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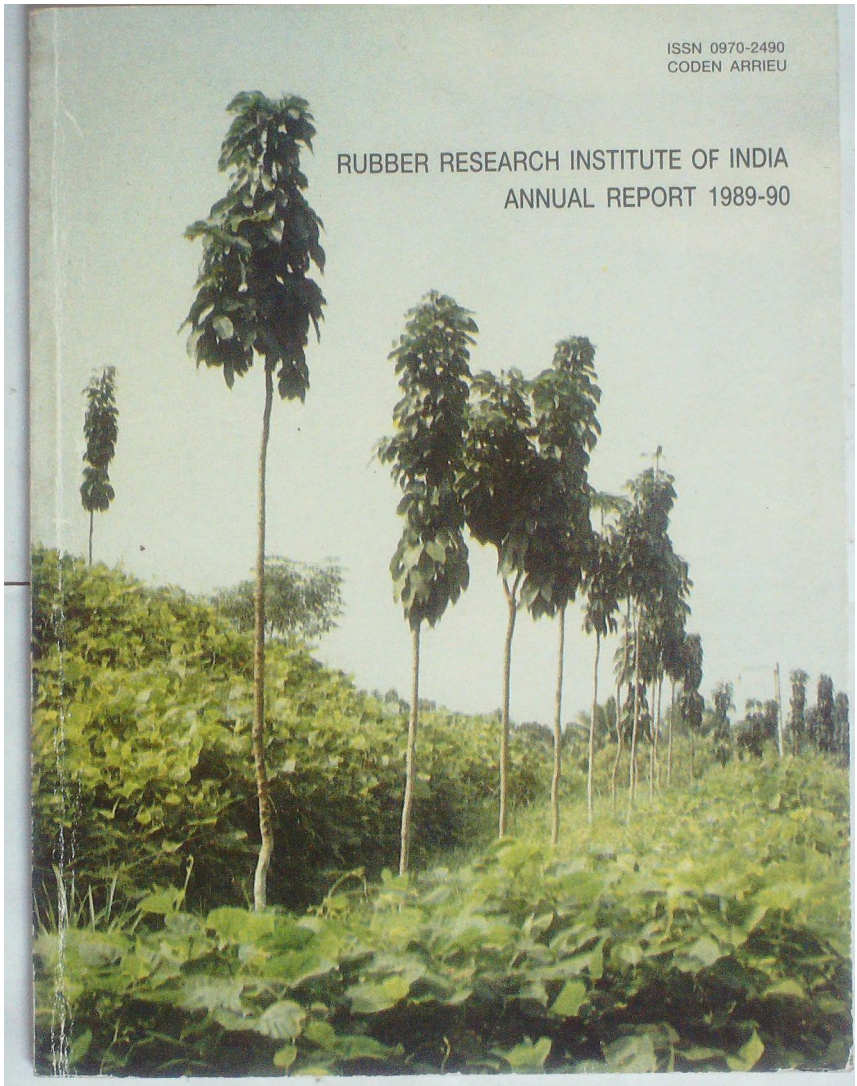
CODEN ARRIEU

# RUBBER RESEARCH INSTITUTE OF INDIA
# ANNUAL REPORT 1989-90



# Rubber Research Institute of India

**Annual Report 1989-90**

ISSN 0970 2490

CODEN ARRIEU

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**Cover**
A genetic variant of *Hevea brasiliensis* at the 15th vegetative generation (vM 15) four years after planting

**Photograph**
Mr. K. P. Sreerenganathan

**October 1991**

The Rubber Research Institute of India (RRII), under the Rubber Board (Ministry of Commerce, Government of India) had its inception in 1955. With a very modest beginning, the RRII is now capable of handling most of the problems associated with natural rubber (NR) on production technology, processing aspects and product applications. The steady growth of the RRII in its scientific worth and research contributions has won it the recognition as one of the international centres of excellence on NR research.

**Location**

The RRII is located on a hillock 8 km east of Kottayam in Kerala State and is easily accessible by road. Kottayam is connected to all major cities in the country by rail. The nearest airport is at Cochin, 70 km north. The capital of the state is Trivandrum, 160 km south where there is an international airport. The distance to New Delhi, the capital of the country, is 2950 km.

**Functions**

Undertaking, assisting and encouraging scientific, technological and economic research and dissemination of knowledge to the NR industry are the statutory functions of the RRII.

**Organisation**

For the efficient discharge of its functions, the RRII has established major research divisions and research supporting sections at its head-quarters and regional research establishments at appropriate locations where *Hevea brasiliensis* is commercially grown or is likely to be grown.

*continued to inside back cover*

# ANNUAL REPORT
# 1989-90

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

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## 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 six main departments, viz. Administration, Rubber Production, Research, Rubber Processing, Finance & Accounts, and Training.

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Rubber Production Commissioner

**Research**
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Director

**Administration**
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Secretary

**Rubber Processing**
C. M. George
Project Officer

**Finance & Accounts**
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Financial Adviser

**Training**
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Joint Director

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**Agrometeorology**

15. Dr. P. S. Sreenivasan, Consultant in Agrometeorology, 7/231, Chandranagar, Palakad-678 007.

## DIRECTORS' REVIEW

The thrust areas of investigation of the Rubber Research Institute of India (RRII) continued to be (a) providing adequate research support for developing appropriate agrotechnology (b) evolving and evaluating clones suitable for nontraditional areas (c) refining the package of practices for the traditional areas aimed at monetary savings in inputs and their application and (d) technological research for product improvement with the ultimate objective of conserving natural rubber (NR).

At the headquarters of the RRII, a Germplasm Division was established during the period under review, to take care of introduction, collection, conservation and evaluation of wild genotypes and older cultivars of *Hevea*. The Germplasm Section of the Botany Division was merged with the new division. Action was in progress to establish a Regional Research Station (area about 47 ha) at Sukma (106 km from Jagadalpur) in Bastar District of Madhya Pradesh. A seedling nursery and a budwood nursery were under establishment. About one thousand plants were also being established in polybags for experimental planting during 1990 planting season. Actions were also initiated for construction of farm house and quarters and removal of scattered trees in the area.

Refinement of discriminatory fertilizer recommendation system continued to receive attention. Diagnosis and Recommendation Integrated System (DRIS) was introduced to formulate the optimum nutrient ratios and efforts were being initiated to computerise the norms. The response to applied fertilizers to immature rubber was found to be up to 30 kg N, 30 kg P and 20 kg K. Based on these results more field experiments were laid out in different locations with the objective of generation of data leading to clonewise and regionwise fertilizer recommendation in the immature phase. The biotechnology laboratory has been expanded. Propagation systems were developed for many commercial clones and a fresh set of 90 tissue cultured plants of elite clones was planted in the field. Activities connected with breeding and clonal selection were continued and selections from the progenies were at different stages of evaluation. The clone RRII 105 continued to enjoy maximum popularity. The RRII is concerned with this trend of monoclonal planting and

action has been initiated to change this attitude over a period of time. Potential clones were planted for a multidisciplinary evaluation so that the most promising ones could find place in planting material recommendation.

For cataloguing and evaluating the germplasm genotypes, a descriptor format was designed to record morphological observations. For the control of abnormal leaf fall disease, the dosage adopted by some planters is different from that recommended by the RRII and it is proposed to take up exeperiments with low dosage on clone RRII 105. To identify genotypes resistant to powdery mildew disease, a method was being tried for early prediction of clonal susceptibility. Tapping panel dryness being a syndrome of concern, and still an enigma even after several years of research, the RRII is now attempting to explore the fundamental aspects involved in collaboration with the Indian Institute of Science, Bangalore. Reaction conditions for the preparation of epoxidised NR of 25 and 50 mole per cent epoxidation have been standardised at 50°C and bench scale batches of these modified forms prepared. Technological properties of these rubbers were evaluated in comparison with NR and nitrile rubber and were found promising. The RRII is participating in the UNIDO funded project on NR based truck tyre retreads and the evaluation of the first batch was in progress. Evaluation of planting materials under commercial practice showed that the clone RRII 105 recorded the highest commercial yield. Recognising the awareness of the vast potential of rubber wood, the RRII organised a seminar on rubber wood.

The regional research stations of the RRII concentrated on location specific investigations for evolving appropriate planting materials, agro-management techniques for the local situations and related aspects. Several field experiments were laid out with this prupose in addition to the ongoing ones. The RRII is now endeavouring to use satellite data for identification of land suitable for rubber cultivation in Orissa.

During the year under review two issues of the Indian Journal of Natural Rubber Research were brought out. The RRII also published a book 'Rubber Wood : Production and Utilisation', consolidating the current knowledge in a single volume.

# AGRONOMY AND SOILS DIVISION

The Agronomy and Soils Division is engaged in nutritional studies on immature and mature rubber in different agroclimatic regions of South India. The other aspects of investigation are irrigation and soil moisture management, intercropping, weed management, forms and methods of fertiliser application, water requirement of rubber at its various stages of growth, etc. With a view to further refining the interpretation of foliar analytical values, a Diagnosis and Recommendation Integrated System (DRIS) is being perfected. Five regional laboratories are now operating under the technical guidance of the Division.

## 1. Nutritional studies (immature phase)

1.1 Three experiments, one each in three agroclimatic regions, are being conducted. The mean girth increment for clone RRII 105 at Kanyakumari (Kanthimathy Estate) for the period 1988–90 indicated significant response to application of N at 30 kg $ha^{-1}$ P at 30 kg $P_2O_5$ $ha^{-1}$ and K at 20 kg $K_2O$ $ha^{-1}$ (Table-Ag. 1). Further increasing the levels of these nutrients was not beneficial and only depressed growth in the case of P and K. At Punalur (Shaliacary Estate) with clone PB 235 similar results as in Kanyakumari were obtained for mean girth increment during 1987–1990 (Table-Ag.2). No significant response to N, P or K was obtained at Mundakayam (T R & T Estate) for girth increment during the same period. The soil nutrient status at this location was superior to that in the other two locations.

Table-Ag. 1. **Mean girth increment 1988-1990, Kanyakumari**

| Levels of nutrients (kg $ha^{-1}$) and girth increment (cm) | | | | | |
|---|---|---|---|---|---|
| N | cm | $P_2O_5$ | cm | $K_2O$ | cm |
| 0 | 17.53 | 0 | 17.40 | 0 | 17.39 |
| 30 | 19.01 | 30 | 19.75 | 20 | 19.32 |
| 60 | 18.99 | 60 | 18.38 | 40 | 18.83 |

SE = 0.13 CD = 0.38

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| 0 | 17.53 | 0 | 17.40 | 0 | 17.39 |
| 30 | 19.01 | 30 | 19.75 | 20 | 19.32 |
| 60 | 18.99 | 60 | 18.38 | 40 | 18.83 |
| | SE = 0.13 | | CD = 0.38 | | |

Table-Ag. 2. **Mean girth increment 1987-1990, Punalur**

| Levels of nutrients (kg ha$^{-1}$) and girth increment(cm) | | | | | |
|---|---|---|---|---|---|
| N | cm | $P_2O_5$ | cm | $K_2O$ | cm |
| 0 | 26.60 | 0 | 26.30 | 0 | 26.78 |
| 30 | 27.63 | 30 | 28.47 | 20 | 28.45 |
| 60 | 27.84 | 60 | 27.30 | 40 | 26.85 |

SE = 0.12 CD = 0.35

1.2 Five more field experiments were laid out in five different regions to assess the fertiliser need of clone RRII 105 and the treatments were imposed.

1.3 With the objective of finding out the nutritional requirement of new RRII experimental clones, two experiments were laid out, one at Koney estate in 1988 with ten clones and another at RRII in 1989 with four clones. An evaluation of the girth of plants at Koney estate during 1990 revealed no significant difference in the response to different levels of fertilisers by the different clones.

## 2. Nutritional studies (mature phase)

### 2.1. Clonal/regional requirements

Seven field experiments were in progress involving three high yielding clones, to ascertain the nutritional requirement of different clones in different agroclimatic zones.

During the year 1989, there was significant response in yield to application of N at 20 kg ha$^{-1}$ in the experiment at Vadakencherry (Vaniyampara Estate) with clone RRII 105. Higher level of N (40 kg ha$^{-1}$) did not register any significant increase in yield (Table-Ag. 3). There was no response in yield to application of P and K. Similar results were obtained during 1988 also.

Table-Ag. 3. **Mean yield (g tree$^{-1}$ tap$^{-1}$), 1989**

| kg $P_2O_5$ ha$^{-1}$ | kg N ha$^{-1}$ | | | |
|---|---|---|---|---|
| | 0 | 20 | 40 | Mean |
| 0 | 59.63 | 64.59 | 58.12 | 60.78 |
| 20 | 64.41 | 79.04 | 57.79 | 67.08 |
| 40 | 55.39 | 71.11 | 65.01 | 63.84 |
| Mean | 59.81 | 71.58 | 60.30 | 63.90 |

SE for N means: 3.26 CD for N means: 9.54

The girth of trees in January 1990 showed significant response to application of both N and P (Table-Ag. 4). Application of N at 20 kg ha$^{-1}$ level significantly increased the girth. Whereas at 40 kg ha$^{-1}$ level there was no response. There was significant increase in girth with application of P at 40 kg $P_2O_5$ ha$^{-1}$ level, but at 20 kg ha$^{-1}$ level there was no response.

Table-Ag. 4. **Mean girth (cm), January, 1990**

| kg $P_2O_5$ ha$^{-1}$ | kg N ha$^{-1}$ | | | |
|---|---|---|---|---|
| | 0 | 20 | 40 | Mean |
| 0 | 57.92 | 60.04 | 58.99 | 58.98 |
| 20 | 57.29 | 61.43 | 59.34 | 59.35 |
| 40 | 61.17 | 63.62 | 60.40 | 61.73 |
| Mean | 58.79 | 61.69 | 59.58 | 60.02 |

CD for N and P means : 1.87
SE for N and P means : 0.64

An examination of Tables-Ag. 3 and Ag. 4 indicates that the increase in girth at 20 kg ha$^{-1}$ level of N application could be a direct effect of N on girth as the yield also increased with the same level of N application. With 40 kg ha$^{-1}$ level of P application the girth improved at the expense of yield though not to a significant extent. Similarly

the absence of response in girth at the 20 kg $ha^{-1}$ level of P could be the result of a relatively higher yield at this level.

No response, in terms of yield, was obtained for any of the nutrients with clone RRII 105 at Calicut and Thodupuzha and with clone PB 28/59 at Kanyakumari during 1989.

### 2.2 Multilocational trial on fertiliser use efficiency

The treatments at the rate of 30:30:30 kg $ha^{-1}$ of N, $P_2O_5$ & $K_2O$ through different sources were imposed from 1989 premonsoon season in experiments laid out in seven locations. The analysis of variance of the yield data during 1989–90 did not show any significant difference among the treatments.

## 3. Density of planting, growth and yield

The experiment which is aimed at finding out the optimum density of planting and the manurial requirement at different densities, started in 1985, is being continued. The girth of trees recorded in January 1990 is presented in Table-Ag. 5.

Neither the main effects of density and manure nor their interaction was significant. The girth data recorded five years after planting does not indicate the effect of planting density on growth of rubber. Differential requirement of fertilisers under different densities of planting is also not indicated. Observations on light interception did not show any definite pattern according to density.

## 4. Irrigation and moisture management

### 4.1 Immature phase

4.1.1 Due to acute scarcity of water, irrigation and split application of fertilisers could not be given during 1989–90 summer. The treatments given during the previous two seasons did not give a significant carry over effect as indicated by girth recorded during 1990.

#### 4.1.2 Evaluation of micro and macro irrigation methods

Treatment was continued as per the schedule and the girth recorded during 1990

Table-Ag. 5. **Mean girth of trees, January 1990**

| Spacing (m) | Density (plants $ha^{-1}$) | Mean girth (cm) | | |
|---|---|---|---|---|
| | | Levels of NPKMg (kg $ha^{-1}$) | | Mean |
| | | 40:40:16:6 | 60:60:24:9 | |
| 6.7 x 3.4 | 445 | 34.50 | 35.51 | 35.01 |
| 6.7 x 3.0 | 489 | 35.59 | 28.27 | 31.93 |
| 6.1 x 3.4 | 489 | 34.11 | 34.55 | 34.33 |
| 6.1 x 3.0 | 539 | 33.43 | 34.33 | 33.88 |
| 5.5 x 3.4 | 544 | 34.16 | 34.18 | 34.17 |
| 5.5 x 3.0 | 598 | 35.11 | 35.37 | 35.21 |
| Mean | | 34.48 | 33.70 | 34.09 |

SE for densities: 2.10. SE for fertiliser dose: 2.03

(Table-Ag. 6) showed significant differences between treatments.

Table-Ag. 6. **Mean girth (cm), 1990**

| Treatment | | Mean girth |
|---|---|---|
| Drip | 15 l tree$^{-1}$ day$^{-1}$ | 30.97 |
| Drip | 22.5 l tree$^{-1}$ day$^{-1}$ | 31.83 |
| Basin | 105 l tree$^{-1}$ week$^{-1}$ | 29.87 |
| Basin | 157.5 l tree$^{-1}$ week$^{-1}$ | 28.43 |
| Control | | 27.69 |

SE: 0.92 CD: 2.84

The plants which received drip irrigation were significantly superior to unirrigated plants. But the basin irrigated plants were on par with the unirrigated plants.

### 4.2 Microirrigation at mature phase

Irrigation could not be given in the experiment at Cheruvally Estate during the summer season of 1990 due to scarcity of water. However, the growth and yield data collected during this period did not show any significant response to irrigation given during the previous seasons.

### 4.3 Water requirement of immature rubber (lysimeter technique)

Daily monitoring of water balance was being continued. Observations on girth and soil moisture were recorded periodically. The evapo-transpiration and crop coefficient values (Kc) computed using different empirical methods from January 1990 to March 1990 are given in Table-Ag. 7

Table-Ag. 7. **Mean evapotranspiration and crop coefficient of rubber**

| Period | Lysimeter | E.T.(mm day$^{-1}$) | Kc (Pan evaporation method) | Kc (Penman method) |
|---|---|---|---|---|
| January 1989 to March 1990 | I | 4.45 | 0.96 | 0.79 |
| | II | 4.53 | 0.98 | 0.81 |

### 4.4 Soil and water conservation

This observational trial started in 1988 at RRII farm is being continued. The girth of plants recorded one year after planting and the mean soil moisture data recorded during the summer period of 1989–90 are presented in Table- Ag. 8. In the first three treatments, where contours are maintained, the moisture status appeared to be slightly higher. Further observations are in progress.

## 5. Weed management systems

In the study on bio-control of *Chromolaena odorata*, the larvae of *Pareuchaetus pseudoinsulata* did not thrive due to some unidentified disease.

All the herbicide trials were concluded and the results were published as recommendations.

## 6. Intercropping in rubber

### 6.1 Immature rubber (CES, Chethackal)

In the observational trial at CES, all the intercrops have inhibited the growth of rubber. In plots where coffee and cocoa were intercropped, *Acacia* was also planted to provide shade. These shade trees have affected sun light availability and resulted in poor growth of rubber. Growth of rubber was least affected in the plot where black pepper alone was intercropped. The growth of coffee and black pepper was satisfactory.

Cocoa has made only poor growth probably due to lack of irrigation in the trial area. Among the intercrops only coffee has started yielding.

6.2 **Immature rubber (Nelliyampathy)**

In the intercropping experiment at Nelliyamathy (Palghat), which represent high elevation condition and is located in a private estate, girth of rubber plants, recorded 14 months after planting, did not indicate any adverse effect of intercrops. There was no significant difference at this stage in girth of rubber in the different treatments.

6.3 **Mature rubber (CES, Chethackal)**

Coffee plants, planted in 1987 under mature rubber trees, have not set fruits yet, possibly due to the heavy shade. They also have not affected growth of rubber. The girth increment data (1987–1990) did not reveal significant difference among the treatments.

## 7. Forms and methods of fertiliser application

7.1 **Nitrogenous fertilisers for rubber seedlings**

This experiment was started in 1985 at the Central Nursery, Karikkattoor, to compare different nitrogenous fertilisers. From third year onwards significantly high sulphur status was noticed in ammonium sulphate treated plots as compared to urea treated plots. In the case of diameter of seedlings also, significantly higher values were obtained in ammonium sulphate treated plots. During fourth year also the same trend was continued. The data on girth measurement and total sulphur status are given in Table-Ag. 9.

7.2 **Coated and uncoated nitrogenous fertilisers**

A glass house experiment was laid out in RRII in 1989 with urea, ammonium chloride, ureaform, neem cake mixed urea, neem extract coated urea and neem oil coated urea with four replications. Afte. incorporation of treatments leachates were collected periodically and analysed for nitrate, nitrogen and ammoniacal nitrogen. Loss of N was maximum in urea treated plots and minimum in neem extract coated urea treated plots (Table-Ag. 10).

Table-Ag. 8. **Mean girth and soil moisture, RRII farm**

| Treatment | Mean girth October 1989 (cm) | Mean soil moisture (%) |
|---|---|---|
| Contour + no cover crop | 8.12 | 18.79 |
| Contour + cover crop | 7.90 | 19.69 |
| Contour + staggered silt pit in inter row + cover crop | 8.39 | 19.34 |
| No contour + silt pits on contour + cover crop | 7.62 | 18.17 |
| No contour + continuous trench in between planting lines + pineapple for biological bund on the upper side + cover crop | 7.68 | 17.03 |
| No contour + continous trench in between planting lines + pineapple for biological bund on the upper side + banana as intercrop | 8.55 | 16.61 |
| No contour + stone wall after 3rd contour + staggered silt pits on other rows + cover crop | 8.05 | 15.42 |

Table-Ag. 9. **Seedling diameter and sulphur status**

| Treatment | Diameter (mm) | Total S (ppm) |
|---|---|---|
| Ammonium sulphate | 13.18 | 494.12 |
| Urea | 10.68 | 214.71 |
| 50% Ammonium sulphate +50% urea | 11.33 | 377.45 |
| 50% Ammophos + 50% urea | 11.58 | 336.27 |
| SE | 0.42 | 42.52 |
| CD | 1.27 | 128.14 |

Table-Ag. 10. **Leaching loss of N**

| Treatment | Loss of N (mg/1000 ml) |
|---|---|
| Urea | 233.70 |
| Ammonium chloride | 231.84 |
| Neem oil mixed urea | 213.28 |
| Neem mixed urea | 192.34 |
| Ureaform | 148.92 |
| Neem extract coated urea | 163.66 |
| Control | 0.53 |

A field experiment, with the above treatments was laid out at Mundakayam (T.R. & T. Estate) and treatments were incorporated. Soil samples were collected periodically and analysed for nitrate and ammoniacal nitrogen. Minimum loss of nitrogen was noticed from neem extract coated urea and maximum loss from ammonium chloride.

### 7.3 Effect of methods of application of nitrogenous fertilisers

This experiment was started in 1989 in RRII with two nitrogenous fertilisers (urea and ureaform) applied in broadcast, pocket and ring methods. Treatment incorporation was done and growth measurements were taken.

### 7.4 Effect of (forms of) phosphatic fertilisers

A comparative study on the effect of water soluble and insoluble forms of phosphatic fertilisers on growth of rubber was initiated in 1985 at Mundakayam (Boyce Estate). Girth measurements were taken twice in an year and the girth increment for the period 1985–1989 are furnished in the Table–Ag. 11. The results indicate that application of P as ammophos (AP) at the rate of 40 kg per hectare was superior to rock phosphate (RP). Between 40 kg and

Table-Ag. 11 **Girth increment for the period 1985-1989**

| Treatments | | Girth increment (cm) |
|---|---|---|
| 40 kg $P_2O_5$ $ha^{-1}$ | as RP in 2 split application | 32.38 |
| | as RP in 3 split application | 32.40 |
| | as AP in 2 split application | 33.89 |
| | as AP in 3 split application | 34.19 |
| 50 kg $P_2O_5$ $ha^{-1}$ | as RP in 2 split application | 31.76 |
| | as RP in 3 split application | 32.79 |
| | as AP in 2 split application | 33.73 |
| | as AP in 3 split application | 33.07 |
| Control | | 31.25 |

SE: 0.36 CD : 1.08

50 kg no significant difference was noticed. Between two split and three split application also no significant difference was obtained. Among this treatment the soil and leaf phosphorus was also not significantly different.

### 7.5 Indigenous rock phosphates and phosphorus dissolution pattern

This project was initiated in RRII in 1989 with four indigenously available rock phosphates. The sources tried are Mussoorie, Maton, Udaipur and Purulia rock phosphate, partially acidulated and imported rock phosphates. Available phosphorus content of the soil was estimated two months after fertiliser application. It was found (Table-Ag. 12) that plots receiving Mussoorie rock phosphate registered high available phosphorus values than the other sources tried.

Table-Ag. 12. **Available P content of soil**

| Treatment | Av. phosphorus (mg $100^{-1}$ soil) |
|---|---|
| Control | Trace |
| Mussoorie rock phosphate | 2.16 |
| Maton rock phosphate | 1.22 |
| Partially acidulated rock phosphate | 1.70 |
| Udaipur rock phosphate | 1.16 |
| Purulia rock phosphate | 0.78 |
| Imported rock phosphate | 0.96 |

## 8. Diagnosis and recommendation integrated system

A project on utilisation of Diagnosis and Recommendation Integrated System (DRIS) was initiated to formulate the optimum nutrient ratios for *Hevea*. As the first stage of the study 15 different estates representing the different agroclinatic regions of South India were selected. Soil and leaf analytical values and other relevant details were gathered for seven clones (GT 1, RRIM 600, PB 28/59, PB 5/51, PB 235, RRIM 605 and RRII 105). The different ratios between nutrients are being worked out.

## 9. Standardisation of analytical technique

Investigations were continued on the refinement of tissue analysis being adopted in the mobile laboratories. Leaf samples were collected from NPK fertiliser trials and petiole as well as laminae of the same samples were analysed for potassium, phosphorus and magnesium. Further work is in progress. A cutting device is being developed for taking petiole samples of uniform length. A new Atomic Absorption Spectrophotometer was installed and standardisation done for Ca, Mg, Cu, Mn, Zn and Al.

## 10. Collaborative projects on brown bast

The division collaborated in the multidisciplinary study on brown bast, details of which are given elsewhere.

## 11. Advisory work

The Division has analysed 15900 soil and 2020 leaf samples for advisory purpose and discriminatory fertiliser recommendations were offered to estates and small holdings, based on the analytical results.

## BIOTECHNOLOGY DIVISION

A new laboratory building has been commissioned for the Biotechnology Division, as part of expansion programme. Thrust areas of research were emphasised with short and long term goals.

**1. In vitro propagation system**

Several *in vitro* propagation systems were developed for many commercial clones of rubber. Simultaneously, multidirectional experiments are under way in the efforts to convert the experimental system in to a commercial rubber propagation system. An additional 90 plants of elite clones were planted for further trials.

**2. Anther/pollen culture**

Anther culture and plant regeneration programmes have been successful since 1988. A few anther derived plants are growing in the field. Along with androgenesis, numerous factors influencing androgenesis have been studied in order to standardize the culture protocols. This technique has been extended to several successful commercial clones.

**3. Protoplast culture**

Protoplast culture programme has been initiated during the later part of 1990 in order to fully utilise the scientific merits associated with the techniques involving protoplast/cell as an operational unit for cellular manipulations. Mesophyll protoplast isolation and culture techniques were standardized and the work is in good progress.

**4. Biochemical/molecular biological studies**

No visible somaclonal variation has been observed so far in the population of tissue culture derived plants. Several enzymes in the tissue culture derived plants versus non-tissue culture derived plants are studied.

## BOTANY DIVISION

The Division continued to concentrate on Plant Breeding, Propagation, Anatomy and Cytogenetics. Investigations concerned with germplasm, which were being attended to by the Botany Division, were shifted to the new division established for the purpose, during the year under review.

**1. Hybridization and selection**

Monthly yield, annual girth measurement and observations on secondary characters were recorded in clones resultant of 1979 and 1982 breeding programmes. Clones established from progenies resulting from 1982 hybridizations and planted during 1985, were opened for tapping during November 1989 with the objective of evaluating their performance at an early age. Among the five families, RRII 105 x PR 107 recorded the highest yield during the period.

Observations on morphological characters of the selections from 1973 HP laid out in a small scale trial in 1988 indicated that clones HP 31 and HP 35 of parentage Tjir 1 x RRII 102 appear promising, being the most heterotic among the six hybrid clones (Table-Bot. 1). 184 selections, on the basis of juvenile yield and growth, from the 1986 hybridization programme and their respective parents were multiplied during the 1989 season. The progenies of 1987 and 1988 hybridization programmes were evaluated for a set of growth characters and juvenile yield.

A total of 395 seedlings belonging to 18 cross combinations of the 1989 hybridization programmes was maintained in a seedling nursery. During the 1990 flowering season, 11163 hand pollinations were carried out using RRII 105, RRIM 600 and GT 1 as female parents and clones from newly introduced Brazilian germplasm as male parents.

Table-Bot. 1. **Heterosis for juvenile traits**

| Clone | Plant height | | | Girth | | | No of flushes/ plant | | | No of leaves/plant | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Relative heterosis | Hetero beltiosis | Standard heterosis | Relative heterosis | Hetero beltiosis | Standard heterosis | Relative heterosis | Hetero beltiosis | Standard heterosis | Relative heterosis | Hetero beltiosis | Standard heterosis |
| RRII 105 | 27.80* | 24.73 | — | 5.45 | 5.24 | | 3.19 | — | — | — | — | — |
| RRII 102 | 6.06 | 3.51 | — | — | — | — | 6.83 | 1.08 | 3.53 | — | — | — |
| HP 55 | 9.95 | 7.31 | — | 11.62 | 11.45 | 5.84 | — | — | — | — | — | — |
| HP 99 | — | — | — | — | — | — | — | — | — | — | — | — |
| HP 31 | 17.88 | 15.88 | — | 18.43* | 17.83* | 11.40 | 38.91** | 30.92** | 35.59** | 64.27** | 61.90** | 56.17** |
| HP 35 | 20.76 | 18.71 | — | 14.46* | 13.88 | 7.66 | 57.01** | 47.97** | 53.20** | 69.58** | 66.29** | 61.21** |

| CD values | $F_1$–MP | $F_1$–BP/$F_1$ Std clone | $F_1$–MP | $F_1$–BP/$F_1$ Std clone | $F_1$–MP | $F_1$–BP/$F_1$–Std clone | $F_1$–MP | $F_1$–BP/$F_1$–Std clone |
|---|---|---|---|---|---|---|---|---|
| CD (0.05) | 73.00 | 84.30 | 1.17 | 1.56 | 0.786 | 0.91 | 18.15 | 20.96 |
| CD (0.01) | 100.00 | 115.46 | 2.15 | 2.48 | 0.879 | 1.24 | 24.86 | 28.70 |

* Significant at 5% and **significant at 1% levels of probability

### 2. Ortet selection

From a preliminary selection of 192 mother trees in a large estate at Pathanamthitta district, 52 were selected based on yield data over four different seasons as well as secondary characters, for multiplication and laying out a small scale trial. In another large estate four rounds of yield recording were carried out in 75 mother trees selected from an area of 465 ha. Six holdings were also visited and budwood collected and multiplied from four mother trees. Forty-three ortet selections from another large estate along with three popular clones (RRII 105, RRIM 600 and GT 1) were planted at Mundakkayam over an area of three hectares for evaluating their performance. Annual recording of girth and secondary characters was carried out in another small scale trial laid out with 63 ortet clones. A good number of clones recorded better growth compared to the control clone.

### 3. Special techniques in breeding

Seventyfive seedlings from the seed (RRII 105) irradiated population were multiplied and fifteen budgrafted plants from each were raised in polybags. Vigour of these genotypes at ten months' growth in polybags showed that eighteen were better in terms of plant height and basal diameter.

Twenty plants showing morphological variations at the vM7 generation after colchicine treatment were multiplied for further observations. Ten genotypes showing good secondary attributes were selected for multiplication from a population resultant of mutagen treatment.

### 4. Evaluation of clones

Three large scale trials of modern clones, two at CES, one with nine and the other with eight clones and one at HBSS, Karnataka with 14 clones were laid out. A polybag nursery of 15 clones was established at HBSS, Paraliar for laying out a large scale trial during the 1990 planting season. Annual paint marking, numbering, recording of girth and other secondary characters were carried out in the large scale trials. During the first five years of tapping the slections from RRII 200 series recorded better yield compared to the control. RRII 208, RRII 206 and RRII 203 were the top yielders, with 51.19, 50.87 and 50.19 g tree$^{-1}$ tap$^{-1}$ respectively.

Data on yield and growth for the first five years of tapping for the 1978 clone trial at Malankara revealed (Table-Bot. 2) that among the 12 clones RRII 105 recorded the highest yield, followed by RRIM 703, RRIC 36 and RRIC 102. The clone RRIC 52, the most vigorous one, however, recorded the lowest yield.

Table-Bot. 2. **Performance of clones in a block trial**

| Clone | Mean girth on commencement of tapping (cm) | Percentage girth increment for five years of tapping | Mean yield over first five years kg ha$^{-1}$yr$^{-1}$ |
|---|---|---|---|
| RRIM 703 | 47.95 | 24.73 | 1424 |
| RRIM 707 | 51.54 | 21.18 | 1131 |
| Ch 153 | 54.73 | 22.51 | 1085 |
| Nab 17 | 51.80 | 18.13 | 1129 |
| Wagga 6278 | 47.86 | 25.49 | 893 |
| RRIC 36 | 48.69 | 25.59 | 1306 |
| RRIC 45 | 47.99 | 23.07 | 1069 |
| RRIC 52 | 61.64 | 20.86 | 704 |
| RRIC 102 | 51.89 | 13.95 | 1207 |
| GT 1 | 54.44 | 16.57 | 1190 |
| RRII 105 | 49.85 | 24.17 | 1812 |
| RRII 118 | 48.22* | 37.18 | 1086 |

* Mean girth at sixth year after planting

Among the 12 clones planted at Chithelvetty Estate, Punalur, girth during the fifth year revealed PB 260 as the most vigorous clone. A block trial with eight modern clones was laid out at Chittadi Estate. A Study on intraclonal variability was initiated incorporating four popular clones. Regular recording of data on growth characters in the multi-disciplinary trial at the RRII was undertaken.

### 5. Estimation of genetic parameters

Open pollinated progenies of 14 clones were raised in polybags along with their parent clones at HBSS, Nettana, for laying out a field trial during 1990 planting season. Test tapping by test incision method was carried out in the 1987 trial. The mean yield and girth of the ten open pollinated progenies as well as parents at the age of 18 months are presented in Table Bot-3 and 4 respectively.

Table-Bot 3. **Mean juvenile yield (g tree$^{-1}$ tap$^{-1}$) of parent clones and their progenies**

| Clone | Parents | Progenies |
|---|---|---|
| PB 86 | 0.37 ± 0.05 | 0.23 ± 0.04 |
| PB 213 | 0.15 ± 0.03 | 0.18 ± 0.04 |
| PB 235 | 0.19 ± 0.02 | 0.12 ± 0.02 |
| PB 5/51 | 0.11 ± 0.02 | 0.19 ± 0.05 |
| PB 242 | 0.27 ± 0.05 | 0.29 ± 0.07 |
| PB 252 | 0.21 ± 0.05 | 0.22 ± 0.04 |
| IAN 45-873 | 0.25 ± 0.07 | 0.20 ± 0.02 |
| Tjir 1 | 0.11 ± 0.03 | 0.31 ± 0.05 |
| GT 1 | 0.31 ± 0.05 | 0.18 ± 0.02 |
| RRII 105 | 0.27 ± 0.04 | 0.16 ± 0.02 |

Table-Bot. 4 **Mean girth (cm) of parent clones and their progenies**

| Clone | Parents | Progenies |
|---|---|---|
| PB 86 | 10.28 ± 0.81 | 12.78 ± 1.13 |
| PB 213 | 9.38 ± 0.87 | 12.53 ± 0.78 |
| PB 235 | 11.39 ± 0.79 | 11.69 ± 0.90 |
| PB 5/51 | 8.64 ± 0.68 | 12.15 ± 0.93 |
| PB 242 | 9.25 ± 0.89 | 14.54 ± 0.94 |
| PB 252 | 7.85 ± 0.89 | 15.07 ± 0.99 |
| IAN 45-873 | 8.61 ± 0.60 | 13.47 ± 0.86 |
| Tjir 1 | 10.88 ± 1.35 | 12.88 ± 0.86 |
| GT 1 | 10.33 ± 0.83 | 13.61 ± 0.78 |
| RRII 105 | 10.26 ± 0.84 | 12.74 ± 0.87 |

Analysis of variance for yield and girth showed that the 20 treatments exhibited significant difference between themselves.

### 6. Cytogenetical investigations

Mitotic and meiotic studies of polyploids and male sterile clones were continued. A total of 700 self pollinations were carried out in the genetic variant (dwarf) and one of its progenies.

Progenies of three male sterile clones (GT 1, Ch 2 and RRII 35), along with a fertile clone as standard, were evaluated in the nursery. Seeds from the male sterile clones recorded early and higher percentage of germination. The progenies of male sterile clones were more vigorous compared to the control clone Mil 3/2. Test tapping yield also indicated the superiority of the progenies of male sterile clones. Among the male sterile clones, GT 1 showed significant superiority in growth and juvenile yield over the other clones.

### 7. Floral biology and fruit set

A preliminary study on improving fruit set under hand pollination indicated mechanical injury to floral parts during plugging of hand pollinated flowers with cotton wool and latex to be one of the reasons for low fruit set. Enclosing hand pollinated panicles in butter paper covers of suitable size gave significantly better fruit set than the conventional procedure. Application of boric acid: sucrose solution (1:1) to stigmatic surfaces prior to pollination also appeared promising.

During the 1990 flowering season, the two promising treatments were repeated on the cross combination RRIM 600 x RRII 33. A combination of the two treatments was also attempted and the conventional hand pollination procedure was included as control. Fruit set was low for treatments in which hand pollinated flowers were protected by the conventional method.

### 8. Anatomical (general) investigations

SEM studies on wax pattern and phenology of wax formation revealed that the reticulate pattern is clearly exhibited from the pendant stage onwards. At the late hardened stage of the lamina, stomata are completely sunken and covered. On the fruit wall, petiole, vein and tender stem, the stomata are large and exposed. On these organs the epicuticular wax is not reticulate. Information on the developmental stages of wax formation in relation to the phenology of leaves can be utilized in disease management and clone selection. The organographic variability in the epicuticular wax pattern and topography of stomata could explain organographic specificity of *Phytophthora* leaf fall disease in *Hevea*.

The stomatal frequency and size of stomata in six clones, three of which are considered drought tolerant and the other three drought susceptible, were observed at the age of two years. The data indicated that the drought susceptible clones have higher stomatal length compared to the tolerant ones.

### 9. Bark anatomical investigation

In connection with early evaluation studies, bark thickness and number of latex vessel rows were recorded on six clones at the age of three years. The high yielding clones and one of the medium yielders showed high number of latex vessel rings.

A set of bark anatomical characters of eleven clones were recorded at the age of four years and the data is being summarised. Fifteen *Hevea* clones planted at Dapchari were characterised for the bark thickness and number of latex vessel rows at the age of four years and the data are under study. Five second selections from 1954 HP clones in the small scale trial, along with RRII 105, were characterised for bark thickness and number of latex vessel rows of virgin and renewed bark (ten years renewal) and a summary is given in Table-Bot. 5. The clones showed different trends for the two traits. Bark regeneration studies were continued and paraffin blocks were prepared for sectioning. Periodic recordings of bark thickness were carried out. The nature and extent of bark regeneration of the hail storm affected trees at the Regional Research Station, Tripura were observed and samples have been collected for further study.

Table-Bot. 5 **Bark thickness and number of latex vessel rows in virgin and renewed bark**

| Clone | Bark thickness (mm) | | Number of latex vessel rows | |
|---|---|---|---|---|
| | Virgin | Renewed | Virgin | Renewed |
| HP 185 | 15.00 | 7.33 | 42.89 | 29.22 |
| HP 187 | 11.00 | 8.00 | 38.67 | 31.00 |
| HP 204 | 15.00 | 8.50 | 29.83 | 24.50 |
| HP 223 | 11.00 | 5.00 | 29.00 | 13.50 |
| HP 372 | 13.50 | 6.50 | 41.34 | 33.67 |
| RRII 105 | 12.50 | 8.00 | 44.50 | 33.14 |

### 10. Wood anatomy

Three seedling trees and their corresponding budded trees of identical age were chosen to study anatomical variation. The percentage of tension wood increased in seedling trees when compared to that of budded trees at all height levels in HP 131 and HP 133, whereas, its percentage was more or less comparable in HP 154 (Table-Bot.6). In general the proportion of tension wood wa, maximum at 360 cm height level and minimum at 60 cm height level irrespective of being seedlings or budded (Table-Bot.7). To study the percentage area occupied by pores in the cross sectional surface of wood at different height levels, the pore area was measured in one tree of clone PB 86. To study the effect of Ethrel stimulation on rubber wood quality, a project was initiated using two popular clones and the stimulation treatments were given as per schedule.

### 11. Propagation techniques

Budding trial being carried out at Tripura for assessing the influence of various climatic factors on budtake as well as to identify the optimum season for budding in the north eastern region was continued. Brown budding and green budding were carried out at weekly intervals. Budding success was noted. Data on meteorological factors were also recorded during the period.

Plants raised in the trial on depth of planting were observed for growth and other secondary characters (two plots were damaged by fire and hence discarded). Bag plants (control) continued to maintain better growth over other forms of planting materials.

Benchgrafted plants raised in bags were observed and their growth characters were recorded. Benchgrafted plants established in the field were maintained properly and their secondary characters were recorded.

### 12. Genetic basis of stock–scion relationship

Annual girth data for the immature trial on genetic basis of stock-scion combination (Table-Bot.8) revealed that among the 14 different stock-scion combinations, RRII 203 continued to be the most vigorous clone. Diallel budding of three popular clones were carried out and the plants were established in polybags for laying out a field trial.

### 13. Horticultural manipulations

Transplanting of crown budded bagplants to the field was completed. Due to the drying of crownbud, enough plants could not be transplanted in the case of three treatments. To compare the performance of different types of polybags, a nursery study was taken up. Plants are being raised in the bags with a view to assessing their growth.

Table-Bot. 6.. **Proportion of tension wood, normal wood and pith at different height levels in seedling and budded trees (%)**

| Sampling height (cm) | Nature | HP 131 (Tjir 1 x PB 5/60) | | | HP 133 (Tjir 1 x PB 5/60) | | | HP 154 (Tjir 1 x PB 5/139 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Normal wood | Tension wood | Pith | Normal wood | Tension wood | Pith | Normal wood | Tension wood | Pith |
| 60 | Seedling tree | 78.50 | 21.45 | 0.05 | 84.75 | 15.21 | 0.04 | 83.47 | 16.49 | 0.04 |
| | Budded tree | 94.62 | 5.37 | 0.01 | 89.17 | 10.78 | 0.05 | 84.68 | 15.26 | 0.06 |
| 210 | Seedling tree | 80.25 | 19.20 | 0.05 | 74.89 | 24.97 | 0.14 | 76.17 | 23.74 | 0.09 |
| | Budded tree | 86.16 | 13.76 | 0.08 | 81.74 | 18.24 | 0.02 | 76.15 | 23.78 | 0.07 |
| 360 | Seedling tree | 68.63 | 31.32 | 0.05 | 68.59 | 31.31 | 0.10 | 74.94 | 25.02 | 0.04 |
| | Budded tree | 83.59 | 16.30 | 0.11 | 75.03 | 24.89 | 0.08 | 75.00 | 24.92 | 0.08 |

Table Bot. 7. **Proportion of normal wood, tension wood and pith in seedling and budded trees (tree average)**

| Trees | Nature | % of normal wood | | % of tension wood | | % of pith | |
|---|---|---|---|---|---|---|---|
| | | Mean | SE | Mean | SE | Mean | SE |
| HP 131 | Seedling | 75.79 | 3.62 | 24.16 | 3.61 | 0.05 | — |
| | Budding | 88.12 | 3.33 | 11.81 | 3.30 | 0.07 | 0.03 |
| HP 133 | Seedling | 76.08 | 4.70 | 23.83 | 4.68 | 0.09 | 0.02 |
| | Budding | 81.98 | 4.08 | 17.97 | 4.08 | 0.05 | 0.02 |
| HB 154 | Seedling | 78.19 | 2.66 | 21.75 | 2.66 | 0.06 | 0.02 |
| | Budding | 78.61 | 3.05 | 21.32 | 3.05 | 0.07 | 0.01 |

Table-Bot. 8. **Girth of different stock-scion combinations**

| Stock | Scion | Mean girth (cm) |
|---|---|---|
| RRII 105 | RRII 105 | 30.62 |
| RRII 118 | RRII 118 | 25.55 |
| RRII 203 | RRII 203 | 36.16 |
| RRII 208 | RRII 208 | 28.30 |
| GT 1 | GT 1 | 30.63 |
| Gl 1 | Gl 1 | 27.20 |
| RRIM 600 | RRIM 600 | 26.53 |
| Assorted | RRII 105 | 26.10 |
| Assorted | RRII 118 | 29.64 |
| Assorted | RRII 203 | 39.67 |
| Assorted | RRII 208 | 29.25 |
| Assorted | GT 1 | 26.68 |
| Assorted | Gl 1 | 20.03 |
| Assorted | RRIM 600 | 27.22 |

## 14. Early evaluation

The clones in the trial on early evaluation for yield were test tapped. All the data gathered are being processed. Simple correlations were computed for test tap yield during the third year of growth with girth, panel length, d.r.c. and plugging index (Table-Bot.9). Correlation coefficients for nursery yield with other characters revealed highly significant positive association for girth, panel length and d.r.c. and a negative association for plugging index. Test tapping was continued in the trial plants.

Table-Bot. 9. **Correlations of yield and yield components at an age of three years**

| Character | X2 | X3 | X4 | X5 |
|---|---|---|---|---|
| Girth (X1) | 0.84** | -0.34** | 0.68** | 0.59** |
| Panel length (X2) | — | -0.32** | 0.51** | 0.59** |
| Plugging index (X3) | — | — | -0.19 | -0.60** |
| d.r.c. (X4) | — | — | — | 0.38** |
| Yield (X5) | — | — | — | — |

** $P<0.01$

### 15. Studies on inbreeding

The 1988 seedling progenies, resultant of selfing and open pollination, were studied for a set of growth characters at the age of one year (Table-Bot. 10). Inbreeding depression was generally apparent in all the clones.

A total of 2183 selfings were attempted during 1989 flowering season in clones RRII 105, RRII 118 and PB 86. The fruit count recorded in the case of selfing was 0.5 per cent, while that after open pollination recorded 0.55 per cent. Simultaneously some monoclonal fruits were also collected from large estates and seedlings were raised in the nursery and maintained properly.

### 16. Genetic divergence, prepotency and inbreeding depression

Forty two clones were subjected to detailed observation on yield and yield components. Wintering, refoliation and flowering pattern of the clones were also studied.

Seedling progeny analysis was conducted in an attempt to identify prepotents among twenty promising clones. Performance indices were computed for each family taking into account the mean performance and variation of the seedling progeny with respect to vegetative vigour and juvenile yield. The families have been ranked in terms of their indices (Table-Bot. 11). Clones AVT 73 and RRII 105 indicated good juvenile vigour in their seedling progeny.

Monoclonal seeds of selected clones were collected and the seedlings raised in nursery beds along with the corresponding open pollinated seedlings. Eighteen selected clones were also subjected to selfing.

Table-Bot. 10. **Growth characters and juvenile yield of selfed and O.P. seedlings at the age of one year**

| Material | Height (cm) | Girth (cm) 4 cm above the collar | No. of flushes | No. of leaves | Juvenile yield (g) |
|---|---|---|---|---|---|
| RRII 105 (selfed) | 175.72 ±6.308 | 6.80 ±0.271 | 3.44 ±0.116 | 26.62 ±1.437 | 0.0595 ±0.005 |
| RRII 105 (O.P) | 183.85 ±17.829 | 8.57 ±0.639 | 3.85 ±0.552 | 24.14 ±3.912 | 0.0715 ±0.009 |
| RRIM 600 (selfed) | 161.12 ±10.002 | 7.29 ±0.276 | 3.06 ±0.172 | 19.72 ±1.931 | 0.0784 ±0.011 |
| RRIM 600 (O.P) | 171.00 ±18.152 | 7.29 ±0.755 | 3.50 ±0.337 | 21.17 ±3.007 | 0.0774 ±0.026 |
| Tjir 1 (selfed) | 174.25 ±51.487 | 7.00 ±1.826 | 4.00 ±0.500 | 27.00 ±2.000 | 0.0599 ±0.037 |
| Tjir 1 (O.P) | 192.33 ±24.014 | 8.58 ±1.114 | 3.33 ±0.516 | 34.67 ±15.770 | 0.0644 ±0.036 |

Table-Bot. 11. **Performance indices of families**

| Rank | Clone/family | Performance index | Rank | Clone/family | Performance index |
|---|---|---|---|---|---|
| 1 | AVT 73 | 321 | 11 | Ch 26 | 206 |
| 2 | RRII 105 | 292 | 12 | PB 230 | 201 |
| 3 | PB 86 | 245 | 13 | Ch 153 | 195 |
| 4 | PB 28/83 | 237 | 14 | LCB 1320 | 187 |
| 5 | PB 215 | 235 | 15 | PB 206 | 180 |
| 6 | Ch 32 | 234 | 16 | Ch 2 (control) | 179 |
| 7 | PB 242 | 229 | 17 | PB 235 | 174 |
| 8 | BD 5 | 227 | 18 | PB 5/51 | 167 |
| 9 | PB 252 | 220 | 19 | GI 1 | 164 |
| 10 | PB 217 | 210 | 20 | PB 5/76 | 148 |

## GERMPLASM DIVISION

The Germplasm Division started functioning in the new laboratory in December 1989. The Division is concentrating on the introduction, collection, conservation and evaluation of *Hevea* germplasm.

### 1. Introduction, collection and conservation of germplasm

#### 1.1 Wickham materials from the secondary diversity centres

A collection of 174 older and elite cultivars of indigenous and exotic origin is being conserved *in situ*. They are being evaluated in the source bush conservatories and utilised for various investigations in plant breeding. Gap filling in the germplasm museum at RRII campus has been carried out.

Preliminary steps are under way to procure IRCA clones on bilateral clone exchange basis.

#### 1.2 Wild germplasm from IRRDB exploration

Introduction of wild (Brazilian) germplasm was continued. 800 genotypes belonging to the Acre, Rondonia and Mato Grosso locations were introduced during the period. Of these 38 genotypes were detained by the Plant Quarantine Department suspecting the presence of certain nematodes in the packing materials. It was later identified by the CAB International Institute of Parasitology, U. K., as *Ditylenchus* sp. which is not parasitic to rubber. However, the debris were incinerated and proper phytosanitary precautions are ensured before despatch from the IRRDB Germplasm Centre. The remaining 762 genotypes were multiplied and 3974 budgrafts were planted in polybags. Census of the germplasm accessions accrued so far at the RRII base nursery is given in Table – Gplm. 1. All the genotypes were introduced from the Malaysian Centre.

Table-Gplm. 1. **Brazilian germplasm conserved in the RRII base nursery**

| Location /source of origin | Number received |
|---|---|
| Acre | 2011 |
| Rondonia | 1738 |
| Mato Grosso | 529 |
| Ortet clones | 111 |
| Mixed seedlings | 38 |

9158 plants raised in polybags, belonging to 2080 genotypes were planted in a source bush nursery at the Central Experiment Station. Very severe drought was experienced during last season and life saving irrigation was given to individual plants through subsoil water injector.

## 2. Evaluation of germplasm

### 2.1 Conservation gardens

Regular yield records and annual girth data were collected from the three germplasm gardens established in 1977, 1979 and 1981. Of the 51 clones in garden 1, only 22 clones gave an average yield above the field average. PB 217 and PB 235 were found superior to the control with regard to yield and girth. Most of the PB clones gave better yield (Table-Gplm. 2).

Yield and girth data of the 35 clones conserved in garden 2, showed that only 14 clones including the control gave an average yield higher than that of the field average and five clones better (Table-Gplm 3) than the control.

In the germplasm garden 3, out of the 16 clones, only one showed a better performance than the control and field average during the period.

### 2.2 Nursery evaluation, juvenile characterisation and cataloguing

Genotypes of the 1984-85 introduction were allowed to flower. Preliminary observations on the floral biology and fruitset was initiated in sixteen genotypes. Characters like sex ratio, variation in the weight and length of male and female flowers, number of anthers etc., are being studied.

A descriptor format has been designed to record observation on the morphological variations among the genotypes.

Table-Gplm. 2. **Average yield and girth of 22 clones in garden 1**

| Clone | Average yield 4th year ($g\ t^{-1}\ t^{-1}$) | Average girth 12th year (cm) |
|---|---|---|
| PB 215 | 63.23 | 83.33 |
| PB 252 | 62.49 | 83.75 |
| PB 28/83 | 52.94 | 70.28 |
| PB 253 | 53.51 | 66.84 |
| PB 230 | 50.01 | 76.58 |
| PB 206 | 43.39 | 62.24 |
| PB 242 | 57.66 | 77.13 |
| PB 5/139 | 44.49 | 68.78 |
| PB 5/60 | 45.55 | 72.64 |
| PB 5/76 | 52.26 | 68.13 |
| PB 217 | 73.90 | 78.23 |
| PB 5/63 | 61.02 | 72.33 |
| PB 235 | 68.44 | 86.44 |
| CHM 3 | 43.96 | 71.61 |
| AVT 77 | 49.15 | 69.72 |
| LCB 1320 | 48.96 | 82.02 |
| GT 1 | 50.81 | 80.46 |
| Ch 153 | 54.01 | 80.76 |
| Dj 7 | 49.60 | 75.42 |
| Ch 26 | 50.81 | 77.84 |
| Tjir 1 | 50.96 | 79.25 |
| RRII 105 | 66.86 | 73.37 |

Table-Gplm. 3. **Average yield and girth of 15 clones in the garden 2**

| Clone | Average yield 3rd year ($g\ t^{-1}\ t^{-1}$) | Average girth 10th year (cm) | Clone | Average yield 3rd year ($g\ t^{-1}\ t^{-1}$) | Average girth 10th year (cm) |
|---|---|---|---|---|---|
| IAN 717 | 35.05 | 55.15 | RRIM 513 | 49.60 | 61.12 |
| IAN 873 | 38.73 | 64.38 | RRIM 605 | 48.18 | 65.19 |
| RRIM 519 | 35.50 | 65.26 | RRIM 608 | 34.15 | 57.21 |
| RRIM 622 | 39.40 | 67.10 | RRIM 501 | 40.20 | 62.69 |
| RRIM 632 | 39.85 | 74.40 | RRIM 607 | 41.56 | 67.79 |
| RRIM 621 | 41.10 | 59.60 | RRIM 701 | 38.40 | 64.22 |
| RRIM 623 | 42.80 | 72.19 | RRIM 703 | 49.98 | 60.64 |
| | | | RRII 105 | 41.35 | 57.07 |

## MYCOLOGY AND PLANT PATHOLOGY DIVISION

The Plant Pathology and Entomology sections under the Division concentrate on crop protection aspects of rubber. Basic studies of pathogens are carried out by Mycology section. Improvement to soil fertility and biological control of pollution are being done by Microbiology section.

### 1. Abnormal leaf-fall disease

This most important disease of rubber caused by *Phytophthora* spp. is largely confined to high rainfall areas. But recently this disease appeared in two consecutive years in Kanyakumari district of Tamil Nadu also. The leaf-fall and die-back of shoot caused by the disease debilitate the trees.

Two copper oxychloride 56% oil based formulations, manufactured by two firms, were subjected to preliminary testing and recommended for large scale screening. Three improved samples of spray oil, supplied by M/s. Indian Oil Corporation, were tested and among these one was found to retain almost double the quantity of copper during the disease season.

The dosages adopted by some private estates and that recommended by RRII for aerial spraying, were compared in five locations. In two locations, the recommended dosage was more effective. The experiment is being repeated.

Arrangements were made to start a new experiment to assess region-wise dosage requirements in clone RRII 105, with low dosages at Punalur and high dosages at Palapilly.

### 2. High volume spraying

In most of the small holdings, high volume spraying is being practised. Efforts are on to reduce the cost of spraying and improve the results. Different volumes of 1% Bordeaux mixture were tried in susceptible and tolerant clones and the results are furnished in Table-Path. 1.

Table-Path. 1. **Spray volume of 1% Bordeaux mixture and leaf retention**

| Clone | Treatment | Leaf retention |
|---|---|---|
| GT 1 | 1000 l/ha | 68.0 |
| | 2000 l/ha | 64.0 |
| | 3000 l/ha | 79.0 |
| RRIM 600 | 3000 l/ha | 63.0 |
| | 4000 l/ha | 77.0 |
| | Micron sprayed | 80.0 |

The results indicate that GT 1 requires only less dosage to obtain similar leaf retention as in RRIM 600. This finding will lead to evolution of clone-wise recommendations resulting in fungicide saving.

### 3. Shoot rot disease

Eight fungicides, found effective in earlier trials, were tested again and the statistical analysis of results (Table-Path. 2) indicates that the effect of treatments significantly differs. 0.5% Bordeaux mixture + 0.5% zinc sulphate was found to be on par with 1% Bordeaux mixture and 1% instant Bordeaux and these were superior to other treatments.

Table-Path. 2. **Disease intensity in shoot rot control experiment**

| Treatments | % Disease intensity |
|---|---|
| Bordeaux mixture 1% | 1.54 (1.9) |
| Bordeaux mixture 0.5% | 2.15 (4.2) |
| Bordeaux mixture 1%+ Zinc sulphate 0.5% | 1.15 (0.8) |
| Bordeaux mixture 0.5%+ Zinc sulphate 0.5% | 1.20 (1.1) |
| Cobox L 1% | 1.96 (3.3) |
| Instant (stabilised) Bordeaux 1% | 1.47 (1.7) |
| Copper oxychloride WP 0.5% | 1.60 (2.1) |
| Aliette 0.4% | 2.06 (3.8) |
| CD : | 0.36 |

Figures in parenthesis indicate the actual percentage disease intensity; CD for transformed values.

### 4. Evaluation of panel/wound dressing compounds

In heavy rainfall areas, when tapping is continued during rainy days, bark rot disease caused by *Pnytophthora* occurs. A new experiment to compare the effect of approved panel protectant compound, sopkot, with that of furr ace oil was started. One more panel dressing compound was approved after necessary tests.

The bark rot disease control experiment with four different fungicides in different dosages was repeated and the results are furnished in Table-Path. 3. Under each treatment 1600 trees were included of which 400 were closely observed.

Table- Path. 3. **Per cent disease index in bark rot control experiment**

| Treatment | Frequency | Dosage (%) | Mean PDI |
|---|---|---|---|
| Thiride | Weekly | 0.75 (10 g/l) | 28.95 |
| Thiride | Fortnightly | 0.75 (10 g/l) | 37.54 |
| Foltaf | Weekly | 0.8 (10 g/l) | 21.80 |
| Foltaf | Fortnightly | 0.8 (10 g/l) | 26.21 |
| Dithane M-45 | Weekly | 0.75 (10 g/l) | 12.92 |
| Dithane M-45 | Fortnightly | 0.75 (10 g/l) | 25.00 |
| Emisan (control) | Weekly | 0.015 (2.5 g/l) | 47.00 |
| SE : | | | 2.75 |
| CD : | | | 8.13 |

The results indicate that Dithane M-45 0.75% with weekly application was significantly superior to other treatments.

### 5. Crown budding for disease resistance/ tolerance

In spite of considerable technical problems, crown budding is being tried as a technique to resist diseases. A field trial was initiated during 1987 and crown budding was completed in 1989, in clone PB 311. The final budding success with the resistant crown clones RRII 33 and Fx 516 was 84 and 94 per cent respectively. Pink disease incidence was noticed in 5 per cent of RRII 33, 0.07 per cent in Fx 516 and 8 per cent in the control (PB 311). Girth measurements at 125 cm height, in the second year (Table- Path. 4) indicated that the growth of crown budded plants was inferior to the control.

Table-Path. 4. **Girth (cm) of crown budded plants**

| Crown clone | Pre-treatment | 1st year | 2nd year |
|---|---|---|---|
| RRII 33 | 13.00 | 18.36 | 22.00 |
| Fx 516 | 13.62 | 17.93 | 24.00 |
| PB 311 (control) | 13.73 | 23.35 | 33.00 |

### 6. Pink disease

This most important stem disease is found to be very serious in recent years in the plantings of the highly susceptible clones RRII 105 and PB 217. Severe incidence of the disease is being noticed in plantations where the mature trees of these clones are found adjacent to the immature areas.

Disease incidence in different clones was evaluated from the records of Kaliyar Estate (Thodupuzha) and Manikal and Boyce estates (Mundakayam). Percentage pink disease affected plants varied from 6.48 to 59 per cent in areas planted in different years from 1971 to 1987, in clones PB 217, RRII 105, PB 235 and GT 1. Maximum incidence was noticed in PB 217.

### 7. Powdery mildew disease

A definite negative relation is found on the incidence of powdery mildew disease and abnormal leaf-fall disease, as powdery mildew disease can considerably reduce the pod formation due to attack on inflorescence and reduce inoculum for abnormal leaf-fall disease. The field trial conducted to reduce the dosage of Calixin 1.5% dust and alternate application of systemic and non-systemic fungicide, indicated that seven kg per hectare of Calixin is adequate and the best result could be obtained by alternate application of Calixin, sulphur and Calixin (treatment B). The other treatment (A) was sulphur-Calixin-sulphur-Calixin while the control (C) had four rounds of sulphur (Table-Path. 5).

### 8. High pressure injection for disease control

The copper sulphate injected rubber wood pieces were found to have moderate attack of fungus and very mild attack of insect borer

Table-Path. 5. **Percentage disease incidence in the dusting trial, 1989 season**

| Name of estate | Clone | Year of planting | Disease incidence in treatments (%) | | |
|---|---|---|---|---|---|
| | | | A | B | C |
| Vaikundam Estate | PB 5/139 | 1966 | 36.00 | 32.08 | 37.50 |
| Cheruvally Estate | PB 235 | 1975 | 66.25 | 49.92 | 77.25 |
| Lahai Estate | PB 5/51 | 1970 | 72.67 | 62.58 | 75.83 |

after two years in the case of immature trees and after 10 months in the case of 30 year old mature trees.

**9. Pollution studies**

A proprietory phenol based detergent, formalin and phenol were evaluated for reducing the bacterial population in barrels used for storing centrifuged latex. The proprietory product was found to be very effective in reducing the population.

**10. Minor leaf-spot diseases**

Minor leaf spot diseases may turn into major problems, as seen in the case of *Corynespora* leaf spot in Sri Lanka. The experiment for the chemical control of *Gleosporium* leaf spot disease was repeated with six chemical treatments, water sprayed control and an unsprayed control. Dithane M-45 and Bavistin 0.5% were found to be promising in visual observation. The data are being analysed.

**11. Residual copper from copper fungicides**

The problems that can arise due to copper residue are being constantly monitored. The data for the first five years of the experiment on copper residue due to spraying against abnormal leaf-fall disease have been analysed. It is found that the leaf retention does not increase commensurate with the increase in the dosage of copper. The annual accumulation of copper in latex and soil was found to increase steadily. The increase of copper content in latex is considerably reduced and brought down to acceptable limits when the serum is removed from the latex.

**12. Yield loss due to diseases**

The field experiment conducted in 1984 was concluded. Carryover effect of leaf-fall in unsprayed year to the subsequent year after spraying was found to be more than the unsprayed year. A crop loss of 14.57 per cent was found in 15 year old RRIM 600 and 17.98 per cent in 25 year old PB 86. The impacts of the disease on yield components were significant increase in plugging index and decrease in dry rubber content.

**13. Over summering of *Phytophthora***

Both sporangia and oospores were trapped in the spore traps kept in the field before the onset of the disease in the trees, indicating that primary inoculum is available in the soil.

**14. Host parasite relations**

By repeated studies, it has been confirmed that in the initial stages, the pink disease pathogen *Corticium salmonicolar* enter the plant bark only through the lenticels. Longitudal sections of the wood portions showed the presence of the fungal mycelium in medullary rays and xylem vessels.

A method is being developed for the early prediction of susceptibility of clones to powdery mildew disease caused by *Oidium heveae*.

**15. Epidemology of diseases**

The dew guage for estimating the dew in summer months was installed at RRII and regular recording was started to study the relations between dew formation and powdery mildew disease. In the last season, powdery mildew disease did not appear in a severe form. The weather parameters for triggering of abnormal leaf-fall disease were monitored and in the last season it was found to comply with the weather parameter model already developed.

**16. Regional isolates of fungal pathogens**

Collection, classification and comparison of morphology of regional isolates were continued. Isolates of various fungal

pathogens of rubber numbering 140 are being maintained. Ten new isolates were added to the collection. Among this, one is from Tripura which was identified as *Phytophthora palmivora*.

**17. Root disease**

Soil surface application of fungicides for the control of brown root disease is found to be yielding satisfactory results. Application of the systemic fungicides Kitazin and Calixin gave better check of the disease in the neighbouring plants. The experiment has to be repeated to confirm these results.

**18. Multi-disciplinary evaluation of clones**

Regular field observations on the diseases that occur on the rubber plants in the two trials are being recorded.

**19. Early prediction of diseases**

A total number of 20 germplasm genotypes and 30 HP seedlings were screened for *Phytophthora* resistance by artificial inoculation.

**20. Microbiology of leguminous cover crops**

Comparative study on soil moisture at 30, 60 and 90 cm depths in fields under *Mucuna bracteata* and *Pueraria phaseoloides* was carried out during April 1989 in Palghat where prolonged drought is experienced. Soil moisture was more at all three depths under *M. bracteata*. The results are furnished in Table-Path. 6.

Table-Path. 6. **Soil moisture under different cover crops**

| Cover crop | Moisture (%) | | |
|---|---|---|---|
| | 30 cm | 60 cm | 90 cm |
| *P. phaseoloides* | 11.89 | 14.81 | 16.56 |
| *M. bracteata* | 13.12 | 15.49 | 17.17 |

Field experiments are being conducted at Kinalur, Pudukad and Malankara estates with selected Rhizobium isolates. In all the three locations, the two isolates chosen were found to be effective with regard to nodulation and biomass production. Comparative study was made on nitrogen fixing capacity of *Mucuna* and *Pueraria phaseoloides* with gas chromatograph using acetylene reduction activity (ARA) and the result was 2541 n mol/g and 2048 n mol/g, respectively. The ARA activity of *P. phaseoloides* grown under shade and light, when compared, indicate that it is more under light.

The effect of cover crop seed pre-treatments on Rhizobium growth and population as well as total phenol content was evaluated. The results (Table-Path. 7) clearly indicate that hot-water treatment reduces the inhibitory activity of cover crop seeds, except in the case of *Mucuna bracteata*, against *Rhizobium*. Moreover, the hot-water treatment gave better nodulation and biomass production in comparison with acid treatments. It also reduced the total phenol content.

**21. Antagonistic microorganisms**

Field testing of the actinomycete against pink disease has been repeated and the control achieved is comparable to that with Bordeaux paste.

**22. Non-symbiotic nitrogen fixing micro-organisms**

The effect of the pH and carbon source on the total nitrogen fixed by *Beijerenckia* spp. was estimated and pH 6 and fructose as carbon source, were found to be more suitable.

The effect of different mycorrhizae at different levels of phosphate on growth of *Pueraira* was investigated. Result indicated that VAM isolates, *Glomus* spp. (RRII isolate), *G. fasciculatum* and *G. maryarita*

in general increased root mycorrhizal infection as well as spore count at higher phosphatic levels. Studies on phosphate solubilising bacteria are being continued.

### 23. Mushroom culture

Rubber wood wastes like small branches and saw-dust are found to support the growth and sporocarp production of *Oyster* mushroom (Table-Path. 8). *Pleurotus saiorcaju*, *P. citrinopileatus* and *P. florida* were tested. *P. florida* was found to grow better.

Table-Path.8. **Comparison of mushroom production in different substrates**

| | Rubber wood saw-dust | Paddy straw |
|---|---|---|
| Yield (g/500 g) | 444.0 | 250.0 |
| Bio-conversion efficiency | 88.8 | 50.8 |
| Sporocarp | | |
| 1. Shape | Umbrella | Oyster |
| 2. Size (cm) | 8.2 | 4.8 |
| 3. Weight (g) | 20.0 | 8.0 |
| Days taken for sporocarp production | 14 – 16 | 16 – 18 |

Thorough mixing of spawn with saw-dust was found to be superior compared to application of spawn in layers.

### 24. White grubs

The field trial on the control of white grubs was repeated and it was found that all the biological and insecticidal treatments were significantly superior to control in protecting rubber seedlings from white grubs (Table-Path. 9). Plots broadcast with *Beauveria brongniarti* and *B. bassiana* spores were on par and recorded 94.25 per cent and 94.00 per cent plant survival respectively and lowest grub population followed by plots broadcast with Isofenphos 5 G (89 per cent). Control plots recorded 7.5 per cent plant survival.

Population sampling of white grubs revealed the predominance of *Anomala* spp. at the Regional Nurseries at Kadakkamon and Perumpulickal. Presence of *Anomala* spp. was noted in the nursery at Regional Research Station at Kamakhya Nagar (Orissa).

### 25. Vertebrate and non-insect pests

Bromadialone and brodifacoum baits at 0.005% concentration and $Zn_3P_2$ baits at

Table-Path. 7. **Effect of cover crop seed pre-treatment on Rhizobium growth and phenol content**

| Cover crop seed | Inhibition zone (sq cm) | | | Phenol content (mg/g) | | |
|---|---|---|---|---|---|---|
| | Un-treated | Acid treated | Hot water treated | Un-treated | Acid treated | Hot water treated |
| *Pueraria phaseoloides* | 2.20 | 1.61 | 0.77 | 30.0 | 20.0 | 8.0 |
| *Calopogonium mucunoides* | 1.83 | 1.31 | 0.80 | 16.8 | 15.0 | 3.3 |
| *Mucuna bracteata* | 3.38 | 2.20 | 3.17 | 23.3 | 22.0 | 9.5 |
| *Centrosema pubecens* | 3.17 | — | 0.61 | 25.3 | — | 7.0 |
| *Mimosa invisa* var. *inermis* | 2.05 | — | — | 30.8 | — | — |

2% concentration were evaluated against three rat species infesting rubber seedlings. Post-control census revealed 94.28 per cent success with Bromadiolone, 98.00 per cent success with Brodifacoum and 67.50 per cent success with $Zn_3P_2$ baits on the basis of active burrow counts. At 3, 6 and 9 months' stages in the growth of seedlings, the pre and post-control damage to rubber were evaluated by studying 300 plots of $1m^2$ each. At every stage in the growth of rubber seedlings, significant reduction in the rodent damage were obtained with Brodifacoum baits.

Aldicarb baits at 0.043%, Bromadiolone at 0.005% and $Zn_3P_2$ baits at 2% concentrations were tested against *Bandicota bengalensis* at the Regional Research station, Dapchari (Maharashtra State). Adicarb and Bromadiolone baits proved to be effective.

**26. Bark feeding caterpillar**

Comparative efficacy of Fenval 0.4% D and quinalphos 1.5% D at the rate of 12 $kg^{-1}$ ha. was evaluated against *Aetherastis circulata* infesting rubber. In block trials (Kundai Estate), Fenval proved to be supe-

Table-Path. 9. **Comparative evaluation of biological and insecticidal treatments against** *Holotrichia serrata* F

| Treatment | Dose (kg $ha^{-1}$) | Mean percentage survival and plants/plot* | Grub Population 30 $cm^2$ |
|---|---|---|---|
| Phorate 10G | 25 | 82.50 (65.27) c + | 0.10 |
| Carbofuran 3G | 25 | 81.00 (64.16) c | 0.15 |
| Carbaryl + Lindane (Sevidol 4: 4G) | 25 | 80.00 (63.44) c | 0.15 |
| Carbaryl 4G | 25 | 62.75 (52.39) d | 0.20 |
| HCH 10 D | 100 | 35.00 (36.27) e | 0.30 |
| Phosalone 4D | 100 | 38.25 (38.20) e | 0.25 |
| Carbaryl 5D | 100 | 38.75 (38.50) e | 0.25 |
| Malathion 5D | 100 | 24.25 (29.50) f | 0.35 |
| Isofenphos 5G | 25 | 89.00 (70.63) b | 0.10 |
| *B. brongniartii* | $10^6$ spores/g soil | 94.25 (76.12) a | 0.05 |
| *B. bassiana* | $10^8$ spores/g soil | 94.00 (75.82) a | 0.05 |
| Control | — | 7.50 (15.89) g | 1.15 |
| F test | | Significant | |
| S. E. of X | | 1.56 | |

* Mean of four replications. Figures in parenthesis are arc sine values. + Means with the same letter within a column do not differ significantly ($P < 0.05$)

rior to quinalphos. *Himertosoma* sp. was identified as pre-pupal parasitoid of *A. circulata*.

**27. Termites**

In the field trial laid out against termites infesting rubber at the Regional Research Station, Kamakhya Nagar (Orissa), all insecticidal treatments were effective in controlling termites, in the preliminary observations.

**28. Slugs and snails**

Metaldehyde bait at 2.5 per cent concentration was not as effective as 0.01% aldicarb maida slurry for the control of slugs.

**29. Beekeeping in rubber plantations**

*Manihot glaziovii* and *Kleinhovia* spp. were established as off-season bee forage plants. Among the plants established for off-seasonal bee forage, *Albezzia lebeck* showed flowering from September to November. *Strobilanthus haeniamus* showed peak flowering during December-January. Low incidence of pollenfeeding mites *Neocypholaelaps* spp. was observed during December-January and peak incidence in August.

**30. Nematodes**

Roots of rubber seedlings heavily infested with *Meloidogyne incognita* were recorded this year also from Kadackamon Regional Rubber Nursery. Incidence of plant parasitic nematodes on rubber seedlings was also recorded at RRS Nursery, Orissa.

**31. Wood preservation**

Rubber wood will be a potential substitute to presently used timber species in future years. Efforts are on to improve its quality. In preliminary studies Na PCP in combination with boric acid and borax effectively controlled both fungus and insect borer attack. Monocrotophos with oxycarboxin was also found to be effective.

## PLANT PHYSIOLOGY AND EXPLOITATION DIVISION

**1. Physiological and biochemical subcomponents of yield**

The carbohydrate and lipid profiles in latex from high yielders and low yielders were analysed. Studies to elucidate the role of these subcomponents in latex flow and latex regeneration are in progress.

**2. Rubber biosynthesis**

The ratio of HMG-CoA to mevalonate in the bark of *Hevea brasiliensis* were estimated in clone PB 235, RRII 105 (high yielding), Ch 4 and Pil B 84 (low yielding). Significant difference was observed between the high yielding and low yielding clones. The ratio of HMG-CoA to mevalonate is a possible indication of the activity of HMG-CoA reductase which converts the former to the latter, a higher ratio indicating a lower enzyme activity.

**3. Early prediction of yield and stress tolerance**

Biochemical studies for early prediction of yield and stress tolerance were continued. Latex samples were collected from four year old plants belonging to six clones representing high, medium and low yield levels. Reducing sugars, free amino acids, cyclitols and total phosphorus were estimated. The data showed that the values were significantly low in the low yielders compared to those in the high yielders.

**4. Lipid metabolism and latex production**

Latex samples were collected from two high and two low yielders. Total lipids, triglycerides, sterols and phospholipids in the rubber cream and bottom fraction were estimated. Latex samples from RRII 105 and GT 1 under normal tapping and intensive tapping were also analysed for various lipid fractions. The results are being analysed.

**5. Clone identification by protein mapping/ isozymes**

A clone identification study was initiated with 10 clones. Leaf samples were collected and isozyme pattern of esterase and peroxidase were studied by polyacrylamide gel electrophoresis. Marked clonal differences in the number, relative intensity and electrophoretic mobilities were observed.

Four esterase isozymes (Rf 0.65, 0.73, 0.80 and 0.85) were present in all the clones studied. Isozyme with Rf 0.61 and 0.89 were commonly present in clone RRII 105, Gl 1, RRIM 600 and Tjir 1. However, an esterase isozyme with Rf 0.54 is present only in clone Tjir 1. Isozymes with Rf 0.61 and 0.54 are absent in the remaining clones. Moreover, in clones Hil 28, PB 86 and RRII 300 isozyme with Rf 0.89 is also absent (Table-Phy. 1).

Eight peroxidase isozymes were commonly present in clones RRII 105, Tjir 1, Gl 1 and RRIM 600. Major differences were observed in the cationic isozymes in the remaining six clones. Anionic isozymes were common in all clones. Isozymes with Rf 0.38 and 0.41 are absent in clones Mil 3/2, Hil 28 and RRII 118 and with Rf 0.45 and 0.48 are absent in PR 107, RRII 300 and PB 86. (Table- Phy. 2) Further studies using additional enzyme systems are in progress.

**6. Yield constraint analysis**

The experimental recordings of latex flow characteristics (monthly) were continued in two locations on clone GT 1. The annual yield and monthly mean dry rubber yield was 66% higher at New Ambadi (Kanyakumari area) compared to Kinalur (Calicut area). The monthly yield was consistently high at New Ambadi than at Kinalur, except for the month of September when the number of tapping day was only one at New Ambadi. The girth increment was similar in both places. The annual rainfall during the period indicate very high rainfall (60% more)

Table–Phy. 1. **Variation in leaf esterase isozymes**

| Clone | Rf values | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0.54 | 0.61 | 0.65 | 0.73 | 0.80 | 0.85 | 0.89 |
| RRII 105 | — | + | + | + | + | + | + |
| Tjir 1 | + | + | + | + | + | + | + |
| Gl 1 | — | + | + | + | + | + | + |
| Mil 3/2 | — | — | + | + | + | + | + |
| Hil 28 | — | — | — | + | + | + | — |
| RRII 118 | — | — | + | + | + | + | + |
| PR 107 | — | — | + | + | + | + | + |
| RRII 300 | — | — | + | + | + | + | — |
| PB 86 | — | — | + | + | + | + | — |
| RRIM 600 | — | + | + | + | + | + | + |

+ presence — absence

at Calicut compared to that at Kanyakumari. The monthly soil moisture status in Kanyakumari area at all depths studied (0–30 cm, 30–60 cm and 60–90 cm) showed better soil moisture availability.

The pre-tapping turgor pressure was consistently high at Kanyakumari area during 1989–90 (Table-Phy. 3). However, the turgor pressure values, 5 minutes after tapping showed a slightly high value at Calicut compared to Kanyakumari area. This may probably be due to a faster plugging and pressure build up in the vessels, thus leading to a short duration of flow. The pre-tapping values were much higher at New Ambadi and the difference was more especially from November to January. A similar pattern of high initial flow rate and total volume was also noticed at Kanyakumari area during the same period, which are the highly productive months accounting for 40–50 per cent of the annual rubber production (Table-Phy. 4). The d.r.c. values during these months as well as the mean annual d.r.c. values were slightly high at New Ambadi. Thus higher total volume and higher d.r.c. supplement high production. The plugging index was higher at Calicut in almost all the months. This could be due to the low percentage of soil moisture, and its effect on turgor pressure, initial flow and higher d.r.c. Along with the recordings of flow characteristics, latex solute potential was also determined at monthly intervals. The values were in the range of 0.8 to 1.0 –MPa at both locations. However, in most of the months, though not statistically significant, it was slightly high at New Ambadi.

## 7. Physiological evaluation of clones

Besides growth, various physiological parameters were also recorded in the 1982 multilocational trial. Girth, seven years after planting, is presented in Table-Phy. 5. Seventy per cent plants attained tappable girth in CES and in Dapchari. Girthing

Table–Phy. 2. **Variation in leaf peroxidase isozymes**

| Clone | Rf values | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0.38 | 0.40 | 0.41 | 0.45 | 0.48 | 0.71 | 0.75 | 0.79 | 0.82 |
| RRII 105 | + | + | + | + | — | + | + | + | + |
| Tjir 1 | + | + | + | + | — | + | + | + | + |
| Gl 1 | + | + | + | + | — | + | + | + | + |
| Mil 3/2 | — | + | — | + | — | + | + | + | — |
| Hil 28 | — | + | — | + | + | + | + | + | — |
| RRII 118 | — | + | — | + | + | + | + | + | — |
| PR 107 | + | + | + | — | — | + | + | + | — |
| RRII 300 | + | + | + | — | — | + | + | + | — |
| PB 86 | + | + | + | — | — | + | + | + | — |
| RRIM 600 | + | + | + | + | — | + | + | + | + |

+ presence — absence

pattern at CES was similar to that of last year. Under Dapchari conditions, there was a 7.5 per cent decrease in mean girth compared to CES. The girth was 34 per cent less at Mudigere compared to that at CES.

In RRS, Dapchari, physiological parameters were recorded in three seasons i.e., November 1989 (high soil moisture), January 1990 (low atmospheric temperature) and March-April (high atmospheric temperature and low soil moisture levels). Seasonal changes in peak photosynthetic rate (A), transpiration rate (E), stomatal diffusive conductance (GS) and water use efficiency (WUE) are presented in Table-Phy 6. During November 1989 the mean assimilation rate was 9.36 $\mu$ mole $m^{-2}$ $sec^{-1}$. A fifty per cent decrease in mean A was observed during January 1990 compared to November 1989. In clone Tjir 1 and PB 235, in which severe winter leaf fall was observed, A has decreased by nearly 90 per cent. However, a marginal decrease from January 1990 was noticed during March-April 1990. Similar trends were observed for E and GS. However, WUE increased marginally in January and March-April compared to November 1989 and this indicates the avoidance of stress.

### 8. Performance of clones at high elevations

Since the plantations in Poonoor was removed, observations were discontinued. However, growth monitoring was continued

Table-Phy. 3. **Latex vessel turgor and latex solute potential**

| Month | KINALUR | | | NEW AMBADI | | |
|---|---|---|---|---|---|---|
| | Latex vessel turgor pressure(Mpa) (Mpa) | | Solute potential (—Mpa) | Latex vessel turgor pressure (Mpa) | | Solute potential (—Mpa) |
| | Before tapping | 5 min after tapping | | Before tapping | 5 min after tapping | |
| 1989 March | 0.51 | 0.32 | 0.92 | 0.59 | 0.29 | 0.97 |
| ,, April | 0.62 | 0.31 | 0.91 | 0.69 | 0.26 | 0.98 |
| ,, May | 0.71 | 0.25 | 0.90 | 0.78 | 0.21 | 0.94 |
| ,, June | 0.85 | 0.21 | 0.90 | — | — | — |
| ,, July | 0.81 | 0.21 | 0.88 | 0.83 | 0.18 | 0.96 |
| ,, August | 0.85 | 0.14 | 0.87 | 0.88 | 0.12 | 0.95 |
| ,, September | 0.66 | 0.15 | — | 0.70 | 0.21 | — |
| ,, October | 0.69 | 0.24 | 0.93 | 0.74 | 0.18 | 0.90 |
| ,, November | 0.60 | 0.22 | 0.86 | 0.86 | 0.16 | 0.96 |
| ,, December | 0.71 | 0.18 | 0.85 | 0.93 | 0.15 | 0.95 |
| 1990 January | 0.75 | 0.15 | 0.90 | 0.90 | 0.13 | 0.88 |
| ,, February | 0.72 | 0.14 | 0.92 | 0.83 | 0.12 | 0.96 |
| Mean | 0.71 | 0.21 | 0.89 | 0.79 | 0.18 | 0.95 |

Table-Phy. 4. **Latex flow characteristics Clone GT 1**

| Month | KINALUR | | | | NEW AMBADI | | | |
|---|---|---|---|---|---|---|---|---|
| | Initial flow rate (ml/min) | Total volume (ml) | d.r.c. (%) | Plugging Index | Initial flow rate (ml/min) | Total volume (ml) | d.r.c. (%) | Plugging Index |
| 1989 March | 2.68 | 40.7 | 38.3 | 7.09 | 2.87 | 48.7 | 33.9 | 6.37 |
| ,, April | 3.04 | 42.5 | 38.6 | 8.36 | 3.23 | 54.8 | 37.2 | 6.23 |
| ,, May | 3.15 | 73.0 | 37.6 | 5.02 | 3.21 | 81.1 | 40.0 | 4.21 |
| ,, June | 3.51 | 79.0 | 35.3 | 5.06 | — | — | — | — |
| ,, July | 2.86 | 114.0 | 35.1 | 3.12 | 2.99 | 121.2 | 40.2 | 2.60 |
| ,, August | 3.07 | 123.6 | 38.0 | 3.08 | 3.69 | 150.2 | 37.6 | 2.59 |
| ,, September | 2.78 | 118.0 | 38.6 | 2.98 | 2.70 | 87.4 | 42.6 | 3.46 |
| ,, October | 2.82 | 135.0 | 38.4 | 2.61 | 3.60 | 142.1 | 43.7 | 2.78 |
| ,, November | 2.60 | 97.4 | 36.6 | 3.37 | 4.09 | 190.8 | 41.7 | 2.28 |
| ,, December | 3.14 | 140.0 | 39.3 | 2.99 | 4.70 | 273.5 | 34.8 | 1.76 |
| 1990 January | 3.28 | 206.8 | 36.5 | 1.75 | 4.64 | 251.4 | 34.7 | 1.91 |
| ,, February | 2.94 | 127.4 | 35.1 | 2.96 | 4.69 | 176.5 | 32.6 | 2.89 |
| Mean | 2.99 | 108.07 | 37.28 | 4.03 | 3.67 | 143.43 | 38.09 | 3.37 |

Table-Phy. 5. **Girth (cm) at 7th year of *Hevea* clones at different agroclimatic regions**

| Clone | CES | Dapchari | Mudigere |
|---|---|---|---|
| RRII 300 | 51.41 | 42.41 | 32.01 |
| PB 235 | 49.05 | 42.40 | 32.34 |
| RRII 105 | 49.16 | — | 29.38 |
| RRIM 600 | 45.89 | 48.56 | 32.99 |
| GT 1 | 44.94 | 41.60 | 32.57 |
| PR 107 | 38.98 | 43.64 | 27.54 |
| Gl 1 | 44.94 | 42.59 | 24.11 |
| RRIM 501 | 43.30 | 40.66 | 27.52 |
| RRII 118 | 51.29 | — | 30.21 |
| RRIM 703 | 48.78 | — | 34.60 |
| Tjir 1 | 49.86 | 43.89 | 29.66 |
| RRIM 612 | 49.49 | 46.94 | 33.18 |
| Mean | 47.20 | 43.63 | 31.19 |

Table–Phy.6 **Photosynthetic rate (A), transpiration rate (E), stomatal diffusive conductance (GS) and water use Efficiency (WUE) in different seasons (1989-90) at RRS., Dapchari**

| Clone | A ($\mu$ mole $m^{-2}$ $sec^{-1}$) | | | E (m mole $m^{-2}$ eec $^{-1}$) | | | GS (mole $m^{-2}$ $sec^{-1}$) | | | WUE = A/E | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | November | January | April | November | January | April | November | January | April | November | January | April |
| GT 1 | 11.82 | 5.50 | 0.12 | 7.47 | 2.70 | 0.20 | 0.32 | 0.09 | 0.01 | 1.58 | 2.04 | 0.60 |
| RRIM 501 | 12.67 | 4.71 | 1.00 | 8.60 | 3.70 | 0.27 | 0.38 | 0.07 | 0.01 | 1.47 | 1.27 | 3.70 |
| Tjir 1 | 9.45 | 0.86 | 2.36 | 9.37 | 1.77 | 0.87 | 0.36 | 0.03 | 0.03 | 1.01 | 0.49 | 2.71 |
| RRII 300 | 8.53 | 1.43 | 2.10 | 9.63 | 2.53 | 1.60 | 0.23 | 0.04 | 0.03 | 1.12 | 0.52 | 1.31 |
| PB 235 | 10.85 | 0.40 | 5.46 | 9.97 | 1.67 | 3.30 | 0.32 | 0.03 | 0.07 | 1.09 | 0.24 | 1.65 |
| RRIM 612 | 7.74 | 8.87 | 3.42 | 8.13 | 3.07 | 1.73 | 0.21 | 0.14 | 0.04 | 0.95 | 2.89 | 1.98 |
| PR 107 | 8.25 | 3.22 | 3.15 | 9.00 | 2.97 | 2.20 | 0.25 | 0.07 | 0.05 | 0.92 | 1.08 | 1.43 |
| RRIM 600 | 5.92 | 2.94 | 5.70 | 6.17 | 2.00 | 4.03 | 0.17 | 0.05 | 0.09 | 0.96 | 1.47 | 1.41 |
| Gl 1 | 9.01 | 8.50 | 4.99 | 11.83 | 3.57 | 3.13 | 0.39 | 0.15 | 0.07 | 0.76 | 2.38 | 1.59 |
| Mean | 9.36 | 4.05 | 3.14 | 8.69 | 2.66 | 1.93 | 0.29 | 0.07 | 0.04 | 1.10 | 1.38 | 1.82 |
| SE | ±1.50 | ±0.70 | ±0.45 | ±1.14 | ±0.41 | ±0.27 | ±0.05 | ±0.01 | ±0.01 | ±0.96 | ±0.96 | ±0.95 |
| CV (%) | 28 | 30 | 25 | 23 | 26 | 24 | 29 | 28 | 21 | 24 | 66 | 50 |

at Mullenkolly (Wynad) and the girth recorded in February 1990 showed that the clones RRII 118, RRII 203 and RRIM 612 have attained more than 40 cm.

**9. Soil moisture stress, growth and yield**

The physiological performance of young *Hevea* plants in two seasons representing optimum soil moisture (November 1989) and severe stress (March 1990) was observed. The study was conducted in the multi-disciplinary clone evaluation trial area at RRII comprising two sub trials in which 13 clones were planted in randomised block design. RRII 105 was common in both subtrials. Photosynthetic rate (A), transpiration rate (E), stomatal diffusive conductance (GS), intercellular $CO_2$ concentration (Ci) and water use efficiency (WUE) were recorded. The results are presented in Table-Phy. 7 & 8.

In trial 1, the mean A rates decreased by 40 per cent during severe summer and a clear variation among clones were also noticed. Though a similar decrease in transpiration rate was observed, variation among clones was not significant. The Ci values were almost stable in both seasons and there was not much variation among clones. In trial 2, decrease in A rate during summer was similar to that in trial 1. But the transpiration rates were more in PB clones during summer. This indicates the efficient use of water by RRII series than the PB clones.

Pre-dawn leaf water potential measurements of a few clones during mid summer (March 1990) and end of summer (April 1990) indicated that the mean leaf water potential of –6.38 bars during March was further decreased to –13.09 bars during April when the soil moisture levels depleted during the unusual extension of summer this year.

Clones RRII 105, 118, 300, GT 1 and Tjir 1 were planted around the micro climatological tower in RRII. They were maintained under adequate daily watering. The photosynthetic rates and other physiological characters were maintained at a better level compared to plants which were not given irrigation.

**10. Exploitation systems and yield**

The trial started in 1985 to evaluate the effect on the yield of modern *Hevea* was continued and the yield obtained during the reported year is presented in Table-Phy.9 along with the data on brown bast incidence. The yield during fifth year of tapping was comparable under 1/2S d/2 and 1/2S d/3 systems. The yielding pattern of double cut system and brown bast incidence percentage shows the same trend as in previous year.

A large scale trial was initiated on RRII 105 in the State Farming Corporation, Punalur incorporating low intensity tapping systems. The first year yield showed a better performance of 1/3 S d/2 system compared to 1/2 S d/3 system.

**11. Effect of rest periods on yield**

The trial was continued and the results indicate that tapping rest upto two months during summer period may not reduce annual yield per block in the case of clone PR 107. Based on the observation, more studies on other popular clones are being programmed.

**12. Comparison of yield stimulants**

The small scale trial at Central Experiment Station for the evaluation of calcium carbide as yield stimulant in comparison to ethephon was continued during 1989-90. The yield data shows the same trend as observed in the previous year. However, the stimulatory effect has come down with both stimultants,

Table-Phy. 7. **Photosynthetic rate (A), transpiration rate (E), water use efficieecy (WUE) stomatal diffusive conductance (GS) and intercellular$CO_2$ concentration (Ci) (Trial 1) during November 1989 and March 1990**

| Parameter | A ($\mu$ mole $m^{-2}$ $sec^{-1}$) | | E (m mole $m^{-2}$ $sec^{-1}$) | | WUE = A/E | | GS (m mole $m^{-2}$ $sec^{-1}$) | | Ci — PPm | |
|---|---|---|---|---|---|---|---|---|---|---|
| Clone | November | March | November | March | November | March | November | March | November | March |
| RRII 5 | 11.24 | 0.41 | 10.30 | 1.60 | 1.09 | 0.26 | 442.7 | 48.7 | 268 | 339 |
| RRII 105 | 11.77 | 2.17 | 10.50 | 1.25 | 1.12 | 1.74 | 428.6 | 45.3 | 253 | 261 |
| RRII 118 | 9.42 | 8.31 | 9.25 | 3.95 | 1.02 | 2.10 | 403.1 | 156.7 | 269 | 237 |
| RRII 208 | 7.72 | 6.88 | 6.25 | 2.50 | 1.24 | 2.75 | 261.7 | 229.5 | 278 | 285 |
| RRII 300 | 7.17 | 7.45 | 7.40 | 3.90 | 0.97 | 1.91 | 294.8 | 145.3 | 277 | 237 |
| RRII 308 | 10.33 | 7.04 | 6.05 | 3.25 | 1.71 | 2.17 | 321.4 | 112.7 | 276 | 229 |
| RRIM 600 | 13.90 | 12.16 | 11.95 | 5.05 | 1.16 | 2.41 | 594.5 | 275.8 | 264 | 255 |
| RRIM 703 | 8.95 | 4.68 | 7.85 | 3.80 | 1.14 | 1.23 | 328.4 | 110.1 | 279 | 249 |
| PCK 1 | 11.57 | 2.31 | 8.25 | 1.95 | 1.40 | 1.18 | 491.2 | 53.9 | 272 | 259 |
| PCK 2 | 8.50 | 7.49 | 8.00 | 3.90 | 1.06 | 1.92 | 355.1 | 128.0 | 272 | 233 |
| SCATC 93114 | 8.17 | 6.27 | 8.80 | 3.20 | 0.93 | 1.96 | 323.8 | 147.3 | 267 | 248 |
| SCATC 8813 | 13.97 | 5.25 | 8.95 | 3.45 | 1.56 | 1.52 | 507.5 | 93.0 | 267 | 240 |
| HAIKEN 1 | 9.81 | 10.19 | 7.10 | 3.70 | 1.38 | 2.75 | 321.2 | 172.7 | 266 | 241 |
| Mean | 10.19 | 6.20 | 8.51 | 3.19 | 1.21 | 1.84 | 390.31 | 132.26 | 269 | 254 |
| SE | ±0.616 | ±0.907 | ±0.474 | ±0.300 | ±0.07 | ±0.019 | ±27.11 | ±18.92 | ±1.9 | ±7.6 |
| CV (%) | 22 | 53 | 20 | 34 | 19 | 37 | 25 | 52 | 2.62 | 11 |

Table–Phy.8. **Photosynthetic rate (A), transpiration rate (E), water use efficiency (WUE), stomatal diffusive conductance (GS) and intercellular $CO^2$ concentration (Ci) (Trial 2) during November 1989 and March 1990**

| Clone | A ($\mu$mole $m^{-2}$ $sec^{-1}$) | | E (m mole $m^{-2}$ $sec^{-1}$) | | WUE — A/E | | GS (mole $m^{-2}$ $sec^{-1}$) | | Ci — PPm | |
|---|---|---|---|---|---|---|---|---|---|---|
| | November | March | November | March | November | March | November | March | November | March |
| PB 217 | 11.29 | 6.35 | 10.90 | 5.80 | 1.04 | 1.09 | 401.1 | 137.7 | 246 | 236 |
| PB 235 | 11.08 | 6.50 | 10.70 | 5.70 | 1.04 | 1.14 | 298.6 | 144.1 | 233 | 234 |
| PB 255 | 14.18 | 8.32 | 11.75 | 5.65 | 1.21 | 1.47 | 478.0 | 181.9 | 254 | 236 |
| PB 260 | 10.91 | 3.73 | 9.45 | 3.50 | 1.15 | 1.07 | 304.2 | 96.0 | 233 | 245 |
| PB 280 | 12.82 | 9.76 | 10.90 | 5.95 | 1.18 | 1.64 | 417.4 | 200.3 | 251 | 226 |
| PB 310 | 11.08 | 10.09 | 8.85 | 7.95 | 1.25 | 1.27 | 324.0 | 254.8 | 248 | 233 |
| PB 311 | 12.75 | 8.16 | 10.15 | 6.80 | 1.26 | 1.20 | 404.9 | 162.0 | 239 | 244 |
| PB 312 | 11.01 | 4.83 | 7.65 | 5.40 | 1.44 | 0.89 | 276.8 | 103.6 | 228 | 232 |
| PB 314 | 10.40 | 7.29 | 8.90 | 5.20 | 1.17 | 1.40 | 292.6 | 199.2 | 241 | 247 |
| KRS 25 | 6.00 | 0.98 | 6.45 | 2.85 | 0.93 | 0.34 | 147.4 | 57.6 | 223 | 287 |
| KRS 125 | 11.95 | 9.43 | 11.55 | 3.40 | 1.03 | 2.77 | 464.0 | 231.8 | 249 | 249 |
| KRS 163 | 12.09 | 11.52 | 11.15 | 7.95 | 1.08 | 1.45 | 433.6 | 274.0 | 245 | 232 |
| RRII 105 | 11.77 | 2.17 | 10.50 | 1.25 | 1.12 | 1.74 | 428.6 | 45.3 | 253 | 262 |
| Mean | 11.33 | 6.85 | 9.92 | 5.03 | 1.15 | 1.34 | 359.3 | 160.7 | 241.8 | 243.3 |
| SE | ±0.527 | ±0.885 | ±0.438 | ±0.635 | ±0.04 | ±0.15 | ±26.15 | ±20.01 | ±2.76 | ±4.50 |
| CV (%) | 17 | 47 | 16 | 46 | 11 | 41 | 26 | 45 | 4 | 6.7 |

Table-Phy. 9. **Dry rubber yield * (kg ha$^{-1}$) under different tapping systems-Clone RRII 105**

| Tapping system | 1985–86 (9 months) | 1986–87 (12 months) | 1987–88 (12 months) | 1988–89 (12 months) | 1989–90 (12 months) | Total (57 months) | Brown bast (%) |
|---|---|---|---|---|---|---|---|
| 1/2 S d/2 | 1027.25 | 1491.00 | 2030.50 | 3328.79 | 2206.57 | 10084.11 (100%) | 22.5 |
| 1/2 S d/3 | 845.50 | 1246.98 | 1737.28 | 2631.95 | 2190.04 | 8651.75 (85.80%) | 10.8 |
| 2 x 1/4 S d/2 (1 c) | 704.00 | 1201.03 | 1374.82 | 2169.39 | 1389.15 | 6838.39 (67.81%) | 10.5 |

* 300 trees ha$^{-1}$

resulting in only 22 per cent increase with ethephon and 40 per cent increase with calcium carbide, over control. The annual mean dry rubber yield is presented in Table-Phy. 10. A few onfarm trials were initiated during the report period. In one trial the mean dry rubber yield of three months (November 1989 to January 1990) also indicates better stimulatory effect of calcium carbide. In the second trial, two groups of trees (seedling and budded) were separately stimulated and the effect was studied. The mean latex yield of three months under calcium carbide (dumping at 30 cm depth) was around 10 per cent less than that of ethephon.

Table-Phy. 10. **Evaluation of calcium carbide as yield stimulant in comparison to Ethepon**

**A. Small scale trial at Central Experiment Station-Clone RRIM 600**

| | 1/2 S d/2 Control | 1/2 S d/2 + Ethepon (5%) | 1/2 S d/2 + Calcium carbide |
|---|---|---|---|
| Mean annual dry rubber yield (g tree$^{-1}$ tap$^{-1}$) | 98.09 (100) | 119.43 (121.75) | 137.18 (139.85) |

**B. Onfarm trial**

**1. Clone RRIM 600**

| | 1/2 S d/2 + ET | 1/2 S d/2+Ca $C_2$ |
|---|---|---|
| Mean dry Rubber Yield of 3 months (kg tap$^{-1}$ ha$^{-1}$) | 10.37 (100.00) | 12.27 (118.32) |

**2. Following dumping of $CaC_2$ at 30 cm depth**

| | Ethephon (5%) | | Calcium carbide | |
|---|---|---|---|---|
| | Seedlings | Budgrafts | Seedlings | Budgrafts |
| Mean latex yield of 3 months (litre month$^{-1}$ ha$^{-1}$) | 872.68 (100) | 953.48 (100) | 812.0 (93.05) | 870.68 (91.32) |

## 15. Tapping systems for small growers

In most of the small holdings it is observed that tree is tapped daily on the same cut. This leads to high incidence of brown bast, poor tree growth and a faster uneconomic stage. In clones like RRII 105, even under alternate daily tapping incidence of brown bast is reported to be high. Hence a tapping experiment was initiated in 1988 at the Central Experiment Station on clone RRII 203. The specific objectives are to quantify yield

Table–Phy.11. **Tapping treatments**

$T_1$ – 1/2 S ↑ d/2 6d/7 (Opening at 30 cm from bud union)

$T_2$ – 1/2 S d/2 6d/7 Control (125 cm opening)

$T_3$ – 1/2 S d/2 6d/7 (90 cm opening)

$T_4$ – 1/3 S d/1 6d/7 (125 cm opening)

$T_5$ – 2 x 1/2 S d/1 6d/7 ($t_1$, t)
A– 90 cm opening on Bo–1
B 130 cm opening Bo–2
(for the tree daily tapping, but for the cut alternate daily tapping)

$T_6$ – 2 x 1/2 S ↑ ↓ d/1 5d/7 ($t_1$ t) (90 cm opening– both cut on Bo–1)
(for the tree daily tapping with rest on Wednesday and Sunday, but for the cut alternate daily)

performance under various systems of tapping and to identify a system which compromise with growth and yield.

The trees were classified into various girth groups and the tapping treatments (Table-Phy.11) were imposed in a completely randomised single tree single plot design. The experiment was suspended during 1988–89 due to some problems and was restarted in Apil 1989. The annual yield of 1989–90, was high under all treatments compared to control (Table-Phy-12). The highest yield was recorded under $T_5$ and $T_6$ (167% and 156%). Under upward tapping ($T_1$ – 30 cm from bud union) the bark consumption was very high (151%) compared to control and severe bark damage was also noticed in almost all trees in the initial 10 cm of the tapping panel.

### 16. Effect of an ayurvedic oil on brown bast

A large scale trial (21 blocks) was initiated to test the effect of a herbal preparation on clone RRII 105 (2nd year tapping) under 1/2 S d/3 tapping system. The treatments imposed are monthly and bimonthly application of oil with control (no application). The experiment is in progress.

Table–Phy.12. **Dry rubber yield during 1989-90 under various treatments (Clone RRII 203)**

| Treatments | Dry rubber yield | | Projected annual yield(kg) for 300 trees |
|---|---|---|---|
| | Monthly mean g tree$^{-1}$ tap$^{-1}$ | Kg tap$^{-1}$ for 300 trees | |
| $T_1$ – 1/2 S ↑ d/2 6d/7 | 40.90 | 12.270 | 1840.500 (114) |
| $T_2$ – 1/2 S d/2 6d/7 (Control) | 35.64 | 10.692 | 1603.800 (100) |
| $T_3$ – 1/2 S d/2 6d/7 (90 cm opening) | 38.10 | 11.430 | 1714.500 (106) |
| $T_4$ – 1/3 S d/1 6d/7 | 21.87 | 6.561 | 1968.300 (122) |
| $T_5$ – 2 x 1/2 S d/1 6d/7 ($t_1$, t) | | | |
| A – 90 cm opening – Bo–1 | 30.13 | 9.039 | 1355.850 |
| B – 130 cm opening– Bo–2 | 29.70 | 8.910 | 1336.500 |
| | 59.83 | | 2692.350 (167) |
| $T_6$ 2 x 1/2 S ↑ ↓ d/1 5 d/7 ($t_1$, t) | | | |
| 90 cm Bo–1 | 32.15 | 9.645 | 964.500 |
| 90 cm | 34.20 | 10.260 | 1539.000 |
| | 66.35 | | 2503.500 (156) |

Figures in parenthesis are percentage of control

### 17. Intercropping of medicinal plants

Six species of medicinal plants were selected based on their performance under mature canopy. Sample harvesting data are presented in Table-Phy. 13. It is found that raising of these medicinal plants as intercrops in mature rubber estate, if profitable, can fetch additional income. Three onfarm trials were initiated during the report period. A trial to study the yield potentials, nutrient requirement of intercrops and the effect of intercrops on latex yield was initiated at CES adopting statistical layout.

### 18. Multi-disciplinary study on brown bast

Tree-wise yield data for the initial two years of tapping in clone RRII 105 under 1/2 S d/2 6d/7 and 1/2 S d/3 6d/7 were collected. Trees were grouped into yield classes and number of trees affected by tapping panel dryness (TPD) in each class was recorded. Among the trees under both the tapping systems, TPD incidence was found to be more in the lower yield classes. One of the reasons for categorising many trees into low yield classes might be due to partial dryness, which could not be recorded. In majority of the cases incidence of TPD was found to occur during July to October. A number of affected trees turned into normal condition after varying periods of rest. By the end of the fourth year, under 1/2 S d/2 system, three out of 16 recovered trees were re-affected by TPD. In trees under 1/2 S d/3 system two out of seven recovered trees were re-affected. Studies on hormonal relations, involvement of causative organism and the possible role of micro-nutrients were initiated.

Table-Phy.13. **Production of economic parts from medicinal plants intercropped in mature stand of *Hevea* (Clone RRII 105)**

| Name of the species | Year of planting | spacing (cm) | Date of harvest | Dry weight (g plant $^{-1}$) | Production (kg ha$^{-1}$) | Remarks |
|---|---|---|---|---|---|---|
| *Strobilanthus haenianus* (Karimkurunji) | June 1987 | 45 x 20 | January 1990 | 440 | 5300 | Both fresh and dried part are in use |
| *Adathoda vasica* (Valia adalodakam) | July 1987 | 30 x 30 | March 1990 | 209 | 4200 | Do |
| *Adathoda medomnie* (Cheriya adalodakam) | July 1987 | 30 x 30 | March 1990 | 38 | 1100 | Do |
| *Plumbago rosea* (Chuvannakoduveli) | October 1988 | 30 x 30 | March 1990 | 221 | 4400 | Fresh Weight. Only fresh part is in use |
| *Alpinia galanga* (Aratha) | October 1988 | 30 x 30 | March 1990 | 110 | 2200 | Both fresh and dried parts are in use |
| *Kaemferria rotunda* (Kacholam) | October 1988 | 10 x 10 | March 1990 | 15 | 1100 | Do |

## 19. Brown bast incidence and biochemical changes

Randomness in the incidence of tapping panel dryness in any field makes it difficult to experimentally quantify clonal susceptibility to this syndrome. In a preliminary study, using GT 1 as a reference clone, the susceptibility of RRII 105 to this syndrome was quantified by an index based on the duration required to induce total dryness of tapping cut under a high intensity tapping system (Table-Phy. 14). The incidence of tapping panel dryness was faster in RRII 105. The ratio between the rates of incidence of bark dryness in clone RRII 105 and GT 1 was found to be 1.92. Such a ratio with a standard reference clone which is resistant to brown bast incidence, can be used as an index to describe susceptibility of *Hevea* clones to this syndrome.

Biochemical parameters such as bursting index, total and free acid phosphatase activity, proteins and sugars were monitored in the experimental trees. The pattern of changes markedly varied between the two clones studied. A lower bursting index and higher levels of sugars and proteins were observed in the initial months in the latex of the intensively tapped trees of the susceptible clone.

Table-Phy.14. **Cumulative incidence of tapping panel dryness in intensively tapped (1/2 S d/o.5 6d/7) trees in panel BO-1**

| No. of days | No. of TPD affected trees | |
|---|---|---|
| | GT1 | RRII 105 |
| 0-90 | — | — |
| 90-120 | — | — |
| 120-150 | — | 2 |
| 150-180 | 1 | 7 |
| 180-210 | 4 | 12 |
| 210-240 | 5 | 16 |
| 240-270 | 6 | 17 |
| 270-300 | 10 | 20 |
| 300-330 | 12 | 20 |
| 330-360 | 14 | 20 |
| 360-390 | 16 | 22 |
| 390-420 | 20 | 22 |

Total number of trees in each clone = 24

# RUBBER CHEMISTRY, PHYSICS AND TECHNOLOGY DIVISION

## 1. Solar drier for sheet rubber

Steps have been taken to modify the design of the drier with a view to improving its efficiency further and to make it suitable for commercial operation. These modifications include extension of the solar collector area, design of the fire box and reduction in the volume of the drying chamber. Steps have also been initiated to establish a solar-cum-smoke drier in a rubber producers' society.

## 2. Sulphuric acid as alternative latex coagulant

In order to reduce the cost of preparation of sheet rubber, sulphuric acid has been tried as a coagulant. Various aspects such as concentration of acid, residual acidity in sheet, properties of the raw rubber and those of compounds and vulcanizates prepared therefrom and cost were studied in comparison with those of formic acid. The study indicated that sulphuric acid can safely be used as a coagulant for NR latex in the production of sheet rubber. The recommended dosage is 300 ml 0.5% solution for the same day sheeting and 250 ml of 0.5% solution for the next day sheeting. At the optimum dosage, properties of the raw rubber and compounds prepared therefrom are generally comparable with those of the formic acid – coagulated sheets. Corrosion of rollers is negligible if standard practices are followed. Cost of coagulation using sulphuric acid is only about one tenth of that using formic acid.

## 3. Epoxidation of natural rubber

Reaction conditions for the preparation of 50 mole and 25 mole per cent epoxidised natural rubber have been optimised at 50°C. Several one kg batches of these modified rubbers have been prepared. The modified rubbers show strength properties almost comparable to those of (NR) vulcanizates with the same filler loading and cure system. But the plasticity retention index (PRI) of raw ENR and ageing resistance of vulcanizates prepared from it are found to be poor.

Results of the swelling studies of ENR-50 in ASTM No 3 oil at 50°C in comparison with NR and NBR (medium acrylonitrile) are given below:

Table-Chem. 1. **Swelling in ASTM No 3 oil at 50°C**

| | weight increase (%) | | |
|---|---|---|---|
| | after 22 h. | after 46 h. | after 70 h. |
| NR | 120.0 | 145.0 | 161.0 |
| ENR-50 | 21.4 | 30.1 | 39.4 |
| NBR | 8.5 | 11.3 | 14.0 |

A method has also been standardised to estimate the mole percentage of epoxidation using IR spectrophotometer.

## 4. Compression set of NR vulcanizates

To study the influence of process aids on compression set, varying amounts of naphthenic oil ranging from 0–20 phr were incorporated to the conventional mix having an HAF black loading of 50 phr. Here the increase in compression set with respect to oil concentration, was only nominal. The effect of antioxidant on compression set was assessed by incorporating 1 phr PBN (phenyl $\beta$ - naphthylamine) in gum

and HAF black filled compounds. A slight increase in compression set was observed as a result of the addition of the antioxidant.

Table-Chem. 2. **Changes in tensile properties after ageing under phosphoric acid at 90°C for 166 h**

| Sample | | Properties | | |
|---|---|---|---|---|
| | | 300% modulus ($N/mm^2$) | Tensile strength ($N/mm^2$) | Elongation at break (%) |
| Before ageing | (a) | 10.0 | 24.5 | 620 |
| | (b) | 5.6 | 16.6 | 560 |
| | (c) | 2.0 | 15.3 | 815 |
| 1% $H_3PO_4$ | (a) | — | 14.2 | 270 |
| | (b) | — | 3.0 | 285 |
| | (c) | 3.0 | 8.3 | 520 |
| 10% $H_3PO_4$ | (a) | 15.4 | 16.8 | 320 |
| | (b) | — | 8.4 | 295 |
| | (c) | 2.9 | 9.7 | 600 |
| 25% $H_3PO_4$ | (a) | 15.0 | 15.7 | 310 |
| | (b) | 7.5 | 10.2 | 380 |
| | (c) | 2.7 | 9.0 | 630 |
| 40% $H_3PO_4$ | (a) | 12.5 | 15.8 | 370 |
| | (b) | 5.8 | 10.8 | 410 |
| | (c) | 2.9 | 9.5 | 695 |
| 50% $H_3PO_4$ | (a) | 15.3 | 19.0 | 340 |
| | (b) | 7.7 | 11.3 | 390 |
| | (c) | 2.8 | 9.8 | 618 |
| 75% $H_3PO_4$ | (a) | 14.2 | 17.0 | 330 |
| | (b) | 7.3 | 12.6 | 470 |
| | (c) | 2.7 | 9.8 | 650 |
| 90% $H_3PO_4$ | (a) | 12.8 | 22.0 | 500 |
| | (b) | 7.0 | 12.7 | 490 |
| | (c) | 2.3 | 11.5 | 735 |

## 5. NR 1, 2-polybutadiene blends

The study has been concluded. The results indicated that ageing and ozone resistance of NR could be improved by blending with 1,2-polybutadiene. Precipitated silica reinforces the blends significantly. However, for better technological properties blends containing higher proportions of NR are more suitable.

## 6. Development of chemical resistant NR compounds

Chemical resistance of filled natural rubber vulcanizates was studied by ageing the samples in phosphoric acid solution of different concentration at 90°C for 166 h and the results are given in Table-Chem. 2. The compounds were prepared with a conventional sulphur curing system and contained (a) 40 phr HAF black, (b) 100 phr china clay and (c) 100 phr of barytes.

From the studies it was observed that even higher concentrations of $H_3PO_4$ do not have much detrimental effect on strength properties.

Barytes-filled natural rubber vulcanizates were aged in 25, 50, 75 and 98 per cent $H_2SO_4$ at 90°C for 166 h. The properties are as given in Table-Chem. 3.

Table-Chem. 3. **Changes in tensile properties after ageing under sulphuric acid at 90°C for 166 h**

| Sample | Properties | | |
|---|---|---|---|
| | 300% modulus ($N/mm^2$) | Tensile strength ($N/mm^2$) | Elongation at break (%) |
| Before ageing | 2.0 | 15.3 | 815 |
| 25% $H_2SO_4$ | 3.0 | 12.0 | 730 |
| 50% $H_2SO_4$ | 2.4 | 12.0 | 810 |
| 75% $H_2SO_4$ | Sample deteriorated | | |
| 98% $H_2SO_4$ | Sample deteriorated | | |

Carbon black, china clay and barytes-filled natural rubber vulcanizates were aged also in 20, 40, 60 and 75 per cent sodium hydro-

xide solution. The properties are as given in Table-Chem. 4.

From the studies it was observed that carbon black, china clay and barytes-filled vulcanizates after ageing retained about 90, 70 and 85 per cent, respectively, of their original strength.

Table-Chem. 4. **Changes in tensile properties after ageing at 90°C for 166 h under sodium hydroxide**

| Sample | | Properties | | |
|---|---|---|---|---|
| | | 300% modulus ($N/mm^2$) | Tensile strength ($N/mm^2$) | Elongation at break(%) |
| Before ageing | (a) | 10.0 | 24.5 | 620 |
| | (b) | 5.6 | 16.6 | 560 |
| | (c) | 2.0 | 15.3 | 815 |
| 20% NaOH | (a) | 12.7 | 19.4 | 425 |
| | (b) | 7.0 | 9.5 | 440 |
| | (c) | 2.5 | 13.0 | 750 |
| 40% NaOH | (a) | 12.4 | 22.4 | 490 |
| | (b) | 7.1 | 12.4 | 430 |
| | (c) | 2.5 | 14.7 | 800 |
| 60% NaOH | (a) | 12.0 | 23.0 | 500 |
| | (b) | 7.7 | 13.3 | 460 |
| | (c) | 2.4 | 13.7 | 800 |
| 75% NaOH | (a) | 12.0 | 20.5 | 470 |
| | (b) | 7.3 | 12.3 | 450 |
| | (c) | 2.3 | 15.0 | 830 |

## 7. Preparation and application of depolymerised NR

The acetone extractables of depolymerised rubber having different viscosities, prepared under different conditions, were determined. Molecular weight determinations were also carried out using viscosity measurements. Attempts were made to vulcanize liquid rubber. It is seen that the vulcanizates prepared from liquid rubber are having uniform strength properties but the properties are much inferior to those of vulcanizates prepared from dry rubber. Addition of carbon black or precipitated silica does not reinforce LNR effectively.

## 8. Degradation of NR

The effect of tensile strain on the rate of thermo-oxidative ageing of NR vulcanizates has been studied. Results from preliminary trials indicated that degradation is much faster when the specimens are aged under strain.

## 9. Transparency of latex vulcanizates

The different factors affecting transparency of films made from NR latex have been investigated. The effect of compounding ingredients such as sulphur, zinc oxide, process oil, antioxidant, fillers, viscosity modifiers and the type of latex and the coagulants have been studied. Factors such as atmospheric humidity, ball milling time of ingredients, etc., also have been investigated. To obtain maximum transparency, sulphur at the level of 1 phr shall be used and zinc oxide avoided. Paraffinic oil and antioxidants do not influence transparency significantly. A substantial increase in transparency is possible by clarification of prevulcanized latex preferably by centrifuging. Products made by straight dipping are observed to be more transparent than those made by coagulant dipping.

## 10. Development of NR based adhesives

As molecular weight is an important factor influencing bond strength of rubber based solution adhesives, degree of mastication of NR is likely to affect bond strength. To study this aspect NR masticated to different periods were dissolved in petrol to prepare 10 per cent solutions and rubber-rubber bond strength assessed using of these solutions. The highest bond strength was obtained for the unmasticated rubber. As degree of mastica-

tion increased, bond strength was found to decrease progressively. The effect of additives like PF resin, CI resins, fillers like carbon black, china clay and precipitated silica on bond strength has also been evaluated.

**11. UNIDO project on NR based precured retreads**

As a participating Institute in the UNIDO funded project on development of NR based truck tyre retreads, a batch of ten precured retreaded radial tyres have been received by RRII from the Tun Abdul Razak Laboratory, U. K. The performance of these tyres under Indian conditions was closely monitored after fitting on the express buses of the Kerala State Road Transport Corporation. A report on the evaluation was made available to the project headquarters in UK.

**12. Development of rubber compounds/ products**

(i) Rubber band from scrap rubber, (ii) rubber pressure plate for electronic weigh bridges and (iii) rubber brush for cleaning were developed.

## AGRICULTURAL ECONOMICS DIVISION

**1. Commercial evaluation of planting materials**

The study of yield evaluation of important clones was continued and visits were made to three large estates to collect back data. Third report of the study was prepared and communicated for publication. Clone RRII 105 recorded the highest commercial yield.

**2. Production and utilization of rubber wood**

Visits were made to all important centres of rubber wood consumption in Tamil Nadu and Kerala to estimate the consumption of rubber wood. Based on the studies it is estimated that rubber wood use in safety match industry is about 0.112 million cubic metres.

The first national seminar on rubber wood was held at Kottayam on 12th December 1989. Thirty papers were presented in the seminar by scientists and industrialists from various organisations. A book entitled, *Rubber Wood : Production and Utilization* by A. C. Sekhar has been published.

**3. Production and utilization of rubber seed oil**

Visits were made to rubber seed oil producing units at Virudhunagar and Madurai to collect the data. For supplementing the data on the production of rubber seed, visits were made to the check posts in Kerala. The production of rubber seed oil in 1989–90 was estimated at 4000 tonnes. Arrangements were made with the Central Leather Research Institute, Adayar, Madras for a study on tanning of leather with rubber seed oil.

**4. Commercial production of honey**

Visits were made to important honey producing rubber plantations in Kerala for estimating the production of rubber honey.

**5. Condition of workers in rubber processing factories**

The study was initiated and completed during the year under report. The observations have been compiled and a paper is under publication.

**6. Management of rubber smallholdings**

The survey is being continued. 108 small rubber growers in Palai and Kanjirappally regions were contacted and relevant data collected by interview method.

**7. Census of unregistered smallholdings**

The study has been completed and the data revealed that 34.5 per cent of the total area under rubber in a ward in Puliyannoor village is unregistered.

**8. Cover crops and saving in production cost**

The study revealed that the net saving in total cost compared to holdings without cover crops was Rs 2489 per ha for the entire immaturity period of seven years. A paper based on the study has been sent for publication.

**9. Study of brown bast**

The study has been completed in the Palai region. It has been extended to other agro-climatic regions and data were collected from 100 small growers in Palghat, Trichur and Nilambur regions.

**10. Pineapple intercropping in smallholdings**

The study revealed that the discounted net income from pineapple intercropping for the first three years of rubber planting was Rs 22,443 per ha.

**11. Study of rubber smallholdings**

A study has been initiated on input subsidies and changes in cultural practices in rubber smallholdings this year. Visits were made to 11 rubber producers' societies and data were collected from 100 growers.

**12. Economics of rainguarding**

The study shows that to adopt rainguarding, an average yield of 675 kg $ha^{-1}$ $year^{-1}$ should be available. The adjusted three year average cost estimate gave a result in favour of polythene sheet rainguarding compared to tapping shade rainguarding.

**13. Block rubber processing industry in India**

An important conclusion emerging from the study is that in the industry the inverse relationship between capacity utilization and average unit cost of processing is insignificant. Sector-wise analysis of profitability shows that the share of profit was higher in the estate sector even though its unit cost of processing is higher compared to that in the non-estate sector.

**14. Rubber based industries in Kerala**

The study for assessing the missed linkages has been completed and it was seen that a mere monopoly position in the production of natural rubber did not help Kerala to achieve a desirable level of development in rubber based industries. Backward linkages of the rubber plantation industry are weak and forward linkages of the industry in Kerala are mainly confined to NR processing industries with limited linkage effects.

## CENTRAL EXPERIMENT STATION

The Central Experiment Station of the RRII established at Chethackal, Ranni (Pathanamthitta District) about 50 km away from the Institute in 1966, has an area of 254.8 ha. Long term and short term field experiments are being conducted in the entire area by Botany, Agronomy and Soils and Exploitation Plant Physiology and Mycology and Plant Pathology Divisions of the RRII. A seedling nursery and a budwood nursery of over 100 genotypes are maintained in the station.

762 germplasm genotypes imported were multiplied and raised in polybags for planting in the ground nursery. 9158 plants belonging to 2080 genotypes were planted in the ground nursery and they were maintained for screening and evaluation.

An area of about 12.6 ha has been planted under eight different field experiments by the Botany Division during the period under review. A total rainfall of 3952.4 mm (Table-CES-1) was received at the station during 1989-90 period.

There are 198 permanent workers and 184 temporary casual workers attached to the station and a total of 67660 workers were engaged during the period under report for various operations in the station. The total crop produced from the station during the year was 2,11,804.23 kg.

Table-CES-1. **Rainfall (1989-90) distribution at CES**

| Month | Rainfall (mm) |
|---|---|
| April | 273.0 |
| May | 213.3 |
| June | 657.4 |
| July | 768.0 |
| August | 406.0 |
| September | 523.0 |
| October | 742.9 |
| November | 139.0 |
| December | 31.0 |
| January | 41.5 |
| February | — |
| March | 157.3 |
| Total | 3952.4 |

## RESEARCH COMPLEX FOR NORTH-EASTERN REGION

The research complex for North Eastern Region with its headquarters at Guwahati and Regional Research Stations located at Assam, Meghalaya, Mizoram and Tripura tries to evolve agromanagement technology for North East India. The thrust areas of research are breeding and selection of clones, evolving agromanagement techniques, selection of suitable intercrops, evolving effective control measures for diseases and pests, and assessing nutritional requirement of rubber and fertility status of soils in the region. Broadening the genetic base through bio-technology also is being attempted.

# REGIONAL RESEARCH STATION, ASSAM

This station concentrated on evaluation of clones, studies on nutrition, survey of pests and diseases and broadening the genetic base through biotechnology.

## 1. Multidisciplinary evaluation of clones

In the 1985 trial in terms of annual girth increment the clones RRIM 600, RRII 118 and Gl 1 registered almost the same maximum (10.3, 10.1 and 10.3 cm respectively) followed by PB 235 (9.3 cm) and GT 1 (9.1 cm). It was observed that 70–80 per cent of growth was attained during June–November period. The clones RRIM 605 and GT 1 were most affected by temperature stress conditions whereas Gl 1, RRII 118 and PB 5/51 were least affected.

In the 1986 clone trial, RRII 118 recorded the maximum girth (23.25 cm) followed by RRII 208 (21.82 cm). In terms of total girth increment the clone RRIC 105 recorded the maximum(60.43%) followed by RRII 208 (60.01%) and RRII 5 (59.69%). Per cent girth increase during winter period (December–February) was the maximum for clone PB 310 (7.6%).

## 2. Nutritional studies – immature phase

The observations recorded from the onfarm fertilizer trial at Mendipather (East Garo Hills, Meghalaya) with clone RRIIM 600 under natural ground cover indicate positive response to high doses of nitrogen. Application of high doses of phosphorous and potash did not show any such response.

In the fertilizer trial under natural ground cover located at Nayekgaon (Dhubri, Assam) good girth increment was observed when higher doses of N (40 or 60 kg $ha^{-1}$), P and K (both 40 kg $ha^{-1}$) were applied. A lower girth increment was recorded in all the treatments during January–June, compared to July–December indicating adverse effects of the low temperature and soil moisture during the earlier period.

In the onfarm trial located at Bargaon Rubber Plantation (Sonitpur, Assam), to study the optimum nitrogen required for *Hevea* grown in association with three different ground covers, viz., *Pueraria*, *Mucuna* and natural covers, and to observe the impact of these ground covers on the physico-chemical properties of soil, the two leguminous ground covers were destroyed by cattle and wild animals. Attempts were made to re-establish the ground covers.

A new trial was initiated in 1989 at Bargang Rubber Plantation with four different levels of N,P,K and their combinations.

## 3. Interaction between potassium and magnesium

Routine cultural operations were carried out in the trials located at Nayekgaon, and Sarutari. Observations on girth increment recorded in the trial at Nayekgaon indicated positive response to magnesium in the absence of potash application (43.01 % girth increment). At Sarutari the effect of magnesium on girth increment was not pronounced. However, the maximum mean girth was recorded in the treatment which received 40 kg $K_2O$ and 15 kg MgO per hectare. At Sarutari the girth increment was less during January–June while no such seasonal effect was noticed at Nayekgaon. Pre-treatment and post-treatment soil samples have been collected for analysis.

## 4. Rock phosphate and super phosphate as P sources for young rubber

The 1986 trial at Sarutari, Guwahati with clone RRIM 600 aims at studying the effect of different sources of phosphatic fertiliser

and their combinations on the growth of *Hevea* at the immature phase. Observations on girth and height of plants were taken twice a year. Observations on girth increment showed that insoluble form of phosphorous gave better increment during July-December whereas soluble form of P gave better increment during the period January-June.

In the 1987 onfarm trial at Nayekgaon, in the same clone insoluble form of phosphorus gave better girth increment over soluble form during July-December, while this effect was the minimum during January-June. The overall girth increment was more during July to December, irrespective of the treatments, when compared to that in January to June.

### 5. Embryogenesis/organogenesis from excised organs

About 200 phytohormones independently or in combinations were tested to induce embryos/organs on explants. Explants from immature leaves produced callus in the presence of light. Some globular tiny structures resembling somatic embryos were observed on the callus. However, they did not differentiate further although subjected to different combinations of phytohormones.

### 6. Anther culture and plantlet regeneration

Anthers of five clones were subjected for callus induction and all produced callus. However, only callus obtained from anthers of clone PB 5/51 produced somatic embryos. Callus obtained from other clones failed to regenerate somatic embryos though subjected to various phytohormone combinations indicating that morphogenesis in *Hevea* is genetically controlled.

### 7. Genetic transformations of *Hevea* cells by *Agrobacterium*

*Agrobacterium tumefaciens* could effectively transform the genome of *Hevea* in stem and anther derived callus cells rendering them autotrophic. However, bacterial contamination of transformed cultures could not be eliminated although several antibiotics were tested in different combinations.

### 8. Survey of diseases and pests

A survey on diseases and pests of rubber in the region was carried out by visiting 90 plantations and making visual assessments.

Leaf diseases caused by *Gloeoeporium alborubrum* was widespread during rainy season both in nurseries (50–70%) and main fields (30–50%) of Assam, Meghalaya and Tripura. Pods also were found to be affected. *Corynespora cassiicola* caused disease during October-November. Incidence of *Drechslera* and *Colletotrichum* were mild. Powdery mildew disease caused severe and repeated defoliation in some plantations in Assam and Meghalaya during December to April. Pod formation was affected due to infection of the inflorescences. Abnormal leaf fall caused by *Phytophthora* spp. was noticed in Tripura. Pod rot was observed in Assam, Meghalaya and Tripura. The causal organism of a new leaf spot disease which led to defoliation in some areas in the region is being investigated.

Incidence of pink disease in Assam and Tripura and bark rot diseases in Tripura and Meghalaya were noticed. Brown root disease was noticed in all these regions. But the intensity of these diseases was mild.

Infestation of termites was observed in all the plantations. Scale-insects caused severe defoliation in Tripura during June – August. Another type of scale insect was noticed during winter in Assam. A new insect pest which voraciously feed on the leaves of rubber was observed in Sarutari during March–April. Incidence of slugs, snails and caterpiller pests were occasionally encountered but were mild.

9. **Isolation, identification and maintenance of pathogens**

Forty fungal isolates responsible for various diseases of rubber plants in North Eastern region, have been isolated and maintained as stock cultures. Cultural characteristics and pathogenicity studies of some of these isolates are in progress.

10. **Characterisation of agro-topo-climate**

Based on the climatological data crop weather calendar for Tura has been prepared. Water balance analysis of climatological data from two stations in the traditional rubber growing areas of Kerala and five representative stations of the North Eastern region indicated that the water deficiency in the latter is much lower (88 mm $year^{-1}$) than that in the former (193 mm $year^{-1}$) during the summer season (Nov/Dec. to March). The water availability and thermal regime in the North eastern region indicate suitability for rubber cultivation.

11. **Quantification of agrometeorological parameters**

Besides the agrometeorological observatories already established in the five regional research stations in the North East India, a station is being set up at Nagrakata in West Bengal. Data from all the stations are collected regularly.

The weather data collected from the Regional Research Station, Agartala from 1983 to 1989 has been subjected to water balance analysis assuming a root depth of 130 cm for rubber. It was observed that 1986 was the worst drought year with the soil moisture content falling well below the wilting point for four consecutive months (March to June). In general there was no soil moisture stress during winter (December to February) but it may be observed during summer (March to April) in drought years.

12. **Effect of irrigation on temperature**

An experiment was initiated to quantify the temperature variations in soil and air due to irrigation in the nursery beds and to observe the effect of low soil and air temperature on rubber plants. The soil temperature monitored during April and May showed a reduction upto 5.6°C at a depth of 8 cm following irrigation.

13. **Effect of mulch on soil temperature**

The property of mulches in altering the soil temperature may play a crucial role in the agronomic management of rubber in north eastern region. A study was initiated using three types of mulches (organic, used white polythene bags and used black polythene bags) in seedling nurseries. Soil temperature observations were made under both mulched and nonmulched beds during April-May 1990.

Organic mulch reduced soil temperatures at 5 cm and 10 cm levels to the order of 2.5°C to 3.5°C during day time. During night time the mulch increased soil temperature at the same depths to the order of 0.6°C. Organic mulches had no effect on the soil temperature at a depth of 30 cm.

The black polythene mulch was found to increase the soil temperatures at all the depths (5, 10 and 30 cm) throughout the day. As the polythene sheets used were pieces of used polybags the increase in temperature was of the order of 1.6°C only. Further improvement in the techniques and quality of materials used may ensure a higher soil temperature which can help in combating low soil temperature experienced during winter.

White polythene (used polybag pieces) mulch was found to decrease the temperature

of the top soil (5 to 10 cm) to the order of 2.6°C during any time. This may be partly due to the poor quality of the material used.

### 14. Effect of shade on soil micro environment

The experiment envisages to compare the effect of different types of shades like rubber canopy and artificial shades on micro-climate. Preliminary observations made on the soil temperature under rubber canopy showed a reduction of about 9°C during the day and 0.5 to 1.5°C during night compared to that in the open indicating a moderating effect of the shade on soil temperature.

### 15. Effect of aspect on the rubber micro-climate

This experiment was initiated to quantify the micro-climatic variations on north facing and south facing slopes in the sub-tropical regions of NE India. Sites have been identified for the purpose in the research farm at Kolasib and the instruments required for the studies are being procured.

## REGIONAL RESEARCH STATION, TRIPURA

The Regional Research Station, Tripura started in 1979 is the earliest rubber research station in the North Eastern Region. This station has well equipped laboratories for research in agronomy, soil science, plant physiology, biochemistry and plant breeding. The attached farm at Taranagar has an area of 66.04 ha which includes 11 ha of tapping trees, 1.5 ha seedling nursery and a budwood nursery with 5000 points. The station also has a well equipped library, a mobile soil testing laboratory and a meteorological observatory.

### 1. Nutritional studies on rubber

#### 1.1 Immature phase

The trial was started as a field experiment in the year 1990 with RRIM 600 laid out in a $3^3$ factorial confounded design. The treatments were three levels of Nitrogen (0, 30 and 60 kg $ha^{-1}$), $P_2O_5$ (0, 30 and 60 kg $ha^{-1}$) and $K_2O$ (0, 20 and 40 kg $ha^{-1}$). Periodic girth recording was carried out and fertilizer was applied in two split doses. The trees under the experiment were opened in April, 1989. On statistical analysis of data, collected over the immaturity period, it is seen that the N and K application has effected significant increase in girth during early part of immaturity. From fourth year N, P and K had been found to show significant increase on girth upto sixth year, from then onwards only phosphorus had been showing significance.

#### 1.2 Immature phase (polybag plants)

This trial was laid out in the year 1986 with a view to monitor the response of *Hevea* plants to higher dose of nutrients to assess the requirement of fertilizers when planting material used is polybag plants. A comparison of sources of phosphorus indicated that the use of water soluble phosphorus in the first two years influence the girthing of the trees. The addition of higher dose of fertilizer has been found to increase the available nutrient status of the soil when analysed at the end of third year.

#### 1.3 Seedling nursery

The data generated during four seasons in the trial in seedling nursery to evolve new

fertilizer recommendation are being analysed.

## 2. Density-cum-nutritional trial

### 2.1 Immature phase

The trial was started in 1987 with two clones (RRII 105 and RRII 108) three densities (420, 606 and 824 plants per ha) and three levels of fertilizers. Recording of girth, plant height and number of whorls had been made. The trial is in its early stages and hence there is no marked differences in terms of girth.

### 2.2 Seedling nursery

The trial is aimed at standardising the optimum number of plant population and requirement of nutrients in the seedling nursery. The trial was repeated for three seasons and the data collected reveal that 188 plants per bed (30 x 25 cm spacing) is the optimum and that at higher plant densities higher fertilizer dose helps in obtaining the maximum number of buddable plants.

## 3. Multiple cropping and mixed farming

A new trial on intercropping in the immature phase of rubber has been taken up during 1990 as an onfarm trial. For a better monitoring of the micro-climatic changes in the new trial laid out, four treatments have been taken up such as banana, pineapple, cover crop and natural cover each in one ha as a block. It is proposed to introduce rabbits also in the cover crop area as a component in mixed farming system.

To monitor the influence of rubber with perennial crops, another trial was laid out on an observational basis in the research farm at Taranagar. Rubber was interplanted with coffee as well as pepper during the year 1989.

## 4. Studies on planting techniques

The trial was laid out in 1981 with five treatments in a randomised block design having five replications. The clone was RRIM 600. The cumulative girth increment over a period of seven years from October '82 to November '89 is summarised in Table-NET 1.

The data suggests that although polybag plants help in the initial establishment of the plants, the overall girthing by the end of the immaturity period of seven years does not show any significant difference between the treatments.

Table–NET. 1. **Girth and girth increment (cm) during immature phase**

| Treatment | Girth | | Girth increment |
|---|---|---|---|
| | October 1982 | November 1989 | |
| Conventional brown budded stumps from 1980 nursery budded during 1981 | 6.84 | 50.60 | 43.76 |
| Brown budded stumps from 1979 nursery budded during 1980 and allowed to grow in nursery till 1981 planting season | 6.79 | 51.99 | 45.20 |
| Brown budded stumps from 1979 nursery budded during 1981 | 7.79 | 52.55 | 44.76 |
| Two months old green budded polybag plants | 8.30 | 52.35 | 44.05 |
| Fourteen months old green budded polybag plants | 12.38 | 56.08 | 43.70 |
| SE | 0.261 | 0.874 | |
| CD (P = 0.05) | 0.553 | 2.553 | |

## 5. Agromanagement practices for *Hevea*

### 5.1 Ground cover and soil moisture depletion

The three covers being tried – *Mucuna bracteata*, *Pueraria phaseoloides* and natural cover – have been established. The girth of plants in each plot has been recorded. Monitoring of soil moisture at different depths and organic matter enrichment will be undertaken.

### 5.2 Effect of shade

The trial was taken up with a view to monitor the influence of shade on the growth of rubber seedling at the nursery stage. The trial also envisaged monitoring of the influence of frequency of irrigation. Shade was taken up as a whole plot treatment and frequency of irrigation as sub plot treatment. The data obtained during 1987 and 1988 were pooled and summarised in Table-NET. 2.

Table-NET. 2. **Growth under shaded and unshaded condition**

| Frequency of irrigation | Diameter (mm) | | | |
|---|---|---|---|---|
| | Shaded | | Unshaded | |
| | 1987 | 1988 | 1987 | 1988 |
| Once in 3 days | 9.56 | 9.88 | 8.98 | 9.53 |
| Once in 6–7 days | 10.68 | 10.47 | 8.57 | 9.60 |
| Once in 10–12 days | 10.57 | 10.88 | 8.87 | 9.51 |

The data suggests that there is marked variation between shaded and unshaded plots with respect to growth of *Hevea* seedlings. It is also noticed that under shade conditions, the frequency of irrigation can be reduced to one third. For undertaking green budding and early budding, provisions of shade will be advantageous.

Two more trials, one on comparison and efficiency of different mulch materials in the seedling nursery and the other on evaluation of budding success with different management practices, also have been completed and data are pooled for analysis.

## 6. Forms and placement of fertilizers

### 6.1 Phosphatic fertilizers (immature phase)

The trial is taken up as a field experiment in Taranagar farm with clone RRIM 600 planted during 1986. Five treatments have been incorporated to have an effective comparison of water soluble source and water insoluble source, combination of both and no phosphorus. The girth was recorded during January 1990. Soil and leaf samples have been collected for assessing the nutrient status.

### 6.2 Phosphatic fertilizers (seedlings)

The trial was carried out during two seasons and the girth recorded at the end of the first season did not show any apparent influence of the source of phosphorus on the girth of the seedlings. However, the growth was adversely affected when phosphorus was not applied.

### 6.3 Phosphatic fertilizers (cover crops)

A pot culture study using *Pueraria phaseoloides* as test crop was conducted to evaluate the different sources of phosphatic fertilizers in soil collected from a ten year old rubber plantation. *P. phaseoloides* harvested after growing for two months in super phosphate added soils gave higher P content in both stem and leaves, more number of root nodules and higher biomass followed by those grown in Mussorie rock phosphate amended soils.

After harvesting the crop, the soil was analysed for phosphorus fractions and results are presented in Table–NET. 3.

Phosphorus incubation study with the above sources had been conducted in the

laboratory with the same soil for a period of 240 days and the results showed higher phosphorus availability in the soil which received Mussorie rock phosphate (2.49 mg $100\,g^{-1}$) followed by superphosphate (2.32 mg $100\ g^{-1}$) treated soils.

## 7. Soil test crop response studies

In a laboratory study to standardise the extractants for phosphorus, Bray II was observed to yield higher quantity of available $P_2O_5$ than Bray I when extracted upto 90 days. Proportionate increase in desorption of P was observed with increase in $P_2O_5$ application.

## 8. Physico-chemical characteristics of soils

### 8.1 Elemental composition

A fertility assessment of rubber growing soils in the region has been made. Analysis of total micronutrients of soils under plantation from Tripura has been carried out and the results are summarised in Table-NET. 4. Studies on soil physical properties also have been conducted.

### 8.2 Nitrogen mineralisation

A study was taken up with a view to monitor the mineralisation pattern of nitrogen in the rubber plantation. The data are summarised in Table-NET. 5.

## 9. Ecological impact of *Hevea* cultivation

### 9.1 Soil physical properties

The experiment to monitor the changes in physical properties brought about by rubber plantation vis-a-vis shifting cultivation initiated in 1989 was continued. The difference in moisture retention characteristics was similar in the profiles with higher retention inside the plantation. A comparison of rubber with other forestry species propagated under social forestry scheme such as acacia, sal and teak has also been undertaken. The moisture retention was observed to be higher in rubber plantation compared to forest trees within a depth of 75 cm.

### 9.2 Micro-climate

To monitor the influence of *Hevea* on the microclimate inside the plantation continuous monitoring of soil and air temperature, humidity, soil moisture, etc. is being made. The data so far generated indicate that there is difference of around 10°C in surface layer soil temperature between within and outside the plantation. While the soil outside the plantation showed a diurnal variation of around 10°C that within the plantation exhibited only 2°C in the soil temperature.

Table-NET. 3. **Fractions of P in residual soil (ppm)**

| | Total P | Al–P | Fe-P | O–P | Ca–P | Fe-occluded P | Al-occluded P |
|---|---|---|---|---|---|---|---|
| Control (no P) | 775 | 193 | 65 | 150 | 13 | 39 | 56 |
| Super phosphate | 895 | 212 | 84 | 183 | 14 | 26 | 67 |
| Mussorie R. P. | 949 | 191 | 69 | 189 | 13 | 33 | 44 |
| Purelia R. P. | 954 | 154 | 75 | 143 | 38 | 40 | 41 |
| Maton R. P. | 956 | 126 | 61 | 180 | 42 | 41 | 50 |
| Udaipur R. P. | 986 | 101 | 50 | 170 | 67 | 38 | 68 |

Table-NET. 4. **Micronutrient composition of soils**

| Profile | Depth (cm) | Total Mn (ppm) | Total Fe (ppm) | Total Zn (ppm) | Total Cu (ppm) |
|---|---|---|---|---|---|
| South Tripura (Inside) | 0–15 | 520 | 14727 | 30 | 49.24 |
| | 15–30 | 400 | 15272 | 24 | 34.09 |
| | 30–60 | 1720 | 15818 | 32 | 37.87 |
| | 60–90 | 640 | 19855 | 34 | 30.30 |
| | 90–120 | 320 | 20184 | 30 | 37.87 |
| | 120–150 | 560 | 23455 | 40 | 56.81 |
| North Tripura (Inside) | 0–15 | 240 | 18655 | 10 | 41.66 |
| | 15–30 | 160 | 23345 | 4 | 37.87 |
| | 30–60 | 80 | 26618 | 6 | 26.51 |
| | 60–90 | 80 | 33709 | 12 | 109.84 |
| | 90–120 | 80 | 30764 | 14 | 196.96 |
| | 120–150 | 80 | 29236 | 36 | — |
| South Tripura (Outside) | 0–15 | 800 | 11891 | 20 | 22.72 |
| | 15–30 | 240 | 13636 | 28 | 7.50 |
| | 30–60 | 160 | 16691 | 18 | 11.36 |
| | 60–90 | 160 | 23564 | 14 | 22.72 |
| | 90–120 | 160 | 26618 | 20 | 22.72 |
| | 120–150 | 240 | 25636 | 20 | 11.36 |
| North Tripura (Outside) | 0–15 | 320 | 19855 | 22 | 60.60 |
| | 15–30 | 200 | 23891 | 40 | 68.18 |
| | 30–60 | 160 | 7418 | 20 | 60.60 |
| | 60–90 | 80 | 19527 | 26 | 53.03 |
| | 90–120 | 680 | 22036 | 28 | 106.06 |
| | 120–150 | 200 | 16364 | 44 | 113.64 |

Table–NET. 5. $NH_4$–N and $NO_3$–N contents (as % total N) and mineralised Nitrogen (as % available N)

| | | AMMONIACAL NITROGEN | | | | | | NITRATE NITROGEN | | | | | | MINERALISED NITROGEN | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Initial | | 4th week | | 7th week | | Initial | | 4th week | | 7th week | | | |
| | | Inside | Outside | Inside | Outside | Inside | Outside | Inside | Outside | Inside | Outside | Inside | Outside | Inside | Outside |
| 5th year | 0–30 | 17.5 | 10.25 | 19.36 | 8.34 | 10.13 | 4.96 | 7.45 | 5.61 | 13.86 | 10.75 | 19.16 | 13.31 | 63.58 | 20.39 |
| | 30–60 | 19.5 | 8.62 | 19.09 | 6.97 | 12.09 | 3.98 | 9.49 | 5.94 | 16.21 | 8.51 | 20.32 | 11.97 | 22.74 | 9.02 |
| 10th year | 0–30 | 14.25 | 12.19 | 12.36 | 9.00 | 9.11 | 6.19 | 4.58 | 3.49 | 5.72 | 8.91 | 11.11 | 10.84 | 15.03 | 14.42 |
| | 30–60 | 17.39 | 11.16 | 11.18 | 9.74 | 9.61 | 7.62 | 4.00 | 5.85 | 7.66 | 9.32 | 12.36 | 10.40 | 4.08 | 7.99 |
| 15th year | 0–30 | 10.00 | 6.90 | 8.18 | 5.09 | 4.16 | 3.48 | 2.87 | 2.26 | 8.56 | 6.67 | 12.10 | 7.47 | 36.54 | 18.74 |
| | 30–60 | 10.93 | 10.99 | 8.01 | 8.91 | 6.88 | 7.14 | 5.02 | 4.93 | 8.32 | 8.48 | 9.29 | 9.46 | 12.19 | 4.65 |
| 20th year | 0–30 | 14.23 | 12.27 | 11.04 | 10.17 | 8.41 | 8.51 | 7.20 | 5.71 | 11.03 | 10.17 | 14.88 | 11.09 | 26.19 | 11.53 |
| | 30–60 | 13.55 | 12.90 | 10.95 | 12.00 | 10.59 | 8.60 | 6.76 | 5.91 | 10.95 | 12.00 | 10.82 | 10.77 | 10.19 | 4.20 |
| 25th year | 0–30 | 15.98 | 9.41 | 12.53 | 6.74 | 8.76 | 5.43 | 2.76 | 3.43 | 12.53 | 6.74 | 12.70 | 7.95 | 48.19 | 9.23 |
| | 30–60 | 10.51 | 9.21 | 9.67 | 6.31 | 5.34 | 5.55 | 3.41 | 5.05 | 9.67 | 6.31 | 10.67 | 9.11 | 27.49 | 6.16 |

9.3. **Microbial population**

The changes in microbial population inside the rubber plantation and on the various nutrient dynamic process including decomposition of organic matter is being studied.

## 10. Standardisation of analytical methods

The seasonal changes in leaf nutrient concentration of different clones is being monitored at a monthly basis.

## 11. Evaluation of planting materials

11.1 **Clone trial** (1979)

This trail was initiated in 1979. Fifteen clones are evaluated for their performance under Tripura conditions. The trees could be opened for tapping only in 1989 due to hail storm injury suffered by them. Girth at 150 cm height was recorded at quarterly intervals. Preliminary yield data are presented in Table-NET. 6, which indicated drastic variation in yield between clones.

Table–NET. 6. **Dry rubber yield (g/tree/tap) recorded ir. 1979 clone trial**

| Clone | Septem-ber | Octo-ber | Novem-ber | Decem-ber |
|---|---|---|---|---|
| RRII 105 | 20.69 | 34.11 | 36.07 | 25.15 |
| RRII 118 | 13.54 | 21.21 | 33.43 | 25.58 |
| RRII 203 | 9.58 | 27.99 | 26.52 | 17.31 |
| RRII 5 | 13.92 | 24.45 | 26.47 | 12.88 |
| RRIM 600 | 22.40 | 30.45 | 40.18 | 27.88 |
| RRIM 605 | 19.94 | 30.70 | 39.63 | 18.91 |
| RRIM 703 | 20.81 | 36.29 | 55.71 | 21.98 |
| RRIC 105 | 13.22 | 24.25 | 29.87 | 19.96 |
| RRIC 52 | 6.93 | 13.79 | 14.49 | 11.39 |
| PB 86 | 17.80 | 28.30 | 39.09 | 24.50 |
| PB 5/51 | 10.42 | 20.30 | 28.63 | 18.89 |
| PB 235 | 30.75 | 46.00 | 46.74 | 26.89 |
| GT 1 | 14.08 | 24.81 | 29.32 | 15.64 |
| Gl 1 | 7.78 | 18.24 | 29.77 | 20.20 |
| Harbel 1 | 8.10 | 18.76 | 25.87 | 13.41 |

To find out the differential response of sun and shade leaves to environmental variations, the specific leaf weight, relative water content and chlorophyll fractions were estimated. Data are presented in Table-NET. 7. Seasonal variations were observed during dry (April) and wet (October) periods. In both the seasons shade leaves have higher SLW, RWC and chlorophyll contents in all the five clones. The SLW was reduced and RWC increased in dry season compared to wet season in all the clones except GT 1. RRII 118 had higher values of SLW and total chlorophyll in both the seasons in sun as well as shade leaves, but RWC was higher in RRIM 600 in wet and RRII 105 in dry season. Studies on yield components and water relations have been initiated.

11.2 **Clone trial** (1987a)

Morphological and physiological parameters are recorded from the sixteen clones included in the trial. Girth was recorded at quarterly intervals. Physiological parameters recorded during April, '89 showed clonal differences. Highest photosynthetic rate was observed in RRIM 600 due to higher conductance amongst all the clones. The transpiration rate was high in RRII 300 and RRIM 605 and the least in PB 86 and PB 235.

The SLW, RWC and chlorophyll contents were estimated during October 1989. PB 235 showed least SLW and RWC whereas PB 86 and RRIM 703 showed higher values.

11.3 **Clone trial** (1987 b)

The trial started in 1987 with twelve stress tolerant clones (including three Chinese clones) was to evaluate their performance in Tripura. Girth was recorded at quarterly intervals. Physiological parameters were recorded during April '89. The data are presented in Table–NET. 9.

Table-NET. 7. **Specific leaf weight, relative water content and chlorophyll fractions of sun and shade leaves of different clones during dry season and wet season**

| Clone | | Dry | | | | Wet | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | SLW (mg $cm^{-2}$) | RWC (%) | Total chlorophyll (mg $g^{-1}$ fw) | Chl 'a/b' ratio | SLW (mg $cm^{-2}$) | RWC (%) | Total chlorophyll (mg $g^{-1}$ fw) | Chl 'a/b' ratio |
| RRII 105 | Sun | 5.38 | 92.18 | 3.207 | 1.07 | 6.32 | 84.8 | 4.070 | 1.08 |
| | Shade | 5.85 | 93.80 | 4.111 | 0.94 | 6.86 | 87.2 | 4.391 | 0.93 |
| RRII 118 | Sun | 5.90 | 91.03 | 4.809 | 1.07 | 6.42 | 83.3 | 5.651 | 1.05 |
| | Shade | 6.17 | 91.77 | 4.922 | 0.93 | 6.96 | 84.6 | 3.908 | 0.96 |
| RRIM 600 | Sun | 4.68 | 90.59 | 4.440 | 1.10 | 5.92 | 85.0 | 3.916 | 1.14 |
| | Shade | 5.61 | 91.33 | 4.746 | 0.88 | 5.99 | 89.2 | 4.648 | 0.70 |
| GT 1 | Sun | 5.05 | 90.05 | 3.422 | 1.18 | 4.85 | 82.5 | 5.140 | 1.80 |
| | Shade | 6.64 | 91.73 | 4.249 | 0.96 | 4.97 | 83.4 | 5.893 | 0.71 |
| PB 235 | Sun | 5.16 | 89.88 | 3.838 | 1.10 | 5.18 | 84.9 | 3.977 | 1.40 |
| | Shade | 5.89 | 91.49 | 4.189 | 0.88 | 6.89 | 85.5 | 4.602 | 0.99 |

Highest photosynthetic rate was observed in SCATC-93-114 and lowest in RRII 105 whereas transpiration rate was lowest in SCATC-93-114 and highest in GT 1. As regards conductance, high values were obtained in RRII 118 and least in GT 1 and PB 5/51. The SLW, RWC and chlorophyll contents were estimated during October 1989. The SLW and relative water contents (RWC) were of higher order in SCATC-93-114 and lower in GT 1 as well as Gl 1, but the chlorophyll content was highest in RRII 105 and lowest in GT 1.

### 11.4 Multiclonal onfarm trials

Three onfarm trials (clone trials) have been started, one in West District of Tripura, one in South district and another in Karimganj district of Assam with eight clones in each.

## 12. Flowering and fruit development

Recording of observations were carried out as per programme. The data so far collected were processed and a paper was published.

## 13. Progeny analysis

This trial was started in 1987 with seeds collected from 1979 clone trial area. The seedlings raised were test tapped and studies on physiological parameters such as chlorophyll, proline, sugars and epicuticular wax are being done.

Table-NET. 8. **Stomatal characteristics and photosynthetic efficiency during dry season**

| Clone | Transpiration (mmol $m^{-2}s^{-2}$) | PAR ($\mu Em^{-2}s^{-1}$) | RH (%) | LT (°C) | St conductance (mol $m^{-2}s^{-1}$) | Photosynthesis ($\mu$mol $m^{-2}s^{-1}$) |
|---|---|---|---|---|---|---|
| RRII 105 | 8.07 | 1142 | 56.16 | 32.97 | 0.53 | 6.36 |
| RRII 118 | 9.21 | 1308 | 58.74 | 33.43 | 0.49 | 7.42 |
| RRII 203 | 8.45 | 1113 | 53.60 | 33.37 | 0.50 | 8.05 |
| RRII 300 | 9.83 | 1410 | 49.02 | 34.63 | 0.46 | 6.77 |
| RRIM 501 | 9.10 | 1235 | 54.45 | 34.06 | 0.33 | 6.10 |
| RRIM 600 | 8.80 | 1230 | 62.52 | 33.89 | 0.62 | 8.60 |
| RRIM 605 | 9.82 | 1495 | 57.63 | 34.30 | 0.59 | 8.22 |
| RRIM 612 | 9.47 | 1469 | 52.65 | 34.21 | 0.60 | 8.30 |
| RRIM 703 | 9.23 | 1447 | 58.61 | 33.77 | 0.36 | 6.75 |
| PB 5/51 | 8.87 | 1183 | 60.21 | 33.58 | 0.42 | 7.32 |
| PB 86 | 7.32 | 1205 | 59.34 | 34.08 | 0.48 | 7.38 |
| PB 235 | 7.29 | 1403 | 52.24 | 32.42 | 0.36 | 6.21 |
| Gl 1 | 7.80 | 1330 | 55.68 | 31.14 | 0.54 | 7.30 |
| GT 1 | 8.72 | 1193 | 58.61 | 33.77 | 0.47 | 6.15 |
| Tjir 1 | 8.25 | 1350 | 53.36 | 33.66 | 0.30 | 6.35 |
| PR 107 | 8.49 | 1113 | 57.30 | 31.28 | 0.60 | 7.12 |

### 14. Performance of polyclonal seedlings

Under the trial, 490 plants are available and periodic girth recording is carried out. The girth recorded in November 1989 showed a mean value of 10.54 cm.

### 15. Mother tree selection

Trees selected are being monitored continuously for yield. Budwood was collected and multiplication has been carried out.

### 16. Optimum season for budding

A trial was initiated in 1985 in order to evaluate the seasonal influence on success of budding in Tripura. Green budding and brown budding were carried out at weekly intervals and budding success was recorded. The experiment was completed in December, 1989. During 1986 no data could be generated due to the severe hailstorm, occurred in April. Monthwise data for the year 1985, 1987, 1988 and 1989 are given in Table-NET. 10.

### 17. Germplasm conservation

A germplasm budwood nursery with 353 strains is being maintained. The strains were multiplied for evaluation in the field.

### 18. Relationship between girth and biomass

Plant height and girth data were recorded and destructive harvest was carried out periodically for determination of dry weight of biomass. It has been observed that RRII 118 is having a marginal superiority over RRIM 600 with respect to average build up of biomass per unit girth. Regression equations were evolved for one year and two year old trees for both clones.

Table–NET. 9. **Stomatal characteristics and photosynthetic efficiency of different stress tolerant clones during dry season**

| | Transpiration (mmol $m^{-2}s^{-1}$) | PAR ($\mu Em^{-2} s^{-1}$) | RH (%) | LT (°C) | Stomatal conductance (mol $m^{-2} s^{-1}$) | Photo-synthesis ($\mu$mol $m^{-2} s^{-1}$) |
|---|---|---|---|---|---|---|
| RRII 105 | 9.10 | 1350 | 54.86 | 33.02 | 0.52 | 06.8 |
| RRII 118 | 8.36 | 1220 | 58.12 | 31.80 | 0.63 | 8.06 |
| RRII 208 | 7.27 | 1288 | 60.39 | 32.60 | 0.48 | 8.24 |
| RRIM 600 | 9.20 | 1330 | 63.56 | 32.76 | 0.60 | 9.02 |
| SCATC 93–114 | 6.04 | 1244 | 60.01 | 33.40 | 0.46 | 8.40 |
| SCATC 88–13 | 6.90 | 1259 | 60.43 | 33.64 | 0.54 | 9.56 |
| HAIKEN 1 | 8.11 | 1337 | 59.31 | 33.88 | 0.58 | 9.11 |
| PB 86 | 8.06 | 1406 | 60.30 | 33.60 | 0.51 | 7.16 |
| PB 5/51 | 8.36 | 1250 | 60.66 | 33.30 | 0.44 | 7.50 |
| GI 1 | 8.60 | 1452 | 56.20 | 32.10 | 0.53 | 8.01 |
| GT 1 | 9.82 | 1358 | 57.62 | 33.20 | 0.44 | 7.03 |
| PR 107 | 8.89 | 1415 | 59.60 | 33.50 | 0.51 | 7.90 |

19. **Environmental parameters, photosynthesis and water retention in young plants**

This experiment was carried out to find out the effect of environmental parameters influencing photosynthesis and water relation in young plants with and without irrigation. Height, girth and physiological parameters of the plants were recorded periodically during different seasons. SLW, RWC, LWT, and chlorophyll contents were estimated. Soil moisture at three different depths were also recorded.

Seasonal differences were observed during summer (April) and winter (December).

Table-NET. 10. **Monthly mean budding success (%)**

| Month | | 1985 | 1987 | 1988 | 1989 | Mean |
|---|---|---|---|---|---|---|
| January | G | 75.83 | 40.87 | 45.00 | — | 41.05 |
| | B | — | — | — | — | — |
| February | G | 93.33 | 78.33 | 97.50 | — | 83.44 |
| | B | — | — | — | — | — |
| March | G | 98.33 | 97.50 | 97.77 | 92.50 | 96.53 |
| | B | — | — | — | — | — |
| April | G | 99.15 | 95.83 | 99.17 | 75.83 | 92.49 |
| | B | 97.77 | 55.83 | 29.16 | 5.83 | 47.15 |
| May | G | 92.50 | 95.83 | 97.50 | 76.66 | 90.62 |
| | B | 75.83 | 59.16 | 92.50 | 40.83 | 67.08 |
| June | G | 75.00 | 90.83 | 83.33 | 79.16 | 82.08 |
| | B | 52.50 | 64.16 | 75.83 | 80.83 | 68.33 |
| July | G | 90.83 | 67.50 | 65.00 | 59.16 | 70.62 |
| | B | 48.33 | 81.66 | 72.50 | 81.66 | 71.04 |
| August | G | 57.50 | 50.83 | 76.67 | 9.17 | 48.54 |
| | B | 63.33 | 65.83 | 80.00 | 59.16 | 67.08 |
| September | G | 21.86 | 35.00 | 47.50 | 3.30 | 26.92 |
| | B | 71.66 | 41.66 | 69.16 | 35.83 | 54.58 |
| October | G | 11.66 | 10.00 | 40.83 | 4.15 | 16.66 |
| | B | 56.66 | 33.67 | 65.00 | 31.66 | 46.75 |
| November | G | 15.83 | 3.33 | 30.00 | — | 12.29 |
| | B | 26.66 | 17.78 | 45.00 | 5.83 | 23.82 |
| December | G | — | — | 3.33 | 1.66 | 1.25 |
| | B | 1.66 | — | 20.83 | 5.00 | 6.87 |

G – Green building B – Brown budding

Under irrigated conditions photosynthesis, conductance and transpiration rates were increased. RRIM 600 and PB 235 has highest and lowest photosynthesis respectively. The photosynthesis increased during summer due to increased conductance and transpiration rate. Amongst the clones RRIM 600 have high photosynthesis in summer as well as in winter suggesting that RRIM 600 may be a drought tolerant clone. Under irrigated condition LWT, RWC and chlorophyll content were higher except chlorophyll a/b ratio. RRII 118 and GT 1 had highest and lowest chlorophyll and LWT in normal condition. RRII 105 showed highest chlorophyll content during summer under irrigated condition.

20. **Exploitation system**

An experiment was started during November, 1989 as an onfarm trial to find out a proper frequency of tapping suitable for Tripura. The clone used is RRIM 600. This experiment will be duplicated in Taranagar farm also with clone RRII 105. Preliminary yields indicated marginal increase in yield under $\frac{1}{2}$ S $d_3$ system.

21. **Biochemical studies**

Studies on thermostability were initiated with a view to evaluate the stress tolerant characters of five *Hevea* clones. In one of the existing experiment, plants of the same five clones are irrigated to alleviate stress effects. Thermostability studies were extended to this trial also to monitor the membrane changes under low and high temperature situation.

The data suggests that membrane damage was more in unirrigated treatment in general except for RRIM 600 where irrigated plants suffered maximum damage at all temperatures.

22. **Advisory**

Of 656 soil samples were analysed and fertilizer recommendations were given.

Table-NET. 11. **Effect of irrigation on thermostability**

| Clone | Irrigation | | | | Non-irrigation | | | |
|---|---|---|---|---|---|---|---|---|
| | % membrane damage at | | | | % membrane damage at | | | |
| | 10° | 20° | 30° | 40° | 10° | 20° | 30° | 40° |
| PB 235 | 29.5 | 14.5 | 8.6 | 13.3 | 33.2 | 21.2 | 11.1 | 19.3 |
| RRII 118 | 29.7 | 26.3 | 11.2 | 23.1 | 32.4 | 17.8 | 16.9 | 16.9 |
| RRII 105 | 27.8 | 14.9 | 9.6 | 13.3 | 46.9 | 24.3 | 21.1 | 25.5 |
| RRIM 600 | 56.4 | 34.3 | 18.3 | 24.1 | 32.5 | 19.8 | 16.4 | 21.1 |
| GT 1 | 27.5 | 16.1 | 8.8 | 17.4 | 41.9 | 29.0 | 27.1 | 30.4 |
| Mean | 34.2 | 21.2 | 11.3 | 18.2 | 37.4 | 22.4 | 18.5 | 22.6 |

# REGIONAL RESEARCH STATION, MEGHALAYA

The Regional Research Station, Meghalaya, established in 1985, has two experiment farms (Ganolgre, 600 m MSL and HARS, Darechikgre, 1100 m MSL). Two polyhouses were maintained. A seedling nursery of 4000 plants was established at Ganolgre. During the year under report, winter was prolonged.

## 1. Field experiments at Ganolgre farm

### 1.1 Multidisciplinary evaluation of clones

Girth of ten clones of *Hevea* were recorded in different seasons in this trial initiated in 1985. The clones RRII 203 (27.31 cm), RRIM 605 (26.84 cm) and RRII 118 (26.74 cm) have attained higher girth during the year. In the trial started in 1986, RRII 208 (17.21 cm) has shown the maximum girth followed by RRII 118 (14.28 cm).

### 1.2 Assessment of potential intercrops

The intercrops paddy, maize, cotton, ginger, pineapple and banana are included under this trial. The growth of maize, ginger, pineapple and banana was satisfactory while paddy and cotton did not grow successfully. The growth of rubber between the banana plants was better. Damage to banana by elephants and to pineapple by rodents reduced the expected yield.

### 1.3 Nitrogen requirement

This trial, started in 1987 to assess the requirement of nitrogen under different ground covers, has been abandoned due to reasons beyond control. The area is treated as bulk planting.

### 1.4 Rubber based cropping system

Under this trial perennial crops like tea, coffee and orange were planted in 1987. During 1989–90, tea harvesting has been started. The coffee plants suffered 50 per cent casualty.

## 2. Field experiments at Darechikgre farm

### 2.1 Multidisciplinary evaluation of clones

In this trial, started in 1985, most of the plants got dried up due to extremely low temperature and only 14 survived.

### 2.2 Intercropping with perennial crops

Tea, coffee and orange were planted between rows of polyclonal seedling stumps of rubber. But due to severe winter all the seedling stumps got dried up and coffee growth was poor, while tea and orange grew satisfactorily.

### 2.3 Selection from the polyclonal seedlings

In this trial started in 1987, to select genotypes from polyclonal seedlings withstanding extreme low temperature, 786 plants are surviving. The mean height, girth and leaf area were 82.14 cm, 2.83 cm and 24.84 $cm^2$ respectively.

## 3. Research programmes in plant pathology

### 3.1 Mushroom culture

Three varieties of edible mushrooms were tried during the year for large scale cultivation. These were *Pluerotus flabellatus*, *P. sajor-caju* and *P. ostreatus*. These species were observed to grow well on dried vines of *Mucuna*, used as a cover crop in rubber plantations. Maize straw is also a good growth medium. Attempts to cultivate *P. flabellatus* and *P. sajor-caju* in large scale during winter were not successful.

### 3.2 Plant diseases

No severe disease was noticed in the young rubber plants except minor occurrences of

powdery mildew and leafspot diseases. About 45 per cent plants in the nursery were infected by the leaf spot diseases during April-June.

### 4. Research programmes in plant physiology

#### 4.1. Diurnal variations in physiological parameters

Ten clones planted in 1985 were selected at an altitude of 600 m MSL and the average values of air temperature, relative humidity, photosynthetically active radiation, leaf temperature, transpiration rate and flow rate were recorded at different times during the month of December 1989. The maximum air temperature was recorded at 12.00 h. Relative humidity decreased from morning till noon and afterwards increased with a decrease in temperature. Photosynthetically active radiation showed a pattern similar to relative humidity. Leaf temperature in different clones varied from 19.4°C in Gl 1 to 22.25°C in RRII 105 at 8.00 am and increased by solar time till 2.00 pm in all clones. Minimum transpiration was recorded in all clones at 10 am and maximum at 12.00 noon and 2.00 pm in all clones. Diffusion conductance, boundary layer conductance and stomatal conductance dropped from 8 am to 10 am in all clones. It has been observed that at 2.00 pm diffusion conductance and boundary layer conductance were higher in all the clones, while stomatal conductance was higher at 1.00 h in all clones. PB 235 and PB 86 showed maximum diffusion conductance while minimum was observed in RRIM 605 and PB 5/51. Maximum stomatal resistance was recorded at 10.00 am in all clones.

#### 4.2 Bud sprouting in polyhouse

The percentage of sprouting of buds within polyhouse and outside at altitudes 600 m MSL and 1100 m MSL during the winter season was recorded. At lower elevation, plants inside polyhouse showed higher percentage of sprouting (47 per cent for RRIM 600 and 33 per cent for RRII 105) than that at higher altitude (20 per cent for RRIM 600 and 6 per cent for RRII 105), while outside the polyhouse all plants dried up due to low temperature.

## REGIONAL RESEARCH STATION, MIZORAM

The Regional Research Station, Mizoram, was established in 1985 at Kolasib. The experiment station is located at Tuichuan, 13 km from Kolasib town and has an area of 50 ha.

### 1. Multidisciplinary evaluation of clones

This trial was started in the year 1985. The data on girth of ten clones included in the trial shows that RRIM 605 had the highest girth as well as annual girth increment (10.12 cm).

### 2. Studies on intercropping

The intercropping trial was affected by landslide. However, data on yield of intercrops and girth of rubber, as far as possible are being collected to assess the effect of different intercrops on the growth of rubber.

### 3. Influence of physiographic features on growth of *Hevea*

The area was planted in 1987, but due to high casualties no observation was

taken. Gap filling in the area is being done.

4. **Rubber based cropping system**

The trial was started in 1987 to compare rubber cultivation with other potential perennial crops like orange, coffee, etc. Due to various uncontrollable local factors considerable vacancy existed. The vacancies in the area has been filled.

5. **Polyclonal seed garden**

An area of about 8 ha was planted in 1988–89 with seven clones (RRII 105, RRII 118, RRII 300, RRIM 600, GT 1, PB 235 and SCATC 93–114). The field is being maintained and gaps are being filled.

6. **Partial shade and irrigation in seedlings nursery**

Sprouted seeds were planted in nursery beds in September 1989 to study the influence of partial shade and frequency of irrigation on the growth of rubber seedlings. Periodic growth measurements were taken.

It has been observed that generally under shade the seedlings grew better. An irrigation frequency of once in 10 days was found to be adequate.

7. **Weed management**

Preliminary investigation on control of Lalang was initiated. An observational trial has been laid out in 1990 and periodic visual observations are being recorded.

## REGIONAL RESEARCH STATION, WEST BENGAL

The Regional Research Station, West Bengal, is located in the Terai region of the Himalayas, in the Grassmore Basti, Nagrakata circle of Jalpaiguri District. The station is located about 80 km from commercial township and 60 km from Jalpaiguri. The station was under establishment from the year 1989, over an area of 47.8 ha. An area of about 4 ha was brought under experimental planting to find out the nutritional requirements of rubber during immature phase in the Terai soils.

An experiment to find out the effect of low temperature on sprouting and survival of budded stumps of different clones was also undertaken. It was observed that 80–90 per cent buds sprouted but only 35–80 per cent of the sprouted stumps survived.

## OTHER REGIONAL RESEARCH STATIONS

The RRII has established other regional stations one each in Maharashtra and Orissa in addition to those in the North-Eastern States. A *Hevea* breeding station has also been established with a sub-station each in Tamil Nadu and Karnataka. A Regional Research Station was being was also under establishment in Madhya Pradesh.

## REGIONAL RESEARCH STATION, MAHARASHTRA

This station located at Dapchari aims at developing agro-techniques suitable for cultivating rubber in the Konkan region of Maharashtra State. The station has an experiment farm of 50 ha.

### 1. Irrigation systems

In an experiment initiated in 1989 different levels of irrigation are compared under two systems viz. drip (0.25, 0.50 and 0.75 ETc) and basin (0.50, 0.75 and 1.00 ETc) irrigation. The observations recorded include girth increment, rate of photosynthesis, transpiration and other physiological parameters. Although no significant difference in the parameters monitored was observed during November, 1989, the observations in January, 1990 indicated favourable physiological performance under basin irrigation.

A study was initiated in the area planted in 1983, on clones RRII 118 and RRII 105, to assess the effect of irrigation on yield components. Three levels of basin irrigation, one of sprinkler and an unirrigated control were the treatments included. Growth and physiological parameters were recorded.

### 2. Physiological evaluation of clones

Out of the 12 clones planted in 1982, nine clones are included in this experiment. Physiological parameters like latex turger potential, solute potential, stomatal diffusive conductance, transpiration rate and net photosynthesis were recorded. The clones RRIM 612, Gl 1, GT 1 and RRIM 501 showed higher photosynthesis during the post monsoon period compared to the other clones (PB 235, Tjir 1, RRII 300, PR 107 and RRIM 600).

### 3. Contact shading

The trial on contact shading was continued in the second year. The girth increment recorded in the experimental plants (RRIM 600) indicated superiority of 10 per cent china clay spray for shading when compared to conventional shading. The water relation in the contact shaded plants were better than that in unshaded or conventional shaded plants.

### 4. Dry farming

In the dry farming trials, RRII 105 planted in 1983 showed positive growth response only when irrigation was given at the rate of 320 litres/10 days, 15 days or 20 days per plant, among the twelve treatments. When the treatments were repeated in one year old plants of the same clone, basin irrigation at the rate of 156 l/plant/10 days, 15 days and 20 days was found to be responding well over other treatments.

### 5. Polyclonal trees for selection

To select genotypes suited to the local environment, a polyclonal seedling population of about 5,500 genotypes were raised during 1985 and 1987 and are being screened for various characters.

### 6. Cost of cultivation in Maharashtra

To evaluate the comparative cost of maintaining rubber plantation both under irrigated and rainfed condition in the area, a trial was initiated in 1987 with clone RRIM 600. The irrigated treatment received 220 litres of water per tree per frequency (1.00 ETc) from December 1989 to May 1990. The trial is being continued.

## REGIONAL RESEARCH STATION, ORISSA

The Regional Research Station, Orissa, established in 1987 at Annapurna Village (Dhenkanal), has an area of 40 ha. An area of 13 ha has been brought under experimental planting and the extent under nurseries is over 3 ha.

### 1. Nurseries

A seedling nursery of 35,000 seedlings which have attained buddable girth was raised. The growth of these seedlings are found to be good. A polyclonal seedling nursery has also been raised which has 1350 plants.

In the budwood nursery, 192 points of 12 experimental clones are maintained. 3448 numbers of budded plants of these 12 clones were raised in polybags for 1990 planting in the station. In addition, 483 points of nine clones (RRIM 600, RRII 105, GT 1, PB 311, PB 260, PB 235, RRIM 703, RRII 118 and RRII 203) are maintained in the station. From this nursery, 400 m budwood was supplied to the Rubber Board Zonal Office, Bhubaneswar.

### 2. Experimental plantings

The growth of plants in the trials as well as bulk/polyclonal plantings was found good. To induce branching of the trees the main stem was cut at a height of 10 ft which is found very effective. The practice of notching was ineffective.

The performance of the plants in the clone trial and the fertilizer trial was also found satisfactory. The soil of these two trial areas is not good as it becomes hard, like cemented floor, during summer. In the silt pit trial, the plants have attained a height of more than three metres within ten months. This practice will, therefore, be adopted in all other plantings.

The density (fan type) trial was abandoned due to technical limitations and shall be treated as bulk.

### 3. Onfarm trials

Two onfarm trials, one (2.00 ha) at Dhenkanal Palace Compound and the other (12.00 ha) in the campus of the Regional Research Laboratory, Bhubaneswar were started during the year. Planting in both the trial plots was undertaken during the period under review and the growth of plants is satisfactory.

## HEVEA BREEDING SUB-STATION, KARNATAKA

The station is located at Nettana, about 100 km from Mangalore and has an area of 50 ha.

1. **Trial on growth, yield and exploitation systems**

The trial laid out during 1987 is in a split plot design covering an area of 7 ha. The clones used are RRII 105, RRII 300, PB 235, PB 311 and PB 260. During the drought period of 1989, due to intense heat and scorching, around 200 trees were lost.

The trial laid out in 1988, with randomised block design and three replications is in an area of 30 ha. Clones in the trial are RRII 118, RRIC 36, RRIC 45, PCK 1 and PCK 2. The area is maintained properly. Here also a small percentage of casualty was noted due to drought.

2. **Small scale trial of ortet selection**

The trial was laid out during 1988 in an area of 2.38 ha using promising ortets selected from various smallholdings from Kerala. The trial consists of three experiments in a randomised block design. The control clones used in each trial are RRII 105, GT 1 and RRIM 600. Girth data and other morphological characters were recorded. A small area (bulk) planted with polyclonal seedlings has been maintained. Test tapping was initiated to identify promising ortets.

3. **Large scale trial of modern clones**

A large scale clone trial using 14 modern clones was laid out during 1989, on randomised block design with three replications and two control clones.

A polybag nursery with five second selections, four modern clones and parents of the selections are maintained for future trials. A source bush nursery of pipe line clones and other important clones have been established and maintained. Meteorological data at the sub-station have been regularly recorded.

## HEVEA BREEDING SUB-STATION, TAMIL NADU

The station is located at Paraliar, approximately 40 km from Nagercoil and has an area of 23.1 ha. Two breeding gardens with wide spacing (12.12m x 12.12m) have been established during 1987 and 1988 and maintained. Fifteen modern clones have been vegetatively multiplied and raised in polybags for field planting during 1990. A small source bush nursery is also maintained. Test tapping of three years old seedlings is in progress to identify superior and promising ortets.

# AGROMETEOROLOGY UNIT

Routine meteorological data collection from experimental stations and regional meteorological observatories and technical support to research activities of the Institute are being attended to by this unit.

## 1. Weather conditions at experiment stations

Normal monsoon was experienced at Kottayam (Kerala) and Agartala (NE Region). At Kottayam the monthly temperatures were varying between 20.9 to 33.7°C. A pan evaporation of 1443 mm, sunshine of 2638 hours and rainfall of 3074 mm distributed in 132 days were recorded. At Agartala, temperature varied between 8.7 to 34.4°C, 2593 hours sunshine, 1462 mm of evaporation and 1848 mm rainfall received in 84 days. For about five months the mean minimum temperatures were less than 20°C. At Dapchari (Konkan region of Maharashtra) temperature varied from 12.5 to 38.5°C, 2851 hours of shine, 1871 mm of evaporation and 1821 mm of rainfall distributed in 83 days were observed. In addition to the low quantum of normal rainfall, during April to June for 5 to 11 days, the maximum temperatures crossed 40°C, with a highest temperature of 46.5°C. The prolonged drought coupled with high ambient temperature and advective conditions kept the plants under severe stress.

## 2. Agroclimatic aspects of rubber cultivation

The agroclimatic conditions prevailing in the rubber growing areas of India were compared with few representative locations from other rubber growing countries. The application of climatic water balance model indicates an annual water deficit of 250 to 350 mm in the marginal areas. Under prolonged stress conditions, interaction of low soil moisture availability and higher air temperatures by 2–3°C might be responsible for low yield and growth inhibition.

A comparison of mean monthly temperature of Kottayam with a few traditional and non-traditional locations (Table-Agromet. 1) indicates that the thermal conditions in the non-traditional regions are highly variable. Thus the need to develop location specific agrotechniques and clones to counteract the thermal stress on rubber trees are indicated.

The intercepted rainfall, reduction in soil temperature, albedo of *Hevea* canopy, dry matter production, soil erosion, etc. are comparable to some forest plantations, which indicate the possibility of considering *Hevea* for afforestation, without much effect on environment.

## 3. Crop weather relations

The rainfall data from a few estates were collected to study the rainfall pattern in the traditional rubber growing regions. Attempts are being made to collect the yield data of popular clones from different agro-climatic regions. In order to quantify the stress conditions, two representative diurnal patterns

of temperature, humidity, irradiance, soil temperature, etc, were monitored at Dapchari. The spectral distribution of solar radiation and transmitted radiation through different canopies of *Hevea* were undertaken. Technical guidelines were provided for fixing the schedule of irrigation in an experiment to evaluate its influence on yield at Dapchari.

4. **Establishment of agrometeorological observations**

Two Regional Meteorological Observatories, one at Keeriparai (Kanyakumari district) and the other at Palapilly (Trichur district) were established. Arrangements were also made to establish one at Regional Research Station, Orissa.

Table-Agromet. 1. **Agroclimatic analogues of temperature (°C) compared to Kottayam in traditional and non-traditional rubber growing regions**

| Station | Mean difference | | Standard deviation | | Largest difference | |
|---|---|---|---|---|---|---|
| | Max | Min | Max | Min | Max | Min |
| Trivandrum | 0.1 | —1.1 | 0.6 | 0.2 | 1.0 | —1.5 |
| Alleppey | 0.0 | —1.5 | 0.4 | 0.2 | 0.8 | —1.9 |
| Cochin | 1.0 | —2.0 | 0.6 | 0.3 | 2.1 | —2.6 |
| Palghat | —1.5 | —1.0 | 1.3 | 0.3 | —4.0 | —1.7 |
| Calicut | —0.1 | —0.8 | 0.6 | 1.9 | 0.8 | —2.2 |
| Punalur | —1.9 | 0.1 | 0.5 | 0.5 | —2.9 | 1.0 |
| Kasaragod | —0.5 | —0.3 | 0.7 | 0.8 | 1.4 | —1.5 |
| Mangalore | 0.2 | —1.3 | 0.8 | 0.7 | 1.7 | —2.5 |
| Dapchari | —1.7 | 1.4 | 1.9 | 4.0 | —4.5 | 7.1 |
| Angol | —1.7 | 0.9 | 4.2 | 4.5 | —8.9 | 8.1 |
| Agartala | 0.4 | 3.0 | 3.3 | 5.1 | 6.4 | 11.0 |
| Guwahati | 1.3 | 2.7 | 4.1 | 5.3 | 7.9 | 10.1 |
| Tura | 2.4 | 3.0 | 3.1 | 3.7 | 8.3 | 8.8 |
| Dibrugarh | 3.0 | 3.7 | 4.3 | 5.1 | 9.4 | 10.9 |
| Sibsagar | 2.4 | 3.2 | 4.8 | 5.5 | 9.2 | 11.2 |
| Silchar | 0.9 | 2.5 | 3.4 | 4.7 | 6.4 | 9.4 |
| Shillong | 9.6 | 10.3 | 4.4 | 5.0 | 16.4 | 17.5 |
| Cherapunji | 10.2 | 8.1 | 3.8 | 3.5 | 16.1 | 13.5 |

## LIBRARY AND DOCUMENTATION CENTRE

During the current year 111 books were added to the library collection, making the total to 20,309. The library subscribed to 308 journals and about 200 other journals were also received as gift/exchange. With a view to disseminate the right information to the right users at the right time, the library and documentation centre arranged translation of articles, compilation of weekly price consolidates, publication of rubber alerts, documentation list, recent additions to RRII library etc. Three issues of Rubber Alert, two issues of Recent Additions to RRII Library, four issues of Documentation lists and 40 weekly bulletins of prices of natural rubber at the Kuala Lumpur market were compiled. The Reprographic Section provided copies of nearly 1.5 lakh materials as per need.

The library is actively participating in the sales promotion of the *Indian Journal of Natural Rubber Research* and the books entitled *Handbook of Natural Rubber Production in India*, *Rubber Wood: Production and utilisation* and *Plant and Soil Analysis*. The facilities and services of the library were also extended to planters, manufacturers and others connected with the plantations industry including students and research workers.

## BUDGET

1989-90

(Rs in lakhs)

| Sl no | Head of account | Approved budget | Actual expenditure |
|---|---|---|---|
| | **Non Plan** | | |
| 1. | Pay and allowances | 87.19 | 89.85 |
| 2. | Contingencies | 18.00 | 20.29 |
| 3. | Other charges (including RRII Estate Nursery) | 39.81 | 51.16 |
| 4. | Non Plan Schemes | 6.50 | 4.76 |
| 5. | Non Plan Projects (CFS Chethackal) | 32.50 | 42.62 |
| | Total Non Plan | 185.00 | 208.68 |
| | **Plan** | | |
| 6. | Plan Schemes | 33.00 | 71.56 |
| 7. | NERDS Research Component | 100.00 | 94.82 |
| | Total Plan | 133.00 | 166.38 |

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## SCIENTIFIC AND SENIOR SUPPORTING PERSONNEL OF THE RRII

**Director of Research**

M. R. Sethuraj, M.Sc. (Ag.), Ph.D.

**Germplasm Coordinator**

S. Narayanan Potty, M.Sc. (Ag.), Ph.D.

**Agricultural Economics Division**

| | |
|---|---|
| V. Haridasan. M. A., Ph.D. | Deputy Director |
| K. Tharian George, M.A., Ph.D. | Market Research Officer |
| P. Rajasekharan, M.Sc. (Ag.) | Junior Scientist |

**Agronomy and Soils Division**

| | |
|---|---|
| M. Mathew, M Sc. (Ag.) | Deputy Director |
| K. I. Punnoose, M.Sc. (Ag.) | Agronomist |
| M. Karthikakutty Amma, M.Sc. (Ag.) | Soil Chemist |
| A. N. Sasidharan Nair, M.Sc. | Soil Chemist |
| Elsie S. George, M.Sc. | Assistant Soil Chemist |
| V. Krishnakumar, M.Sc. (Ag.), Ph.D. (upto 9–11–1989) | Assistant Agronomist |
| Jacob Mani, M.Sc. (Ag.) | Junior Scientist |
| V. K. Syamala, M.Sc. | Junior Scientist |
| Mercykutty Joseph, M.Sc. (Ag.), Ph.D. | Junior Scientist |
| Joyce Cyriac, M.Sc. | Junior Scientist |
| P. R. Suresh, M.Sc. (Ag.) | Junior Scientist |
| Radha Lakshmanan, M.Sc. (Ag.) | Junior Scientist |
| A. Ulaganathan, M.Sc. | Junior Scientist |
| Joshua Abraham, M.Sc. | Junior Scientist |
| Annie Philip, M.Sc. | Junior Scientist |
| Anna Varghese, M.Sc. | Junior Scientist |
| Sarah Jacob, M.Sc. (Ag.) | Junior Scientist |
| M. D. Jessy, M.Sc. (Ag.) | Junior Scientist |
| Siby Varghese, M.Sc. | Junior Scientist |
| C. K. Thankamani, M.Sc. (Ag.) (from 2–11–1989) | Junior Scientist |
| Sherin George, MSc. (Ag.) | Junior Scientist |
| K. Govindan, M.Sc. (Ag.) | Junior Scientist |
| Aleyamma Augusthy, B.Sc. | Senior Scientific Assistant |
| C. K. Chacko, B.Sc. | Senior Scientific Assistant |
| C. P. Mary, B.Sc. | Senior Scientific Assistant |
| M. J. Thomas, B.Sc. | Senior Scientific Assistant |
| Molly Pothen, B.Sc. | Senior Scientific Assistant |
| P. J. Joseph | Assistant Superintendent (Farm) |

**Biotechnology Division**

| | |
|---|---|
| M. P. Asokan, M.Sc., Ph.D. | Deputy Director |
| P. Sobhana, M.Sc. | Plant Physiologist |
| R. Krishnakumar, M.Sc., Ph.D. | Scientist |
| S. Sushamakumari, M.Sc. | Junior Scientist |
| P. Jayasree, M.Sc. | Junior Scientist |

**Botany Division**

| | |
|---|---|
| A. O. N. Panikkar, M.Sc., Ph.D. | Deputy Director |
| Joseph G. Marattukalam, M.Sc. | Botanist |
| D. Premakumari, M.Sc. | Anatomist |
| C. K. Saraswathy Amma, M.Sc. | Cytogeneticist |
| Y. Annamma, M.Sc., Dr. Sc. (Ag.) | Botanist |
| J. Licy, M.Sc. | Plant Breeder |
| Kavitha K. Mydin, M.Sc. (Ag.) | Junior Scientist |
| C. P. Reghu, M.Sc., Ph.D. | Junior Scientist |
| V. C. Mercykutty, M.Sc., Ph.D. | Junior Scientist |
| Alice John, M.Sc. (Ag.) | Junior Scientist |
| N. Bhargavan | Assistant Superintendent (Farm) |

**Germplasm Division**

| | |
|---|---|
| P. J. George, M.Sc. (from 11–1–1990) | Deputy Director |
| K. P. Leelamma, B.Sc. | Senior Scientific Assistant |

**Mycology and Plant Pathology Division**

| | |
|---|---|
| K. Jayarathnam, M.Sc. (Ag.), Ph.D. | Deputy Director |
| R. Kothandaraman, M.Sc. (Ag.), Ph.D. | Microbiologist |
| V. K. Rajalakshmy, M.Sc. | Mycologist |
| Thomson T. Edathil, M.Sc. | Plant Pathologist |
| C. R. Nehru, M.Sc. | Entomologist |
| L. Thankamma, M.Sc. | Mycologist |
| V. Krishnankutty, M.Sc. | Plant Pathologist |
| Jacob Mathew, M.Sc. | Assistant Microbiologist |
| C. Kuruvilla Jacob, M.Sc. (Ag.) Ph.D. | Assistant Pathologist |
| V. T. Jose, M.Sc. (Ag.) Ph.D. | Assistant Entomologist |
| Sabu P. Idicula, M.Sc. (Ag.) | Junior Scientist |
| S. Thankamony, M.Sc. | Junior Scientist |
| Annakutty Joseph, M.Sc. | Junior Scientist |
| Kochuthresiamma Joseph, M.Sc. | Junior Scientist |
| Sanjeeva Rao Popuri, M.Sc., Ph.D. | Junior Scientist |
| M. Jayadevi, B.Sc. | Senior Scientific Assistant |
| P. M. Levi Joseph, B.Sc. | Senior Scientific Assistant |

**Plant Physiology and Exploitation Division**

| | |
|---|---|
| K. R. Vijayakumar, M.Sc. (Ag.), Ph.D. | Deputy Director |
| S. Sulochanamma, M.Sc. | Plant Physiologist |
| Usha N. Nair, M.Sc. (Ag.) | Biochemist |
| Molly Thomas, M.Sc., Ph.D. | Assistant Biochemist |
| P. K. S. Panicker, B.Sc. | Development Officer |
| K. U. Thomas, M.Sc., Ph.D. | Assistant Plant Physiologist |
| C. V. S. Bhasker, M.Sc., Ph.D. (from 26–6–1989) | Assistant Environmental Physiologist |
| R. Rajagopal, M.Sc. | Junior Scientist |
| A. S. Devakumar, M.Sc. (Ag.) | Junior Scientist |
| S. Sreelatha, M.Sc. | Junior Scientist |
| D. Bhuvanachandran Nair, M.Sc., Ph.D. | Junior Scientist |
| Vidyalekshmy, M.Sc. (from 3–11–1989) | Junior Scientist |
| M. Suhasini, M.Sc. (from 1–12–1989) | Junior Scientist |
| S. Visalakshy Ammal, B.Sc. | Senior Scientific Assistant |
| G. Gopinathan Nair | Assistant Superintendent (Farm) |

**Rubber Chemistry, Physics and Technology Division**

| | |
|---|---|
| N. M. Mathew, M.Sc., L.P.R.I., Ph.D. | Deputy Director |
| Baby Kuriakose, M.Sc., L.P.R.I., Ph.D. | Deputy Director |
| N. M. Claramma, M.Sc., L.P.R.I. | Rubber Chemist |
| K. T. Thomas, M.Sc., L.P.R.I., M.Tech. | Rubber Technologist |
| K. Mariamma George, M.Sc. | Junior Scientist |
| N. Radhakrishnan Nair, M.Sc. | Junior Scientist |
| Jacob K. Varkey, M.Sc., M.Tech. | Junior Scientist |
| Leelamma Varghese, M.Sc. | Junior Scientist |
| Benny George, M.Sc. | Junior Scientist |
| C. K. Premalatha, B.Sc., L.P.R.I. | Senior Scientific Assistant |

**Accounts Section**

| | |
|---|---|
| V. Alexander John, M.Com., M.A., LLB. | Senior Accounts Officer |
| Joy Cyriac, B.Sc., A.C.A. | Assistant Accounts Officer |
| N. Vijayamma | Section Officer |

**Administration Section**

| | |
|---|---|
| U. K. Krishnan | Assistant Secretary |
| Josy D'Cruz | Administrative Officer |
| E. K. Thankamma | Section Officer |
| J. Kamala Devi | Assistant Section Officer |

**Art/Photography Section**

| | |
|---|---|
| K. P. Sreerenganathan | Senior Artist/Photographer |

**Instrumentation Section**

| | |
|---|---|
| S. Najmul Hussain, B.Sc., M.Tech., A.M.I.E.T.E. | Instrumentation Officer |
| Thomas Baby, M.Sc., M.Phil. | Assistant Instrumentation Officer |

**Documentation Officer**

| | |
|---|---|
| V.K. Gopinathan Nair, B.Sc.,D.Lib.Sc.,A.D.I.Sc. | Documentation Officer |
| G. Ajithkumar, B.Sc., B.Lib.Sc., A.D.I.Sc. (upto 9–8–1989) | Documentation Officer |
| P. J. Lukose, B.A., B.Lib.Sc. | Senior Librarian |
| Mercy Jose, B.Sc., B.Lib.Sc. | Assistant Documentation Officer |
| Accamma C. Korah, B.Sc., M.L.I.Sc. | Librarian (Documentation) |

**Statistics Section**

| | |
|---|---|
| G. Subbarayalu, M.Sc. | Statistician |
| A. Malathy, M.Sc. | Statistical Officer |

**Experiment Station at RRII**

| | |
|---|---|
| M. D. Issac | Assistant Superintendent (Farm) |

**Maintenance Wing**

| | |
|---|---|
| S. Mohanachandran, B.Sc.(Engg.) (from 3–6–1989) | Electrical Engineer |
| Sheela A. John, B.Tech. (from 3–6–1989) | Assistant Engineer (Civil) |
| T. K. Somanatha Pillai | Assistant Estate Officer |

**Security Wing**

| | |
|---|---|
| C. K. Abraham, B.A., B.Ed. | Assistant Security Officer |

**Central Experiment Station**

| | |
|---|---|
| M. J. George, M.Sc. | Deputy Director |
| Jacob Abraham, B.Sc., M.B.B.S. | Medical Officer |
| Varghese Philip, M.Sc. (Ag.) | Junior Scientist |
| John Kurian | Assistant Accounts Officer |
| C. R. Krishnan | Assistant Section Officer |
| E. A. Raghavan | Assistant Superintendent (Farm) |

**Hevea Breeding Sub-station, Karnataka**

| | |
|---|---|
| M. A. Nazeer, M.Sc., Ph.D. | Senior Plant Breeder |
| K. Soman | Assistant Superintendent (Farm) |

**Hevea Breeding Sub-station, Tamil Nadu**

| | |
|---|---|
| T. A. Soman, M.Sc., M.Phil. | Junior Scientist |

**Regional Research Station, Maharashtra**

| | |
|---|---|
| T. Mohankrishna, M.Sc., Ph.D. | Plant Physiologist |
| T. R. Chandrasekar, M.Sc. | Assistant Botanist |
| S. George | Assistant Superintendent (Farm) |
| K. P. Thankappan | Assistant Section Officer |

**Regional Research Station, Orissa**

| | |
|---|---|
| N. Reghunathan Nair, B.Sc. (Ag.) | Senior Superintendent |
| R. Raveendran | Assistant Superintendent (Farm) |
| P. Abdul Salam | Assistant Section Officer |

**Regional Research Station, Assam**

| | |
|---|---|
| Radha Raman Sinha, M.Sc. (Ag.), Ph.D. | Deputy Director |
| Gopal Chandra Mondal, M.Sc., Ph.D. | Plant Pathologist |
| Ramphool Singh, M.Sc. (Ag.) | Junior Scientist |
| S. A. Saseendran, M.Sc. | Junior Scientist |
| Krishna Das, M.Sc., Ph.D. | Junior Scientist |
| Debasis Mondal, M.Sc. | Junior Assistant |
| Dilip Kumar Daimari, M.Com. | Assistant Accounts Officer |

**Regional Research Station, Meghalaya**

| | |
|---|---|
| A. P. Thapliyal, M.Sc., Ph.D. | Plant Physiologist |
| H. K. Deka, M.Sc., Ph.D. | Junior Scientist |
| K. Chandra Gupta | Junior Scientist |
| Mohan Ram Rao, M.Sc. | Junior Scientist |

**Regional Research Station, Tripura**

| | |
|---|---|
| A. K. Krishnakumar, M.Sc. (Ag.), Ph.D. | Deputy Director |
| N. Dhurjati Chaudhuri, M.Sc. (Ag.) | Plant Physiologist |
| Rajeswari Meenattoor, M.Sc. (Ag.) | Junior Scientist |
| D. V. K. Nageswara Rao, M.Sc. | Junior Scientist |
| Y. A. Nanja Reddy, M.Sc. | Junior Scientist |
| Jiban Chakrabarti, B.Com. | Junior Accountant |

**Regional Research Stataion, Mizoram**

| | |
|---|---|
| Jacob Pothen, M.Sc. (Ag.) | Assistant Agronomist |
| Mary Varghese, M.Sc. (Ag.) | Junior Scientist |

*continued from inside front cover*

**Research divisions and functions**

The major research divisions are Agronomy and Soils; Biotechnology; Botany; Germplasm; Mycology and Plant Pathology; Plant Physiology and Exploitation; Rubber Chemistry, Physics and Technology and Agricultural Economics.

The thrust areas of research of the Agronomy and Soils Division are investigations on the nutritional requirements of rubber, irrigation, intercropping, cover crop management, weed control and the study of the rubber growing soils. Development of tissue culture and anther culture systems for propagation and crop improvement of *Hevea* are the important areas in which the Biotechnology Division is engaged. The important fields of research of the Botany Division are breeding, evaluation and selection of new clones, propagation techniques, planting methods, anatomical studies and cytogenetic investigations. The Germplasm Division is concentrating on the introduction, conservation and evaluation of *Hevea* germplasm. The Mycology and Plant Pathology Division is engaged in investigations on the diseases and pests of rubber and associated cover crops and their control. The Plant Physiology and Exploitation Division conducts studies on identification of characteristics related to yield, physiology of latex flow and yield stimulation. The Rubber Chemistry, Physics and Technology Division concentrates on improvement in primary processing of rubber, its chemical modification, rubber product manufacture and quality control of processed rubber. The Agricultural Economics Division undertakes studies on economic aspects related to rubber plantations.

The research supporting sections include Library and Documentation, Instrumentation, and Art/Photography. There is also a small experimental farm of 33 ha at the headquarters of the RRII.

**Central Experiment Station**

The 255 ha Central Experiment Station at Chethackal (Ranni), 50 km away from Kottayam, was started in 1966. Field trials laid out by the research divisions cover almost the entire area.

**Regional Research Stations**

The RRII has established a Regional Research Complex for North East India with headquarters at Guwahati, having regional research stations at Agartala in Tripura, Guwahati in Assam, Tura and Darachgree in Meghalaya and Kolasib in Mizoram. The RRII has also set up regional research establishments at Dapchari (Maharashtra), Kamakhyanagar(Orissa) Nagrakata (West Bengal), Sukma (Madhya Pradesh), Paraliar (Tamil Nadu) and Nettana (Karnataka).

Regional Laboratories have been established at Thodupuzha, Calicut and Nagercoil each with a mobile unit for soil and leaf analysis.

**Staff**

The staff strength of the RRII has been 368 during the period under review. This includes 150 scientists and senior supporting personnel.

**National/International Collaboration**

The RRII is a member of the International Rubber Research and Development Board (IRRDB), an association of national organizations devoted to research and development on natural rubber. The Rubber Board is a member of the Association of Natural Rubber Producing Countries (ANRPC) and the International Rubber Study Group (IRSG).

The RRII has research/academic linkages with the Banaras Hindu University (Varanasi), Kerala Agricultural University (Trichur), Kerala University (Trivandrum), Mahathma Gandhi University (Kottayam), Cochin University of Science and Technology (Cochin), Indian Institute of Technology (Kharagpur), National Chemical Laboratory (Pune) and Indian Institute of Science (Bangalore).

**Publications**

**Books**

Handbook of Natural Rubber Production in India
Rubber Wood : Production and Utilization
Plant and Soil Analysis

**Serials**

Indian Journal of Natural Rubber Research
RRII Annual Report

**Correspondence**

The Director
Rubber Research Institute of India
Kottayam-686 009, Kerala
India.
Phone : 91 481 8311 (6 lines)
Telex : 888 285 RRII IN
FAX : 91 481 8317