even after long periods of time. In the EV system of curing also blooming was apparent.

6. **Studies on compression set of NR vulcanisates**

The aim of this project is to determine the compression set of NR vulcanisates at near ambient and low temperatures and to study the influence of compounding variables on the value of compression sets. This includes study on the effect of different types of fillers and their loading, different cure systems and plasticizers, antioxidants etc.

NR gum compounds were prepared (without any filler). All three cure systems ie conventional (C), efficient vulcanisation (EV) and peroxide (P) were used in each case, as shown below.

(a) **NR Gum Compound**

	C	EV	P
Natural Rubber	100	100	100
Stearic acid	2	2	..
ZnO	4	4	..
CBS	0.6	2.0	..
TMT	..	1.5	..
Sulphur	2.5	0.5	..
Dicumyl peroxide	..	..	4.25

Compression set buttons were prepared from this compound and compression set values were determined.

In a second experiment a reinforcing black filler (HAF black) was used as per the recipe given under.

	C	EV	P
Natural Rubber	100	100	100
Stearic acid	2	2	..
Zno	4	4	..
HAF black	50	50	50
Naphthenic oil	5	5	5
CBS	0.6	2.0	..
TMT	..	1.5	..
DCP	..	..	4.25

In the third trial, a non reinforcing non-black filler was used (china clay). The recipe was the same as above except for the filler. Clay was used to a level of 100 pphr, for all three systems of cure.

In another experiment the loading of HAF black was increased to 60 pphr instead of the usual 50 pphr.

In all the above cases, compression set values were determined for different time and temperatures. The results are given in the following tables.

Table - Chem. 4. *Compression set of NR gum compound*

Sample	Cure time Min. at 150° C	C.S. at 70°C/22 hrs.	C. S. at 50°C/22 hrs
C	12.5	31.4	20.8
EV	14	11.6	9.5
P	42	5.0	4.15

Table - Chem. 5 *Compression set of NR compound with reinforcing black (HAF) filler(50 pphr)*

Sample	Cure time at 150°C Min.	C.S. at 70°C/ 22. hrs
C	11	34.6
EV	6.5	13.6
P	41.5	8.7

Table - Chem. 6. *Compression set of NR compound with 60 pphr HAF*

Sample	Cure time Min. at		Compression set at			
	150°C	70°C/22hrs	50°C/22hrs	29°C/22hrs	20°C/22hrs	29°C/96 hrs
C	14	60	57	54	50.5	53
EV	15	56	53	51	49	50.5
P	48.5	52	51	49.5	46	49.5

The results indicate that as the test temperature is lowered, the difference among the three cure systems decreases.

7. **Studies on Natural Rubber - 1, 2 polybutadiene blends**

The project was initiated with a view to improving the ozone resistance and heat resistance of natural rubber, by blending with thermoplastic 1, 2 polybutadiene. Blends of NR and 1, 2 polybutadiene were prepared in different proportiions. Compounds having conventional and efficient cure systems were prepared using these blends. The processing characteristics, physical properties, ageing and ozone resistances of the compounds prepared from the above blends were evaluated. The details of the blend ratios and the compounding recipes used for the evaluation are given in tables 7 and 8.

Table - Chem 7. *Blend ratios*

Polymer	Ao	A	B	C	D	E	F	G	H
Natural rubber	100	90	80	70	60	50	40	20	0
1, 2 polybutadiene	0	10	20	30	40	50	60	70	100

Table - Chem. 8. *Compounding recipes*

Ingredients	Conventional system	EV system
Polymer ..	100.0	100.0
Zinc oxide ..	5.0	5.0
Stearic acid ..	1.0	1.0
Phenyl-β-naphthyl amine	1.0	1.0
N-cyclohexyl benzo thiazyl sulphenamide	0.6	1.5
Sulphur ..	2.5	0.5
Tetramethyl thiuram disulphide	..	1.75
	Represented by Ao,A,B,C,D,E,F,G and H.	Represented by Ao^1,A^1,B^1,C^1,D^1, E^1,F^1,G^1,and H^1.

The cure characteristics, physical properties, ageing and ozone resistances of the blends containing conventional system of cure are given in tables 9 to 11 and those of the blends containing EV system of cure are given in tables 12 to 14.

The cure time and scorch time increased and the cure rate index decreased as the proportion of 1, 2 polybutadiene in the blend was decreased. The tensile strength decreased with an increase in proportion of 1, 2 poly butadiene. The tear strength, compression set and hardness increased with increase in 1,2 PB content of the blend. The ageing resistance was better for those blends which contained a higher proportion of 1, 2 PB. The ozone resistance of NR was improved remarkably even by adding small quantities (30 parts) of 1,2 poly butadiene.

Table - Chem. 9. *Cure characteristics of the Blends at* 150°C

Parameter	Ao	A	B	C	D	E	F	G	H
Maximum torque d N.m	62	58	56	55	53	51	48	48	47
Minimum torque d N.m	4.5	4	4	4	3.5	2.5	2.5	2.0	1.0
Cure time t90, Min	12.5	15	16	19	22.5	29.5	47	50	75
Scorch time t2, Min	6.5	8.75	9.0	9.5	10.5	10.75	14.5	24.5	50
Cure rate index $\frac{100}{(t\,90-t2)}$	16.7	16.0	13.8	10.5	8.2	5.3	3.1	3.9	4.0

Table - Chem. 10. *Physical properties of the blends*

Sample No.	Tensile strength MPa	Elongation at break 1%	Modulus 300% 1 MPa	Tear strength KN/m	Hardness shore A	Compression set 1%	Din abrasion loss mm^3	Volume fraction of rubber Vr
Ao	24.7	1048	1.86	37	34	34.9	159	0.2007
A	25.3	997	2.26	39	38	34.0	133	0.1909
B	23.7	927	2.65	39	45	41.5	124	0.1839
C	21.3	930	3.04	45	50	41.5	95	0.1792
D	16.9	835	3.43	47	56	41.3	142	0.1724
E	16.1	831	3.83	48	65	46.8	151	0.1626
F	15.9	810	4.32	48	67	53.4	152	0.1574
G	13.5	748	5.30	57	75	72.9	154	0.1231
H	14.5	665	6.77	61	80	81.0	153	0.1096

Table - Chem. 11 **Ageing and* ***ozone resistances*

Sample No.	Percentage retained after ageing				Time for initiation of of cracks (h)
	Tensile strength	Elongation at break	Modulus 300%	Tear strength	
Ao	35	61	104	57	2
A	32	64	95	56	2
B	27	44	102	46	2
C	22	45	104	46	4
D	24	36	120	57	4
E	32	40	123	64	4
F	47	47	132	82	14
G	77	61	128	96	> 50
H	82	63	125	138	> 50

*Ageing at 100°C for 96 hours
**Ozone at 40°C, 50 pphm concentration

Table - Chem. 12. *Cure characteristics of the blends at* 150°C

Parameter	A'o	A	B	C	D	E	F	G	H
Maximum torque, d N.m	64.5	63.5	63.0	62.0	61.0	61.0	59.0	60.0	65.0
Minimum torque, d N. m	5.0	6.0	7.5	7.5	7.0	5.0	3.5	2.5	2.5
Cure time t90, Min	7.5	7.5	8.5	9.0	10.0	10.5	11.5	15.5	17.0
Scorch time t2, Min	3.75	3.75	4.0	4.0	4.0	4.25	4.50	5.50	6.25
Cure rate index $\frac{100}{(t90-t2)}$	26.7	26.7	21.0	20.0	16.7	16.0	14.3	10.3	9.3

Table - Chem. 13. *Physical properties of the blends*

Sample No.	Tensile strength MPa	Elongation at break%	Modulus 300% MPa	Tear strength KN/m	Hardness shore A	Compression set%	Du pont Abrassion loss CC/h	Volume fraction of rubber Vr
Ao'	21.4	899	1.88	35.3	38	15.3	4.60	0.2011
A'	20.4	818	2.34	35.0	41	17.9	1.98	0.2004
B'	19.7	785	2.75	38.1	46	19.9	0.65	0.1878
C'	19.2	762	3.27	40.0	52	24.4	0.36	0.1842
D'	13.9	689	3.67	43.9	57	28.3	0.28	0.1802
E'	7.9	487	4.37	46.3	62	32.5	0.20	0.1776
F'	5.8	339	5.12	44.0	66	46.0	0.54	0.1727
G'	8.2	367	6.8	53.0	73	52.5	3.00	0.1709
H'	11.5	397	8.6	61.0	76	63.9	3.86	0.1775

Table - Chem. 14 *Ageing* and ozone** resistances*

Sample No.	Percentage retained after ageing				Time for initiation of cracks (h)
	Tensile strength	Elongation at break	Modulus 300%	Tear streangth	
Ao'	69.6	68.8	180.8	82	2
A'	68.1	68.2	156.9	88	2
B'	29.0	40.0	143	87	2
C'	29.0	32.8	137.0	84	4
D'	31.7	33.0	...	73	5
E'	56.0	49.0	...	63	7
F'	79.8	64.6	...	75	> 50
G'	82.9	70.3	...	92	> 50
H'	95.6	84.9	...	103	> 50

Ageing* - At 100°C for 96 hours

Ozone** - At 40°C, 50 pphm concentration

8. **Studies on ozone resistance of NR/Ethylene/Propylene rubbers**

The broad objective of the project is to improve the ozone resistance of NR by blending with ozone resistant rubbers like EPDM. The work done earlier showed that blending of EPDM with NR improves the ozone resistance remarkably. It was also observed that as the proportion of EPDM was increased there was a progressive improvement in the ozone resistance. However, when the proportion of EPDM was raised above 20 parts the general physical properties like tensile strength decreased. Therefore it was thought worth examining the use of a fully saturated polymer like EPM in blends with NR to improve the ozone resistance of the latter.

A series of blends of NR and ethylene propylene rubber (EPM) were prepared. Although EPM is crosslinked only with peroxides, both peroxide and sulphur crosslinking systems were used in the study. The latter was used to see whether the presence of uncrosslinked EPM in a crosslinked NR matrix would improve ozone resistance of the latter. The ozone resistance of the vulcanizates was measured in terms of the critical stress-strain parameters.

Ozone resistance of the blends in terms of the critical stress-strain parameters is given in table 15.

Table - Chem. 15. *Ozone resistance of NR/EPM blends*

Sl. No.	Blend ratio NR EPM	Crosslinking system	Elastic modulus, MPa	Critical stress, MPa	Critical strain (Ec(%)	Critical stored elastic energy density, Wc KJ(m^3)
1	100:0	S/CBS	1.13	0.1051	10.16	5.7
2	90:10	,,	1.11	0.0883	8.63	3.9
3	80:20	,,	0.86	0.1760	25.85	31.3
4	70:30	,,	0.81	0.1791	28.19	36.1
5	60:40	,,	0.84	0.3027	56.80	192.7
6	100:0	Peroxide DCP	1.41	0.1378	10.84	8.0
7	90:10	,,	1.65	0.2465	17.57	26.1
8	80:20	,,	1.84	0.4488	32.18	191.2
9	70:30	,,	..	0.7541	80.96	979.7
10	60:40	,,	..	1.1136	140.86	5635.2

The data showed that blending of EPM with NR improves ozone resistance of the latter considerably. Crosslinking of the EPM phase is necessary in realising high ozone resistance. It was also revealed that a blend ratio of 80:20 gives adequate protection.

9. **Development of Rubber Components for engineering applications**

As the first step of this work, the specifications for automotive rubber components from automobile manufactures and a few international institutions were collected. On examining, it was found that most of the specifications can be met by natural rubber compounds.

The specific properties which improve the performance of the mounting are its high damping character and low creep behaviour. NR inherently is having low creep character but comparatively low damping property. Butyl rubber is having very high damping property but it exhibits very high creep which makes it less suitable for mounting applications.

Developing a high damping and low creep NR compound will be highly useful in vibration damping fields. This can be achieved either by chemical modification or by blending NR with a suitable synthetic rubber. This project was mainly concentrated on blending of natural rubber with synthetic rubber to attain the said properties. Studies were undertaken on natural rubber and neoprene rubber and natural rubber and nitrile blends.

Physical properties of the blends were evaluated. In the above two blends resilience which is an indirect measure of damping was found decreasing as the synthetic rubber content increased. The properties of a few compounds which were reported to be useful for mounting applications were also studied.

Agricultural Economics Division

The Agricultural Economics Division was organised in 1986. The Economics Research Unit formerly attached to the Rubber Production Department of the Rubber Board was merged in the new division. The division undertakes economics studies connected with various investigations.

1. STUDY OF PRODUCTION, CONSUMPTION AND UTILISATION OF RUBBER WOOD

A study was undertaken in 1985 by visiting all the important centres of rubber wood consumption in Madras (Tamil Nadu). The estimated consumption of rubber wood in this city was 87695m^3. The study also revealed that approximately 84865m^3 rubber wood was consumed by the plywood, veneers and splinters sectors.

2. STUDY OF PRODUCTION, CONSUMPTION AND UTILISATION OF RUBBER SEED OIL

Although about 90 per cent of the area under rubber is situated in Kerala, the rubber seed oil extracting industry is situated in Tamil Nadu. The estimate of rubber seed oil production was made by visiting important centres in Tamil Nadu. The production of rubber seed oil during 1985 was found to be about 4,000 tonnes.

3. STUDY OF FARM GATE PRICE OBTAINED BY SMALL RUBBER GROWERS

The study aims at estimating the percentage of terminal price received by the rubber growers in Kottayam district of Kerala. A questionnaire has been designed for this purpose. A sample of 50 dealers was selected in Kanjirappally and Changanacherry Taluks. Collection of data is in progress.

4. STUDY OF THE EVALUATION OF PLANTING MATERIALS UNDER COMMERCIAL PLANTING

Evaluation of planting materials under commercial planting was continued. Data of monthly yield were collected from the participating estates. In order to ensure accuracy of the data four estates were visited and the production figures were verified.

5. ECONOMICS OF DIFFERENT LEVELS OF FERTILISER APPLICATION

A study has been initiated to find out the various manurial practices commonly followed, maily in this small holding sector. Preliminary work has been taken up during the period under report.

6. PRODUCTIVITY IN REPLANTED SMALL HOLDINGS

The study has been taken with a view to finding out the performance of replantings in small holdings with respect to productivity. To enhance the coverage of the study steps were taken for identifying more units replanted with RRII 105 and details like name, address and location were collected from 100 growers.

7. STUDY OF COVER CROPS AND SAVING IN THE COST OF PRODUCTION

Preliminary work relating to the study was completed during the period.

8. STUDY OF INTERCROPS IN SMALL HOLDINGS

Under the replanting and newplanting scheme of the Rubber Board a certain number of intercrops are allowed in the holdings during the first three years of immaturity period. To find out the best intercrop from the point of view of income generated to the rubber growers a study has been taken up in Kottayam district. During the period under report details were collected from 63 small growers.

9. STUDY OF THE EXTENT OF AREA PLANTED WITH RRII 105

With a view to monitoring the performance of RRII 105 under actual commercial practice, the study has been initiated. During the period relevant data were collected from respective regional offices covering Nagercoil, Pathanamthitta, Punalur, Changanacherry, Kottayam, Palai, Thodupuzha, Moovattupuzha, Trichur, Palghat, Kanjirappally, Ernakulam, Calicut, Nilamboor, Tellicherry and Taliparamba.

10. SMALL HOLDING MANAGEMENT AT DIFFERENT LEVELS OF INPUTS

The smallholders generally follow different forms of management. While some of them avail all the facilities available from the Rubber Board, Commercial Banks and Co-operative Banks, others avail of the facilities only partially. Some do not avail of any facilities at all. In order to find out the management performance of these growers a study has been initiated. A questionnaire has been prepared and a sample of small growers was selected in Palai region.

Research Complex for North-East Region

The Research Complex of the Rubber Research Institute of India for the North-East Region has its headquarters at Guwahati. The Complex has Regional Research Stations in Agartala (Tripura), Sarutari (Assam), Kolasib (Mizoram), Tura (Meghalaya) and Darachigre (Meghalaya).

Regional Research Station, Agartala

The station had 18 projects during the period under report. Out of these 18 projects, 12 projects were continued from the previous years and in addition 6 new projects were undertaken during the period. The station was hit by a violent hail storm on 3rd of April 1986 and as a consequence the entire field experiments were severely affected. The experiments planted during 1982 and later are to be replanted since the damages inflicted are beyond recovery. However, recordings of observations were continued in some of these trials and also routine recording of data were carried out in those trials planted prior to 1982.

Nutritional Trial

The trial is aimed at studying the optimum requirement of major nutrients for Hevea under the agroclimatic conditions prevailing in this region. The trial commenced in 1980 covering an area of 4.8 ha on clone RRIM 600 laid out in a factorial confounded design. Routine cultural operations were carried out during the period under report. Girth of the plants were recorded in May and November 1986. The plants were severely affected by hail storm and as a result one side of the trunk was severely damaged.

The data collected so far are being analysed. Soil and leaf samples were also collected from the trial for assessing the nutritional status and the analysis is underway.

Trial on Planting Technique

This trial is a comparison of different planting materials aimed at finding out the extent of reduction in immaturity period of rubber possible by the use of different advanced planting materials. The trial was started in 1981 using clone RRIM 600, laid out in randomised block design covering an area of 1.5 ha. In the trial five different types of planting materials are being assessed. The data on girth recorded during the year (May and November 1986) are given below.

Table - NEA-1: *Mean girth and girth increment of plants under different planting techniques*

Treatment	Mean Girth (cm)		Girth increment (cm)
	May/86*	Nov.86	May to Nov. 86
Conventional brown stumps from 1980 nursery budded during 1981.	23.44	30.71	7.25
Brown budded stumps from 1979 nursery budded during 1980 and allowed to grow in nursery till 1981.	24.30	31.36	6.98
Brown budded stumps from 1979 nursery budded during 1981.	24.96	31.42	6.46
Two months old green budded polybag plants.	25.46	32.92	7.46
Fourteen months old green budded polybag plants.	32.10	37.35	6.97

*After hailstorm.

Soil and leaf samples were collected from the trial for assessing the nutritional status and the analysis is underway.

Studies on Intercropping

This experiment was taken up in 1982 to study the economics of intercrops and their effect on growth of rubber. RRII 105 was the clone used and the experiment was laid out in randomised block design with 6 treatments covering an area of 1.15 ha. This trial was severely affected by hail storm and it is beyond recovery. Due to an appreciable amount of loss suffered to the pineapple crop during the hail storm, a realistic assessment of the treatment was not possible. However, soil samples would be collected making use of core samples for an evaluation of physical characteristics of the soil as influenced by the intercrops.

Studies on High Density Planting

This trial was started in the year 1983 with a view to study growth and yield of rubber under different density of planting and nutrient levels. Three densities were being tried with two clones laid out in a split plot design covering an area of 4.5 ha. This trial has also been damaged severely.

Nutritional Trial in Seedling Nursery

This trial was started in 1986 with a view to evolve an optimum fertiliser recommendation for seedling nursery with respect to the major nutrients. The trial was taken up with nutrient N, P and K at 4, 3 and 3 levels respectively. Before the commencement of the experiment pre-treatment girth and height of the plants were recorded from each plot. Soil samples were also collected during this period.

Density-cum-Nutritional Trial in Seedling Nursery

This trial was started in the year 1986 with a view to find out the influence of three doses of nutrients (one 20% below the recommended dose, another 20% above the recommended dose and the third one being the dose as per Board's recommendations). Three densities being tried are 200 plants, 188 plants and 160 plants per bed of size 12 x 1.2 m. A comparison of water solube and water insoluble forms of phosphorus is also attempted.

Forms of Phosphorus - Immature Phase

This trial was laid out in a randomised block design in 1986 with RRIM 600 as the planting material and the experiment covers an area of 1.5 ha. The trial had been taken up with a view to finding out the ideal type and combination of phosphatic fertiliser during the immature phase of Hevea. The planting was done using polybags during the last week of July and the treatments were incorporated during second week of October. Pre-treatment girth,height and number of flushes were recorded. Post-treatment recordings are being carried out at monthly intervals.

Nutrient Requirement during the Immature Phase of Hevea Planted using Polybagged Plants

This trial was taken up in the NRETC demonstration plot at Tulakona. The trial extents over an area of 1 ha. It was envisaged to incorporate magnesium also in the treatment. Due to non-availability of the fertiliser at the right time, the trial had to be confined to nutrients N, P and K. The trial was taken up with a view to assess the correct nutrient requirement during the initial phase of immaturity when planting is undertaken using polybag plants. There is no distinction made in our recommendation between budded stumps planting as well as polybag planting in the initial phase. With respect to nutrient management, higher nutrient dose would be tried during the first four years of planting with polybags and this would be compared with the existing recommendation. The comparison of water soluble and water insoluble forms also is attempted. The trial had been undertaken using the clone

RRIM 600 laid out in randomised block design and the trial commenced during the second week of November, 1986. Recording of pre-treatment girth, height and number of whorls was done. Quarterly recording of data for girth, height and number of whorls is envisaged.

Clone Trial

The girth of the plants at the height of 150 cm from the bud union was recorded in May, August and November 1986. RRIC 105 recorded the maximum girth while GI 1 gave the minimum girth.

Multidisciplinary Evaluation of Clones

Most of the plants were affected by hail storms and wind during April 1986. Fresh planting with 9 clones was carried out in July 1986.

Induction of Mutation

The plants were severely affected by hail storm during last April. The stem of most of the plants were affected by wind and hail storms causing trunk and branch snaps. The vacancy is high.

Optimum Season for Budding at Tripura

As per programme green budding was carried out in the 1986 nursery. Initial and final success were counted.

Selection from Polyclonal Population

The plants were severely affected by hail storm during last April. The stem of the plants were affected by wind and hail storm.

Mother Tree Selection

One, four and eight plants from Kalsimukh, TFDPC's plantation, Umbling and Wageasi Plantations under Soil Conservation Department, Meghalaya, respectively were marked on the basis of yield and secondary characters. Necessary arrangements had been made for recording the monthly yield.

Physiological Evaluation of Clones

The girth of the plants at 150 cm height from the bud union was recorded in September and November 1986.

The diurnal rhythms of different physiological parameters were worked out in different seasons. It has been observed that in October, highest stomatal conductance was at 8 AM and peak leaf temperature at 11 AM. The minimum leaf water potential (Ψ leaf) was observed at 11 AM during October. During January the highest stomatal conductance and leaf temperature was confound at 8.30 AM and 1.30 PM, respectively. The Ψ leaf was observed to be lowest at 11 .'30 AM.

Effect of Agrometeorological Factors on the Physiological Parameters Related to Growth of *Hevea brasiliense*

The following aspects are under study in this project:

(a) Growth analysis of five clones of *Hevea brasiliensis* under Agartala conditions.

(b) Effect of environmental parameters on influencing photosynthesis and water relations in young plants.

(c) Effect of environmental parameters on factors influencing photosynthesis and water relations in young plants with irrigation.

(d) Effect of artificial shading on interaction between physiological parameters and environmental parameters in young plants, and

(e) Differential response of sun and shade leaves of mature plants to environmental variations.

Physico-Chemical Characteristics of the Potential Rubber Growing Regions in the North-Eastern Region

This project has already been initiated and samples were collected from various studies in the North-Eastern Region. 211 samples from Tripura, 49 samples from Assam and 29 samples from Meghalaya were being analysed for available nutrients. Apart from these, three profiles, one each from Assam, Ganolgre and Darachigre (Tura) has also been collected. As a preliminary study a fertility survey is envisaged.

Regional Research Station, Sarutari

Multidisciplinary Evaluation of Clones

The experiment started during 1985 was continued. In order to study seasonal effects on the growth of rubber plants, height and girth measurements were recorded at pre-monsoon, post-monsoon, pre-winter and post-winter periods.

During the early stages, clone RRIM 600 recorded maximum growth followed by PB 5/51 and RRIM 605. During later stages clone GT 1 recorded higher growth rate. All the clones tried recorded satisfactory growth and the growth rate is comparable to that in traditional rubber growing areas.

Multidisciplinary Evaluation of Clones (1986)

Ten clones were planted in a single tree single plot completely randomized design. Ten clones are being evaluated in the trial.

Trials on the Comparison of Rock Phosphate and Water Soluble forms of Phosphorous for Young Rubber

An experiment was laid out with four treatments in R B D with 5 replications. The treatments are Rock Phosphate (continuous application), Super phosphate (continuous application), 50% Super phosphate, 50% Rock phosphate application, and No Phosphorous.

Nutritional Requirement in Seedling Nursery

In order to find out the optimum combination of N, P and K, a confounded factorial experiment involving 4 levels of N and 3 levels each of P and K was laid out with 3 replications. From the initial observations marked response to applied nutrients was evident.

Survey of Diseases Affecting Rubber in North-East Region

Incidence of Powdery mildew and leaf spot diseases were found to be very severe during winter season in the seedling nursery and in very young plants. Abnormal leaf fall caused by *Phytophthora* was found to be very mild, that too only in a few plantations of Meghalaya. Cases of root rot disease and Pink disease were very rare.

Regional Research Station, Ganolgre (Tura)

Multidisciplinary Evaluation of Clones

Data on mean height and girth of plants were recorded during February, May and August. The growth rate of all clones was found to be very good. Clone RRII 118 recorded maximum girth closely followed by GT 1, RRIM 600 and RRII 203.

Optimum NPK for Immature Phase

A 3^3 NPK factorial confounded experiment in RBD was laid out in North-Eastern Plantation, Mendipathar, East Garo Hills.

Nutritional Requirement in Seedling Nursery

In order to find out the optimum combination of N, P and K, a confounded factorial experiment involving 4 levels of N and 3 levels of P and K was laid out with 3 replications. From the initial observations marked response to applied nutrients was evident.

High Altitude Research Station, Darachigre (Tura)
Multidisciplinary Evaluation of Clones

An experiment on multidisciplinary evaluation of clones started in 1985 was in progress. During the winter season of 1984, about 30 per cent of plants showed defoliation due to the effect of low temperature. However, these plants refoliated subsequently. By December 1986 the defoliation started again and was seen in all the clones except RRII 118 which was found to be relatively tolerant. Even though the effect of low temperature was evident on young rubber plants, growth rate of plants during periods other than winter is found to be satisfactory. Clones RRII 105, RRII 118 and RRIM 600 recorded higher growth than other clones.

Agro-Management Technique for High Altitude

An experiment was started to evolve suitable agro-management techniques for ensuring maximum establishment of plants under high altitude situations with ten treatments. The initial establishment success was only 50 per cent and hence the treatment effects could not be compared.

Regional Research Station, Kolasib
Multidisciplinary Evaluation of Clones

Periodic observations on growth parameters revealed that RRIM 600 and RRII 105 performed better than other clones. Clone RRII 118, which has been observed to be very vigorous in other location is ranked only as third in respect to both height and girth of plants. The better girth rate recorded for GT 1 and PB 5/51 at Guwahati was not observed in this station.

Regional Research Station, Dapchari

A trial rubber plantation was established in 1981 at Dapchari (Maharashtra state) with a view to studying the constraints in extending rubber cultivation to the North Konkan region. The annual rainfall in the region is around 2500 mm contributed entirely by the south west monsoon and is distributed in the months June to October. The dry season extends from November to May. Mild winter is experienced in the months November to February when the mean maximum temperature is around 34°C and the minimum around 13°C. The mean maximum summer temperatures are around 40°C in the months of March, April and May. The soil is lateritic clay loam with reasonable water holding capacity. Drought and heat are the major stresses experienced in the region.

The various trials in progress in the station are:–

1. **Physiological evaluation of clones**

Plants raised in poly bags belonging to 12 promising clones were planted in 1982 as part of a multilocation trial for the non-traditional areas. The plants in the trial area were given limited irrigation during summer months. Clones RRIM 600, PR 107 and RRII 300 were found to be superior as compared to other clones.

2. **Drip irrigation trial**

A large drip irrigation trial was laid out in 1984 in an area of 5. 83 hactares where budded stumps of clones RRII 105 and RRII 118 were planted in 1983. There are seven treatments. The different drip irrigation treatments were disturbed by variations in pressure due to undulating nature of the land and due to insufficient filtering. A new trial was laid out in 1987.

3. **Dry farming techniques in *Hevea* cultivation**

A trial was laid out in 1986, on 1983 plants of clone RRII 105. The various treatments included are limited deep irrigation, pit irrigation, pitcher drip irrigation, dew catching materials, contact shading etc. The trial is in progress.

4. **1985 clone trial**

Poly bag plants of 15 clones were planted in 1985 for extending clone evaluation, the lay out being completely randomised design.

5. **Comparative costing of irrigated and rainfed *Hevea* cultivation**

Plants raised in poly bags were planted in 1987 for cost benefit analysis of irrigated and unirrigated cultivation of *Hevea*.

6. **Contact shading trial**

Under Dapchari conditions even plants raised in poly bags and planted in the field require shading with plaited coconut leaves during subsequent summer. As this is expensive and the raw material is not readily available, a trial was laid out in 1987 to test if contact shading of the young plants with China clay can substitute the conventional shading.

7. **Polyclonal trials**

Two thousand poly clonal seedlings were planted in 1985 and another 3000 in 1987 for field evaluation of comparative performance and subsequent selection.

Hevea Breeding Station

The Rubber Research Institute has initiated steps to establish a Hevea Breeding Station. The proposed station will have two substations, one in Paraliar, (Kanyakumari district, Tamil Nadu) and the other in Nettana (DK District, Karnataka). The substation in Paraliar is envisaged to have an area of 23.1 ha and that in Nettana 50 ha. In the former the emphasis will be on hand pollination and also nursery evaluation of the seedlings resultant of hand pollination as and when they become available. The substation in Nettana will have emphasis in the field evaluation of the new clones generated and also some of the field trials with other experimental materials. Pre-planting operations were initiated to establish seedling and budwood nurseries in both the sub stations.

Agrometeorology Unit

1. Weather Conditions at Experiment Stations

The general weather conditions during 1986 at the RRII and its Regional Research Stations were observed and analysed. The results are summarised and presented in Fig. 1. The rainfall distribution at the traditional areas, like Kottayam and Chethackal, has fairly monthly distribution during the season. The rainfall distribution at Dapchari (Konkan region of Maharashtra) is confined to middle of June to middle of October. About 50 per cent of the annual rainfall was received during July alone. The severe moisture stress conditions with high evaporation rates (9–10 mm/d) and high temperature (around 37°C) were noticed during April-May. At Agartala (Tripura) pronounced low temperatures of 8-9°C were noticed during January and the rainfall distribution extended upto the middle of November. The plantations were destroyed due to a severe hail-storm during first week of April. It was observed that the damage was severe at the edges than the inside as well as vallies.

In the traditional areas, the amount of water deficit varied from 79 to 202 mm, whereas in the non-traditional areas the values ranged from 274 to 1234 mm. At Dapchari, the water deficiency during the moisture stress period and the water surplus during the rainy season were just matched. Due to the heavy falls received during July 1986, the surface run off seems to be more than infiltration into the soil. At the traditional regions as well as at Agartala, a part of the available water surplus during the rainy season can be stored and made use for irrigation purposes, if required.

2. Studies on Climatic Variability, Water Balance and Drought

The inter-annual variability of rainfall and temperature at Kottaym during the past 30 years indicates that a steady increase in mean annual air temperature and a decrease in the amount of rainfall received over the region. The distribution of monthly rainfall at different probability levels (table-1) indicates that during December to March the rainfall is unevenly distributed. The chances of receiving average rainfall once in two years is less. The estimated plant evapotranspirational demand varies from 1550-1700 mm per year.

According to the Thornthwaite's water balance model, the agroclimate of Kottayam is humid (B_4) with little or no water deficiency. The index of moisture adequacy (Ima%) during different years indicates that slight or moderate to severe drought is a common phenomena during December to March. The moisture stress conditions, extending from March to May, will have a significant impact on the cumulative yield of rubber. Thus these studies clearly indicate that distribution of rainfall is more important than the quantum of rainfall received over a region. Under the extreme agroclimatic conditions of Konkan region for rubber cultivation, adaptation of proper agronomic practices are essential (Fig. 1).

The agroclimatic conditions at Agartala indicates that the weather hazards such as low temperature during winter and hail-storm during pre-monsoon period is common. Modification of field micro-climate is one way to reduce the impact of these weather hazards. Analysis of wind observation indicates that the South-south-east (SSE) winds are predominant. Establishment of wind breaks/shelter belts would be of immense use.

3. Establishment of Agrometeorological Observatories

The available meteorological data in the traditional as well as non-traditional rubber growing regions of India are inadequate to study the over all behaviour of weather and its

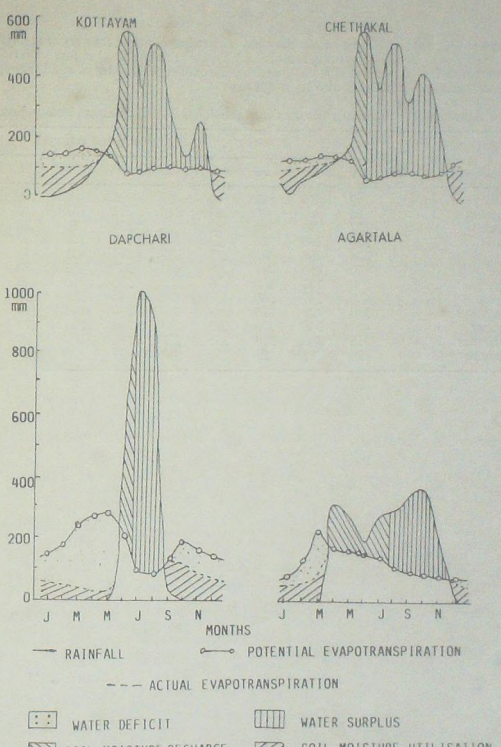


FIG. AGROMET 1. WATER BALANCE CONDITIONS DURING 1986 IN DIFFERENT EXPERIMENT STATIONS

influence on rubber. Hence, action has been initiated to establish four regional 'Agromet' observatories in the rubber growing belt of South India. Establishment of four observatories in the North-East sector of India and improving the existing observatories at all the regional research stations of RRII is also in progress.

Table Agromet - 1: **Probability Distribution of Rainfall (mm) at Experiment Station, Kottayam**

Month	Probability (percentage)								
	10	20	30	40	50	60	70	80	90
January	60	30	12	5	2	0	0	0	0
February	85	64	40	26	16	7	2	0	0
March	127	96	83	68	54	38	36	26	15
April	320	260	225	183	172	148	120	82	70
May	625	480	445	378	277	179	133	128	78
June	900	850	747	719	642	567	495	380	288
July	930	773	702	633	564	530	480	446	360
August	600	545	500	468	425	398	328	315	227
September	530	430	395	349	293	270	180	163	98
October	490	395	350	325	295	260	215	177	149
November	375	310	280	235	225	196	146	80	57
December	130	85	59	59	49	31	23	15	13

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KFRI
1986-87

Budget

Sl. No.	Head of Account	Approved Budget (Rs. in lakhs)	Actual Expenditure (Rs. in lakhs)
Non Plan			
1.	Pay add allowances	63.66	61.86
2.	Contingencies	13.55	12.87
3.	Other charges (Including RRII Estate & Nursery)	43.28	29.74
4.	Non Plan schemes	18.00	18.71
5.	Non Plan projects (CES Chethakkal)	27.00	27.36
	TOTAL NON PLAN	165.49	150.54
	Plan		
6.	Plan schemes	19.50	44.71
7.	NERDS Research Component	59.00	48.71
		78.50	93.42*

* The Excess over sanctionod budget under Plan was met from the total sanctioned Plan budget of the Board.