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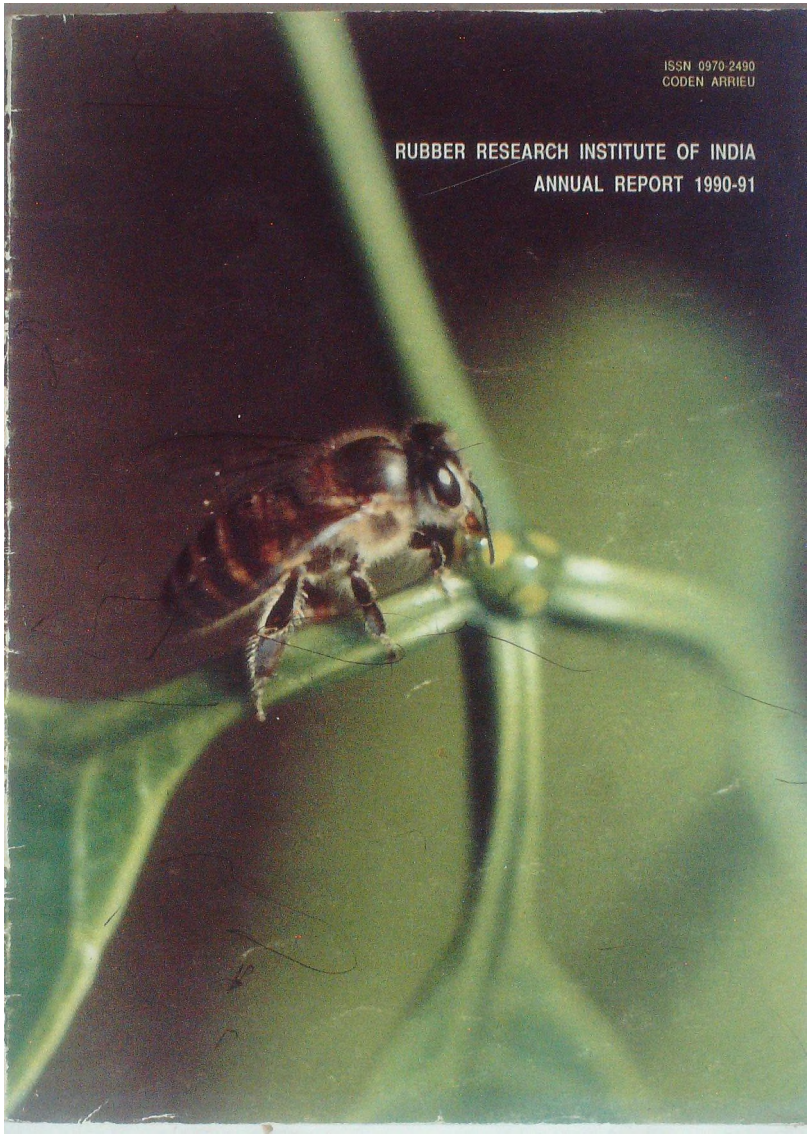
RUBBER RESEARCH INSTITUTE OF INDIA
ANNUAL REPORT 1990-91



Rubber Research Institute of India

Annual Report 1990-91

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Publisher
Dr. M. R. Sethuraj

Cover

About 45 percent of honey produced in India is from rubber plantations. The bees collect nectar from extra floral nectaries of the rubber tree at the tip of petiole, where the three leaflets join.

Photograph
Mr. K. P. Sreerenganathan

August 1992

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 headquarters and regional research establishments at appropriate locations where *Hevea brasiliensis* is commercially grown or is likely to be grown.

continued on inside back cover

ANNUAL REPORT
1990-91

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 which came into force on 19th April 1947. This Act was amended first in 1954 and later in 1960. In 1982 the Act was again amended by the Rubber (Amendment) Act which is now in force.

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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J. Lalithambika, IAS

Rubber Production
P. Mukundan Menon
Rubber Production Commissioner

Research
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Director

Administration
M. O. Joseph
Secretary

Rubber Processing
C. M. George
Project Officer

Finance & Accounts
P. U. George
Financial Adviser

Training
Dr. E. V. Thomas
Joint Director

MEMBERS OF THE EXPERT ADVISORY PANEL OF THE RRII

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1. Dr. N. K. Jain, Co-ordinating Director, CSIR Complex, Palampur-176 001.
2. Dr. M. Velayudham, Asst. Director General (Soils), ICAR, Krishi Bhavan, New Delhi-110 012.
3. Prof. B. Datta, Dept. of Agricultural Engineering, IIT, Kharagpur-721 302.

Genetics and Plant Breeding

4. Dr. S. Kedharnath (Retd. Director, Kerala Forest Research Institure), 12-A, Ramalinga Nagar, Coimbatore-641 038.
5. Dr. C. A. Ninan, Dean, Faculty of Science, University of Kerala, Trivandrum-695 581.
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8. Prof. V. S. Rama Das, Dean, Faculty of Science, Sri Venkateswara University, Tirupati-517 502.

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10. Prof. T. Ramakrishnan, Microbiology & Cell Biology Lab., Indian Institute of Science, Bangalore-560 012.

Mycology and Plant Pathology

11. Dr. S. P. Raychoudhuri, A-61, Alakananda, Kalkaji, New Delhi-110 019.
12. Dr. B. Sripathi Rao, 116, Cunningham Road, Bangalore-560 052.

Rubber Chemistry, Physics and Technology

13. Prof. S. K. De, Dean, Postgraduate Studies, IIT, Kharagpur-721 302.
14. Dr. D. Joseph Francis, Professor & Head, Dept. of Polymer Science & Rubber Technology, Cochin University, Cochin-682 022.

Agrometeorology

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

DIRECTOR'S REVIEW

The Rubber Research Institute of India (RRII) continued to provide adequate research support for developing appropriate agrotechnology, evolve and evaluate clones suitable for non-traditional areas as well as traditional zones, refine the package of practices for the traditional areas aimed at monetary savings in inputs and their application and undertake technological research for product improvement with the ultimate objective of conserving natural rubber (NR). Due emphasis was given to tapping panel dryness, a syndrome causing grave concern in all rubber growing countries.

The thrust areas of research of the Botany Division continued to be breeding and selection of planting materials, anatomy, propagation and cytogenetics. Special emphasis was given for clone evaluation studies and ortet selection programme. Based on premature yield for one year 15 clones which showed better performance over RRII 105 were selected for further evaluation. RRII 105 continued to be the top yielder. Detailed cytological and genetical investigations have elucidated that the spontaneous triploid is an autotriploid. Anatomical studies have shown that the small stomatal aperture is one of the identifying characters of drought tolerant clones. The growth performance of RRII 203 on its own stock was found to be good. Assessment of prepotency of twenty promising clones through seedling progeny analysis was completed and the clones AVT 73 and RRII 105 proved to be the best amongst these.

The Agronomy and Soils Division focussed on investigations on nutritional requirements of high yielding clones of rubber at various stages of growth under different agro-management practices. Work on the Diagnosis and Recommendation Integrated System (DRIS) as a tool to formulate the optimum nutrient ratio was in progress.

The Pathology Division continued its research programmes in mycology, pathology, microbiology and entomology. On preliminary screening, one sample each of COC 56% ODP formulated by three manufacturers and two samples of 'Dithane' M 45 ODP were found to be suitable for further testing. New isolates of the fungal pathogen Phytophthora were added to the stock culture. The Biotechnology Division continued its thrust areas of research activities in the conversion of experimental in vitro propagation system in to a commercial propagation system. Another batch of about 500 tissue culture derived plants were planted in the field during the period.

The Germplasm Division concentrated its research activities on the introduction, collection, conservation and evaluation of Hevea germplasm. Juvenile characterisation and pre-

liminary evaluation of 200 genotypes belonging to different provenances were carried out.

The Plant Physiology and Exploitation Division concentrated its research activities on latex biochemistry, crop physiology, stress physiology, exploitation and intercropping of shade tolerant medicinal plants. Research activities on tapping panel dryness were intensified.

The design for a pilot plant for the production of epoxidised natural rubber has been finalised, by the Rubber Chemistry, Physics and Technology Division. Further experiments on sulphuric acid as an alternative latex coagulant were in progress. The RRII continued to participate in the UNIDO funded project on precured retreads based on NR. A project was undertaken for developing a rubber compound for flex seal for use in rockets. Studies on rubber wood, other ancillary products, performance of planting materials under commercial planting, management aspects etc were continued by the Agricultural Economics Division.

The Regional Research Station of RRII at Assam, Tripura, Meghalaya, Mizoram, Maharashtra, Orissa and the Hevea breeding sub stations at Nettana and Paraliar concentrated on location specific investigations for evolving suitable planting materials, agromanagement techniques for the specific situations and related aspects. Several field experiments were laid out in these locations.

During the year under review two issues of the Indian Journal of Natural Rubber Research were brought out. The RRII maintained good liaison both at the national and at the international level. RRII actively participated in all the international programmes of the International Rubber Research and Development Board. It also maintained academic relations with the Kerala Agricultural University, Mahatma Gandhi University, Indian Institute of Technology, Kerala University, Cochin University of Science and Technology etc. A collaborative project on the biochemical aspects of Tapping Panel Dryness was initiated at the Indian Institute of Science, Bangalore.

A national symposium on New Trends in Crop Improvement of Perennial Species was organised during the year under review. Active involvement was also extended to the organisation of the Planters' Conference held at Kottayam.

Scientists and officers of RRII who are faculty members of the Department of Training, have engaged classes and also imparted practical training to the participants in various courses for planters, estate supervising personnel, product maunfacturers and technical/scientific staff of the Board.

The developments in the production and application of NR during the past decade have been very remarkable. With the objective of having a glimpse of the achievements, identifying lacunae and reviewing thrust areas the RRII, in association with other interested organisations, is convening an international natural rubber conference in February 1992 at Bangalore. Preliminary activities were in good progress during the period under review.

AGRONOMY AND SOILS DIVISION

The major areas of research in the Agronomy and Soils Division are investigations on nutritional requirements of high yielding clones of rubber at various stages of growth in different agroclimatic regions and agromanagement practices like irrigation, moisture management, intercropping, soil conservation and weed management. Work on the Diagnosis and Recommendation Integrated System (DRIS) as a tool for refining interpretation of foliar analytical values is in progress. Discriminatory fertilizer recommendations are being offered to rubber growers in different regions and five regional laboratories, the central laboratory at RRII and four mobile soil and tissue testing laboratories are being utilized for this purpose.

1. Nutritional studies (immature phase)

1.1. The three experiments being conducted in three agroclimatic regions were continued. Application of P at 30 kg P_2O_5 ha^{-1} significantly enhanced the girth increment for the period 1988-91 for clone RRII 105 planted in 1986 at Kanthimathy estate, Kanyakumari (Table Ag. 1). The higher level of P at 60 kg P_2O_5 ha^{-1} had a significant depressing effect. Application of K at 20 kg K_2O ha^{-1} level significantly increased the girth increment, but the 40 kg level had no beneficial effect.

Table-Ag. 1. **Mean girth increment 1988-91, Kanyakumari**

Levels of nutrients (kg ha^{-1}) and girth increment (cm)			
P_2O_5	cm	K_2O	cm
0	26.93	0	26.96
30	28.28	20	27.73
60	26.43	40	26.96
SE = 0.17		CD (5%) = 0.50	

In Shaliacary estate, Punalur with clone PB 235 planted in 1985 there was significant positive response to application of N at both 30 and 60 kg ha^{-1} levels in the case of girth increment for 1987-91 (Table Ag. 2).

Table-Ag. 2. **Mean girth increment 1987-91, Punalur**

Levels of nutrients (kg ha^{-1}) and girth increment (cm)					
N	cm	P_2O_5	cm	K_2O	cm
0	33.48	0	33.12	0	33.72
30	34.80	30	35.84	20	35.78
60	35.05	60	34.38	40	33.84
SE = 0.15		CD (5%) = 0.44			

Phosphorus application at both 30 and 60 kg P_2O_5 ha^{-1} significantly increased the girth increment, but the response at 60 kg was significantly inferior to that at 30 kg. In the case of K application, significant response was obtained only for the 20 kg K_2O ha^{-1} level of application.

1.2. Of the five field trials laid out in 1989 to assess the fertilizer need of clone RRII 105, those at Chemoney estate, Trichur and Kinalur estate, Calicut were discontinued due to insufficient plant population in the experimental area. The trials at Perunthalmanna estate, Malappuram, T. R. & T estate, Mundakayam and Kodumon estate, Punalur were in progress. No significant difference in girth among the fertilizer treatments was noticed during 1991 (18 months after planting).

1. 3. The experiments at Koney estate and RRII farm initiated in 1988 and 1989 respectively to find out the nutritional requirement of new RRII experimental clones were in progress. Analysis of girth data recorded from experiment at Koney estate during January 1991 revealed that the average effect of manuring was significant and positive (Table Ag. 3).

Table-Ag. 3. **Effect of fertilizers on girth, Koney estate**

NPK kg ha^{-1} yr^{-1}	Mean girth (cm)
25:25:10	20.01
50:50:20	19.72
75:75:30	20.22
No manure	19.06
SE = 0.26	CD (5%) = 0.76

Clonal differences in growth were also noticed (Table Ag. 4), with clones RRII 203 and RRIC 100 showing superiority to all others. But the clone x manure interaction was not significant, indicating that in the response to applied fertilizer, clonal differences are not manifested.

Table-Ag. 4. **Mean girth of clones, Koney estate**

Clones	Mean girth (cm)
RRII 5	19.57
RRII 105	18.13
RRII 203	24.31
RRII 208	19.85
RRII 300	18.20
RRII 308	17.38
PCK 1	17.22
PCK 2	19.80
PB 311	20.33
RRIC 100	22.71
Mean	19.75
SE = 1.04	CD (5%) = 3.33

In the experiment at RRII farm also in the case of girth, 1991 (Table Ag. 5), the interaction between clones and manurial treatments was not significant, indicating that there is no clonal difference in the response to the manurial treatment.

Table-Ag. 5. **Mean girth (cm) 1991, RRII**

NPKMg kg ha^{-1} yr^{-1} and number of splits	Clones RRII 5	RRII 118	PB 217	PB 260	Mean
40:40:16:6/ 2 splits	10.87	12.43	11.73	10.32	11.34
40:40:16:6/ 3 splits	11.04	12.03	11.60	11.31	11.50
60:60:24:9/ 2 splits	11.10	12.23	14.40	11.76	12.37
60:60:24:9/ 3 splits	10.68	13.60	10.80	13.36	12.11
Mean	10.92	12.57	12.13	11.69	11.83

SE for clones = 2.33 SE for manurial treatments = 1.08

2. Nutritional studies (mature phase)

2. 1. Clonal/regional requirements

2. 1. 1. In the experiment at Vadakkencherry (Vaniyampara estate) on clone RRII 105 during 1990 there was response in yield to application of N at both 20 and 40 kg ha^{-1} levels (Table Ag. 6). However, the higher level registered a significantly lower yield compared to the lower level of application. There was response to P application also and the difference between the 20 and 40 kg P_2O_5 ha^{-1} levels was not significant. In the case of K also similar trend was noticed. All the interactions viz., NP, NK, PK and NPK were also significant and the medium levels of N, P and K viz; 20 kg N, 20 kg P_2O_5 and 30 kg K_2O ha^{-1} registered the highest yield (Table Ag. 7).

Table-Ag. 6. **Mean yield (g tree^{-1} tap^{-1}) 1990, Vaniyampara**

Levels of nutrients (kg ha^{-1}) and mean yield					
N yield	Mean	P_2O_5 yield	Mean	K_2O yield	Mean
0	73.66	0	74.08	0	75.28
20	86.96	20	82.90	30	82.33
40	80.37	40	84.01	60	83.37
Mean	80.33		80.33		80.33

SE = 0.55 CD (5%) = 1.61

Table-Ag. 7. **Mean yield (g tree^{-1} tap^{-1}) 1990, Vaniyampara**

	No K_2O			30kg K_2O ha^{-1}			60kg K_2 ha^{-1}			
N kgha^{-1} P_2O_5	No P_2O_5ha^{-1}	20 kg P_2O_5ha^{-1}	40 kg P_2O_5	No P_2O_5ha^{-1}	20 kg P_2O_5ha^{-1}	40 kg P_2O_5	No P_2O_5ha^{-1}	20 kg P_2O_5ha^{-1}	40 kg	Mean
0	60.30	70.61	64.12	96.17	89.13	58.78	48.97	79.90	94.99	73.66
20	82.13	97.05	79.91	58.20	105.72	93.52	92.10	79.06	104.93	86.96
40	72.51	70.81	90.13	71.52	70.63	97.30	84.80	83.20	82.42	80.37
Mean	71.65	79.49	74.72	75.30	88.49	83.20	75.29	80.72	94.11	80.33

For comparison of means in the body of the table SE = 1.66, CD (5%) = 4.87.

In the case of girth during January, 1991 (Table Ag. 8) there was response to N at 20 kg ha^{-1}. Phosphorus application at 40 kg ha^{-1} level significantly increased the girth. There was no response to application of K in terms of girth.

Table-Ag. 8. **Mean girth (cm) January, 1991, Vaniyampara**

Kg N ha^{-1}	Mean girth	Kg P_2O_5 ha^{-1}	Mean girth
0	59.59	0	59.85
20	61.12	20	60.48
40	61.49	40	62.86
SE = 0.69		CD (5%) = 2.02	

The response in girth to N and P application could be a direct effect as there was also response in yield in a similar pattern (Table Ag. 6 and 8).

2. 1. 2. In the experiment at Kanyakumari (New Ambady estate) on clone PB 28/59 there was a positive response in yield to application of N at 40 kg ha^{-1} (Table Ag. 9). Application for P at both 20 and 40 kg ha^{-1} levels depressed the yield.

It was observed that the leaf P content even in the no P plots was sufficiently high. In the case of K, there was response only to the 60 kg K_2O ha^{-1} level. No response was noticed to any of the applied nutrients on girth (January, 1991) or girth increment during 1990-91.

2. 1. 3. There was progressive increase in yield with application of N at 20 and 40 kg ha^{-1} levels and K at 30 and 60 kg K_2O ha^{-1} levels (Table Ag. 10) in the experiment at Calicut (Kinalur estate) on clone RRII 105. There was no response to application of P. In the case of girth increment, during 1990-91 there was response to application of N at 40 kg ha^{-1} (Table Ag. 11). Application of P and K gave no response. The response in girth to N at 40 kg ha^{-1} appears to be a direct effect on growth since the yield also increased with the same level of N application (Table Ag. 10 and 11).

Table-Ag. 10. **Mean yield (g tree^{-1} tap^{-1}) 1990, Calicut**

Kg N ha^{-1}	Mean yield	Kg K_2O ha^{-1}	Mean yield
0	54.34	0	54.82
20	57.10	30	56.58
40	58.79	60	58.82
Mean	56.74		56.74
SE = 0.44		CD (5%) = 1.29	

Table-Ag. 11. **Mean girth increment (cm) 1990-91, Calicut**

Kg N ha^{-1}	Mean girth increment
0	0.99
20	1.12
40	1.41
Mean	1.71
SE = 0.11	CD (5%) = 0.32

Table Ag. 9. **Mean yield (g tree^{-1} tap^{-1}) 1990, Kanyakumari**

	Levels of nutrients (kg ha^{-1}) and mean yield				
N	Mean yield	P_2O_5	Mean yield	K_2O	Mean yield
0	66.90	0	71.26	0	67.87
20	67.71	20	69.12	30	67.94
40	72.39	40	66.63	60	71.19
Mean	69.00		69.00		69.00
	SE = 0.61			CD (5%) = 1.79	

2. 1. 4. In the experiment at Thodupuzha (Malankara estate) on clone RRII 105, there was no response in yield to application of N, P or K. However, the interactions NK and PK were significant. With 60 kg level of K_2O, N at 40 kg ha^{-1} significantly increased the yield over no N and 20 kg N ha^{-1}. In the abscence of N, application of K at 60 kg K_2O ha^{-1} significantly depressed yield below no K_2O and 30 kg K_2O ha^{-1} levels. Similarly in the abscence of K, application of P at 40 kg P_2O_5 ha^{-1} significantly depressed yield. Also, in the abscence of P, application of K at 60 kg K_2O ha^{-1} significantly reduced the yield.

2. 2. Multilocational trial on fertilizer use efficiency

This experiment was started in 1989 in seven locations and is being continued. The mean yield $tree^{-1}$ tap^{-1} for the two years 1989 and 1990 did not show significant difference among the treatments. While considering the cost of fertilizers, the use of urea, mussoorie rock phosphate and muriate of potash will be more economic for general recommendation. Discriminatory fertilizer recommendation can be still cheaper in individual cases.

3. Density of planting on growth and yield

The experiment started in 1985 at Shaliacary estate, Punalur is being continued. The mean values of girth recorded during January, 1991 are presented in Table-Ag. 12. The effects of density, manuring and their interactions were not significant. Thus, it is seen that even after six years of planting, density has no effect on the growth of rubber. Also, additional nutrient requirements with increasing density of population is not indicated.

4. Irrigation and moisture management

Two experiments to find out the effect of irrigation on the growth of young rubber, one lysimeter experiment to study the water requirement of immature rubber and one experiment on the soil and water conservation are in progress.

4. 1. Immature phase

4. 1. 1. Irrigation and split application of fertilizers

Irrigation and split application of fertilizers were given as per the schedule.

Table-Ag. 12. Mean girth of trees

Spacing (m)	Density plants ha^{-1}	Mean girth (cm) Levels of NPK Mg (kg ha^{-1}) 40:40:16:6	60:60:24:9	Mean
6.7 x 3.4	445	40.94	42.33	41.64
6.7 x 3.0	489	42.51	42.04	42.28
6.1 x 3.4	489	40.78	41.33	41.06
6.1 x 3.0	539	39.73	41.57	40.65
5.5 x 3.4	544	40.98	40.82	40.90
5.5 x 3.0	598	41.93	42.49	42.21
Mean		41.15	41.76	41.46

SE for density = 1.179 SE for manuring = 2.312

The girth recorded at the end of the summer season 1991 and girth increment (1988-1991) did not show any significant difference among the treatments. Due to scarcity of water, irrigation was not given during the summer season of 1989-90. This coupled with the frequent summer showers received in the experimental area during the dry season of 1991 might have contributed to this lack of response to various treatments.

4. 1. 2. Evaluation of micro and macro irrigation methods

The quantity of water applied through irrigation was observed to be 22.5 and 30 l tree^{-1} day^{-1} for drip irrigation and 157.5 and 210 l tree^{-1} week^{-1} for basin irrigation during the summer season of 1990-91. Girth recorded at the end of the summer season and girth increment (1987-1991) registered significant differences among treatments (Table Ag. 13).

Table-Ag. 13. Mean girth and girth increment (cm)

Treatment	Mean girth 1991	Girth increment 1987-91
Control	32.86	24.85
Drip-22.5 1 tree -1 day -1	37.52	28.54
Drip-30.0 1 tree -1 day -1	38.53	29.35
Basin-157.5 1 tree -1 week -1	35.47	27.33
Basin-210 1 tree -1 week -1	35.43	27.16
SE	0.59	0.54
CD (5%)	1.81	1.65

All the irrigated treatments were significantly superior to the unirrigated treatment irrespective of the method of irrigation, both in terms of girth and girth increment. Considering the girth, drip irrigation was significantly superior to basin irrigation. However, in terms of girth increment, drip irrigation at the higher level was significantly superior to the basin irrigation, and drip irigation at the lower level was on par with the basin irrigation.

4.2. Micro-irrigation at mature phase (Cheruvally)

The experiment at Cheruvally estate was discontinued due to non-availability of water for irrigation.

4.3. Water requirement of immature rubber (lysimeter technique)

Daily water balance studies were continued. Evapotranspiration was worked out for the year 1990. Crop coefficient values were computed using the emperical methods, Penman and Hargreaves methods and pan evaporation method. The mean evapo-transpiration during the summer period (December 1989 to April 1990) was 4.97 mm d^{-1}, and that during May to November 1990 was 2.99 mm d^{-1}. The mean crop coefficient values were 0.82, 0.77 and 0.93 for the Penman, Hargreaves and pan evaporation methods respectively.

4.4. Soil and water conservation

This experiment started in 1988 at RRII farm is being continued. All the treatments imposed were effective in conserving soil and soil moisture as reflected in the growth of plants and soil moisture content.

5. Weed Management systems

Attempts are being made for collection and mass multiplication of larvae of *Pareuchaetus pseudoinsulata* to follow up the work on biological control of the weed *Chromolaena odorata*.

6. Intercropping in rubber

6.1. Immature rubber (CES, Chethackal)

In this unreplicated trial it is observed that all the intercrops have inhibited the growth of rubber. In the coffee and cocoa intercropped plots, the shade tree

Acacia was also maintained to provide shade to the intercrops till early 1991, when they were cut and removed. Among the intercropped plots, growth of rubber was least affected in plots where black pepper alone was intercopped. The growth of cocoa was very poor while that of coffee and black pepper was satisfactory. Among the intercrops, only coffee has started yielding.

6.2. Immature rubber (Nelliyampathy)

The growth of rubber was not affected by the different intercrops at the two year stage.

6.3. Mature rubber (CES, Chethackal)

Coffee planted in mature rubber in 1987 has not affected the growth of rubber as seen from the girth increment of the trees during 1987-91.

7. Forms and methods of fertilizer application

7.1. Comparison of different nitrogenous fertilizers

7.1.1. The experiment to compare the efficiency of ammonium sulphate and urea on the growth of seedlings and on the sulphur status of soil is being continued during the sixth season at the Central Nursery, Karikattoor. Growth measurements and soil and leaf analytical values of fifth season are furnished (Table-Ag. 14.)

The results indicate that total as well as avialable sulphur of soil, diameter and height of seedlings were significantly higher in ammonium sulphate treated plots as compared to urea applied plots.

7.1.2. The glass house experiment to compare the relative efficiency of coated and uncoated nitrogenous fertilizers started in 1989. The plants were uprooted and dry matter determined. The total uptake of nitrogen was also estimated. The results were statistically analysed and given in the Table-Ag. 15.

Table - Ag. 15. Uptake of nitrogen under different treatments

Treatment	Uptake of N (g/plant)
Ureaform	4.07
Neem oil mixed urea	3.52
Coated urea	3.28
Neem cake mixed urea	2.99
Urea	2.69
Ammonium chloride	1.09
Control (without nitrogen)	1.30
CD (5%)	1.09

Table Ag. 14. Height, diameter, total and available sulphur and leaf sulphur content

Treatment (mm)	Diameter (cm)	Height S (ppm)	Total S (ppm)	Available S (%)	leaf
Ammonium sulphate	16.27	134.11	573.33	296.52	0.27
Urea	12.87	101.12	250.00	120.13	0.20
50% Ammonium sulphate + 50% Urea	13.02	104.83	458.33	205.55	0.26
50% Ammonium phosphate + 50% Urea	13.43	103.50	375.00	202.08	0.21
SE	0.35	3.81	34.29	15.60	—
CD (5%)	1.05	11..48	103.34	47.01	—

Uptake of Nitrogen was found to be significantly higher in urea form, neem oil mixed urea, coated urea, and neem mixed urea as compared to urea.

7.1.3. The field experiment started in 1989 is being continued and the growth measurements were taken periodically. Girth of plants taken 1.5 years after planting was analysed statistically and is presented in the Table-Ag. 16.

Ring application of urea form and urea was found to be superior to broadcast and pocket method of application in increasing the girth of plants. Compared to urea, ureaform is found to be significantly superior which might be due to the increased nitrogen use efficiency with the ureaform.

7.2. Evalutaion of phosphatic fertilizers

7.2.1. An experiment to evaluate the effect of two forms of phosphatic fertilizers (ammohos and rock phosphate) on the grwoth of rubber was started in 1985 in Boyce Estate, Mudakayam. Two doses of phosphorus, 40 and 50 kg ha^{-1}, were tried in two and three split applications. Girth increment during the period 1985-91 were analysed statistically and is given in Table. Ag-17

Significant positive response was obtained for Ammophos applied at 40 kg

Table-Ag. 16. Girth of plants 1.5 years after planting

Treatment	Girth (cm)
Ureaform ring	43.9
Ureaform broadcast	42.9
Ureaform pocket	40.7
Urea ring	40.0
Urea broadcast	37.7
Urea pocket	35.8
CD (5%)	1.13

Table - Ag. 17. Girth increment for the period 1985-91

Treatment	Girth increment (cm)
Rock phosphate @ 40 kg P_2O_5 ha^{-1} in 2 splits	40.46
Rock phosphate @ 40 kg P_2O_5 ha^{-1} in 3 splits	40.33
Ammophos @ 40 kg P_2O_5 ha^{-1} in 2 splits	41.70
Ammophos @ 40 kg P_2O_5 ha^{-1} in 3 splits	41.78
Rock phosphate @ 50 kg P_2O_5 ha^{-1} in 2 splits	40.63
Rock phosphate @ 50 kg P_2O_5 ha^{-1} in 3 splits	40.79
Ammophos @ 50 kg P_2O_5 ha^{-1} in 2 splits	41.44
Ammophos @ 50 kg P_2O_5 ha^{-1} in 3 splits	40.95
No phosphorus (control)	39.73
CD (5%)	1.16

and 50 kg ha^{-1} in two and three split doses as compared to control. No significant difference was obtained between the doses or between split applications. The same experiment is being repeated in two more locations during 1990.

7.2.2. The field study started in 1988, to evaluate the usefulness of bowl sludge, a waste product from latex centrifuging factories, as a source of phosphorus for rubber at T.R. & T. estate, Mundakayam, is being continued.

7.2.3. An incubation study was conducted to study the dissolution pattern of Mussoorie, Maton, partially acidulated Maton, Purulia, Udaipur, imported rockphosphate and superphosphate at 30 and 70 kg ha^{-1}. Available phosphorus status was estimated at 10, 20, 30, 40, 50 and 75 days. Availability of P increased from tenth day onwards and maximum availability of phosphorus was obtained at the fourtieth day and thereafter decreased at both the levels. The results obtained was statistically analysed and the results for the fortieth day of incubation is given in Table-Ag. 18.

Among the different indigeneous forms, Maton and Purulia was found to be inferior to imported rockphosphate.

Field studies with these phosphorus sources in immature rubber are being conducted at RRII Experiment Station and at Erumeli Estate.

7.3. Dynamics of K in rubber growing soils and other related studies.

A field experiment on RRIM 600 with seven graded levels of potassium and common dose of nitrogen and phosphorus with three replications was intitiated to study the influence of potassium on yield, latex flow and other related parameters. Initial soil and leaf nutrient status was assessed Before incorporation of treatments, pre-treatment yield, volume of latex and drc were recorded monthly for seven consecutive months.

Table - Ag. 18. Available phosphorus at fortieth day of incubation

Treatments		Available P (ppm)
Control	No phosphorus	Traces
Mussorie	- 30 kg P_2O_5 ha^{-1}	9.5
Mussorie	- 70 kg P_2O_5 ha^{-1}	11.0
Maton	- 30 kg P_2O_5 ha^{-1}	6.0
Maton	- 70 kg P_2O_5 ha^{-1}	6.5
PA Maton	- 30 kg P_2O_5 ha^{-1}	9.0
PA Maton	- 70 kg P_2O_5 ha^{-1}	9.0
Purulia	- 30 kg P_2O_5 ha^{-1}	5.0
Purulia	- 70 kg P_2O_5 ha^{-1}	9.6
Udaipur	- 30 kg P_2O_5 ha^{-1}	7.0
Udaipur	- 70 kg P_2O_5 ha^{-1}	9.0
Imported	- 30 kg P_2O_5 ha^{-1}	10.4
Imported	- 70 kg P_2O_5 ha^{-1}	18.6
Superphos	- 30 kg P_2O_5 ha^{-1}	6.5
Superphos	- 70 kg P_2O_5 ha^{-1}	9.5
	Mean	8.07
	CD (5%)	4.25

8. Physical, chemical and mineralogical characteristics of rubber growing soils.

Soil analytical data on organic carbon, available phosphorus and potassium from all the five taluks of Kottayam district viz., Changanacherry, Vaikom, Kottayam, Meenachil and Kanjirappally were compiled. Nutrient indices were worked out and is furnished in Table-Ag. 19.

As per the nutrient indices worked out, all the five taluks are found to be medium in organic carbon and available magnesium. Available phosphorus was found to be medium in Vaikom, Kottayam and Changancherry taluks. Meenachil and Kanjirappally taluks were found to be low in available phosphours. Available K status was found to be low in all the locations studied.

Table Ag. 19. Nutrient index for five taluks of Kottayam district

Taluk	No. of samples	Nutrient index			
		Organic carbon	P	K	Mg
Vaikom	307	2.03 (M)	1.69 (M)	1.34 (L)	2.31 (M)
Kottayam	667	2.37 (M)	1.57 (M)	1.38 (L)	2.12 (M)
Meenachil	882	2.40 (M)	1.43 (L)	1.50 (L)	2.08 (M)
Kanjirappally	1198	2.47 (M)	1.46 (L)	1.43 (L)	1.97 (M)
Changanacherry	378	2.27 (M)	1.84 (M)	1.34 (L)	1.88 (M)

9. Standardisation of analytical methods

9.1. Seasonal variation in leaf nutrient status of *Hevea*.

Leaf samples were collected every month from 30 trees during the period April 1990 to January 1991 and analysed for N, P, K, Ca and Mg. The experiment is being repeated for one more year in two locations.

9.2. Refinement of petiole analysis followed in mobile laboratory.

Continued the effort to obtain uniform cuttings of petiole samples. Nine samples were analysed in trplicates for phosphorus and potassium. The petioles were cut through a rubber band cutting machine. Concurrent values were obtained in almost all cases.

10. DRIS approach for interpretation of foliar analysis

The project on Diagnosis and Recommendation Integrated System (DRIS) initiated to formulate optimum nutrient ratios in *Hevea brasiliensis* is being continued. The leaf nutrient values and yield data collected from 900 fields were separated into low and high yield groups. A FORTRAN computer programme for working out the DRIS norms was developed. General DRIS norms for the nutrients N, P and K were formulated.

In the Table-Ag. 20 the mean, CV (%) and variance ratio between the low and high yield groups is given. From the ratios or product form of expression for each pair of nutrients, the forms with the highest variance ratio is selected as the DRIS norm.

11. Collaborative studies

In the multidisciplinary project on tapping panel dryness a survey was conducted in estates and small holdings of Calicut, Kottayam and Trivandrum regions. Considerable variation in tapping panl dryness is observed for the same clone in different fields of the same estate.

12. Advisory work

The division has analysed 9020 soil and 1895 leaf samples for advisory purpose and discriminatory fertilizer recommendations were offered to estates and small holdings based on the analytical results.

Table-Ag. 20. Mean, coefficient of variation and variance ratio of the high yield group

Form of expression	Mean	CV (%)	Variance ratio
N	3.5724	6.3	2.4590
P	0.2629	15.9	1.2353
K	1.3589	19.1	1.0000
N/P	13.8762	14.3	1.5423
N/K	2.7300	20.9	0.9466
P/K	0.1993	21.7	0.7895
P/N	0.0738	17.1	1.0000
K/N	0.3824	20.9	0.9688
K/P	5.2585	22.2	0.9650
N.P	0.9398	17.1	1.6148 *
N.K	4.8476	19.4	1.1220 *
P.K	0.3594	27.8	1.1600 *

*Norms for N P and K

BIOTECHNOLOGY DIVISION

The following thrust areas were actively pursued in the Biotechnology Division.

1. Shoot tip/meristem cultures

During the last planting season also another batch of about 500 tissue culture derived plants were planted in the field along with the control plants, as per statistical designs. Simultaneously, media refinements/modifications were made to facilitate the conversion of this experimental *in vitro* propagation system into a commercial propagation system.

2. Somatic embryogenesis

A system has been developed by which plants were regenerated by somatic embryogenesis. Callus tissue initiated from the integumental tissue of the immature fruits was the source of plant regeneration. Plants produced by this process were planted in polybags awaiting field planting.

3. Protoplast culture for plant regeneration

Trials were made to identify the most suitable explant source for this objective. Lamina tissue was observed as the ideal source for abundant protoplast harvest and favourable initial culture response to manipulation. Sporadic micro-calli formation was observed.

4. Anther culture

This is another area which has been very successfull, as in previous years. Cultures were prepared using several commercial cultivars of prominence. It has been observed that pretreatment of explants was not a pre-requisite for plant regeneration in several clones.

5. Enzymology

Biochemical characterization of several enzymes in the tissue culture plants vs bud grafted plants was made. This study would be completed during 1991-92.

BOTANY DIVISION

The Botany Division comprises four sections, Plant Breeding, Propagation, Anatomy and Cytogenetics which continued to concentrate on their respective thrust areas of research activity. The major areas of investigations are genetic improvement through conventional hybridization and ortet selection, clone evaluation, early evaluation, bark and wood anatomy, cytogenetics, propagation and planting techniques.

1. Evolving high yielding clones for traditional area

1.1. Hybridization and selection

Monthly yield recordings in small scale trials of progenies resultant of 1979 and 1980 hybridization programme, laid out during 1982 and 1983 respectively were continued. Sixty three hybrid clones of the 1982 HP series were subjected to test tapping at the age of $4^1/_2$ years after field planting and monthly yield was recorded. Secondary characters were recorded at half yearly intervals. Sixty eight per cent of the clones exhibited significant positive correlation between yield and girth. Correlation coefficients of the juvenile characters with immature characters of the 63 hybrid progenies are furnished in Table Bot. 1.

Table - Bot. 1. Simple correlation coefficients between yield and girth in the juvenile and immature phases

	Yield in the imma-	Girth in the immature ture phase	Juvenile girth phase
Juvenile yield	0.345**	—	0.488**
Juvenile girth	—	0.358**	—
Yield in the immature phase	—	0.290**	—

Based on the premature yield for one year, 15 clones, which showed better performance over RRII 105 were selected for laying out a large scale trial during 1991 planting season.

Casualties were supplied in the small scale trials comprising 184 clones and 45 parents laid out during 1989 at Central Experiment Station, Chethackal. Another 148 clones from selected seedlings of 1986 HP and 19 parent clones were established in eight small scale trials employing simple lattice design in five and RBD in three replications during 1990 at Central Experiment Station, Chethackal. Progenies of 1988 and 1989 hybridization programme are under nursery evaluation for juvenile yield and girth. A total of 262 seedlings resultant of of 1990 HP involving RRII 105, RRIM 600 and GT 1 as female parents and selected clones from the 1981 Brazilian germplasm collection were established in a seedling nursery.

1. 2. Ortet selection

Ortet selection programme was continued. Girth measurements three years after field planting from three small scale trials involving 61 ortet clones in Cheruvally estate revealed a girth above 19 cm in 20 clones in comparison to 14.1 cm, 16.9 cm and 17.9 cm for RRII 105, RRIM 600 and GT 1 respectively. Casualties were supplied in the two field trials at Mundakayam estate involving 46 ortet selections. Budwood was gathered from fifty selected mother trees from Koney estate and these genotypes were established in a source bush nursery. They were further multiplied for laying out a small scale trial during 1991 planting season. Similarly, 50

mother trees from Kodumon estate were finally selected based on mean yield over four different seasons and secondary characters. These selections were established in a source bush nursery. A total of 10 ortet clones from small hodlings have also been raised for laying out a small scale trial.

1. 3. **Special techniques in breeding**

Annual girth measurement, recording of yield and secondary characters were done in all field trials. Based on yield and other secondary characters ten clones were selected from 1977 clone trial (irradiated material). These selections were multiplied for further evaluation. Yield of these selections is being recorded on all tapping days. Monthly recordings of volume yield, plugging index, rate of flow, DRC etc., are being carried out. The selected seedlings from the progenies of male sterile clones and ten genotypes from mutagen treated population were multiplied for further evaluation.

2. Evaluation of clones

2. 1. **Large scale trials**

Various field experiments under the clone evaluation programme were continued. Regular monthly yield recording and annual recording of girth and secondary characters were carried out in all mature large scale trials. Among the 12 clones from a clone trial laid out in 1965, RRII 5 and PB 217 recorded the highest mean yield of 76.42 and 65.99 $g^{tree\text{-}tap}$ over 16 years in comparison to 48.03 g for the control, Tjir 1.

The eight clones included in the 1966 clone trial were in the 18th year of tapping. Long term performance of these clones was assessed and the clones RRII 109 and RRII 105 recorded the highest mean yield of 53.83 and 53.34 $g^{tree\text{-}tap}$ respectively, whereas the control Tjir 1 recorded only 30.98 $g^{tree\text{-}tap}$.

Table - Bot. 2. **Mean yield over 16 years of 12 clones**

Clone	Mean yield over 16 years $g^{tree\text{-}tap}$	Yield during summer (%)
Tjir 1	48.03	70.42
RRII 5	76.42	69.01
RRII 104	57.63	74.50
RRII 116	60.52	80.25
RRIM 513	38.42	73.39
RRIM 519	51.18	76.06
RRIM 600	52.59	77.11
RRIM 628	43.03	68.20
PB 206	46.58	79.59
PB 213	62.16	75.92
PB 217	65.99	81.70
PB 5/76	58.42	76.40
General mean	55.08	75.21
S. E.	4.37	2.68
C. D.	12.85	7.88
C. D.*	14.52	8.90

* For comparing RRIM 513 with other clones

In the 1968 space-cum-clone trial, RRII 105 continued to be the highest yielder and recorded 72.58 g in comparison to 45.30 $g^{tree\text{-}tap}$ for the control Tjir 1 during the 14th year of tapping. In the 1971 foreign clone trial with 10 clones, Harbel 1 recorded the highest yield during the 10th year of tapping. In the 1973 clone trial, RRII 208, RRII 202 and RRII 203 were the top yielders with 86.77, 84.48 and 79.86 $g^{tree\text{-}tap}$ respectively (Table-Bot. 3) during the sixth year of tapping.

All the selections except RRII 205 and RRII 207 recorded significantly better yield than the control. Among 10 Sri Lanka clones planted in 1976, RRIC 104 recorded the highest yield of 49.66 g in comparison

Table - Bot. 3. **Mean Annual yield on sixth year of tapping**

Clone	Parentage			Mean yield years $g^{tree\ tap}$
RRII 201	Tjir	x	PB 25	71.70
RRII 202	PB 86	x	Mil 3/2	84.48
RRII 203	PB 86	x	Mil 3/2	79.86
RRII 204	PB 86	x	Mil 3/2	78.17
RRII 205	PB 86	x	BD 10	56.13
RRII 206	Mil 3/2	x	AVROS 255	72.02
RRII 207	Mil 3/2	x	AVROS 255	55.91
RRII 208	Mil 3/2	x	AVROS 255	86.77
RRII 209	Mil 3/2	x	AVROS 255	70.26
PR 107	Control			46.51
General mean				70.18
S. E.				5.06
C. D.				15.03

to 44.98 $g^{tree\text{-}tap}$ for GT 1 during the 7th year of tapping. In the 1978 clone trial, three clones recorded higher yield over the control GT 1 during the fifth year of tapping, among 11 clones evaluated. Among seven clones in the 1979 clone trial, RRII 105 recorded the highest yield followed by RRII 300. In the 1981 mixed clone trial of 10 clones, PCK 1 recorded a mean yield of 43.29 g. in comparison to 41.68 g and 40.97 $g^{tree\text{-}tap}$ for RRII 105 and GT 1 respectively during the first year of tapping.

Casualties were supplied in the two large scale trials of modern clones comprising nine and eight clones each at Central Experiment Station, Chethackal. PB 312 and SCATC 93-114 recorded highest girth at an age of one year in trial I and trial II respectively. In another large scale trial of 14 clones at HBSS, Nettana, RRII 203 recorded the highest girth at an age of one year. In the two multidisciplinary trials of modern clones at RRII, laid out during 1989, casualties were supplied and juvenile growth characters were recorded during four different seasons. Among the 13 clones in trial I, PB 314 recorded more girth and height at an age of one year. In trial II, among the 13 clones, RRII 118 recorded the highest girth and RRIM 600, the maximum height at an age of one year.

2. 2. On-farm evaluation

Recording of yield and/or girth and secondary characters was continued from the 23 block trials, nine mature and 14 immature as well as three observational trials. RRII 105 continued to be the highest yielder in all mature block trials. Of the three clones planted in Vakayar, PB 235 recorded the highest girth of 52.02 cm. at the 7th year of planting, followed by PB 311 (48.58 cm) and RRII 300)45.56 cm). Among the 12 clones planted at Chithelvetty estate, Punalur PB 260 continued to be the most vigorous clone with a girth of 42.87 cm in comparison to 36.11 cm. for RRII 105 during the sixth year of planting. Of the seven clones at Manikkal estate, Mundakayam, PB 310 recorded the highest girth of 27.93 cm. in comparison to 24.22 cm for RRII 105 four years after field planting. At Mannarghat estate, Palghat, among the six clones PCK 1 recorded a maximum girth of 28.92 cm in comparison to 23.1 cm for RRII 105, four years after planting. Studies on intraclonal variability were completed. Volume yield and DRC were recorded at monthly intervals from 50 trees each of four selected clones. Dry rubber yield data were recorded on all tapping days. Observations on girth and bark thickness were also recorded.

Nine modern clones of *Hevea brasiliensis* were morphologically characterized at the age of 14 months. Seeds were

collected from mature clones and seed morphology was also studied to identify the clones. Mean and C. D. of certain morphological traits and seed characters are given in Tables-Bot 4 and 5 respectively. The results indicate that the nine clones differed significantly for petiole length, petiolule length and leaf area. The morphology of seeds of different clones also showed variations.

5. Estimation of genetic parameters in *Hevea*

Genetic parameters like genotypic and phenotypic coefficients of variations and heritability were estimated for test incision yield and juvenile girth from the 1987 trial on estimation of genetic parameters in the juvenile phase.

Table - Bot. 4. **Morphological traits of nine moden clones**

Clone	Petiole Length (cm)	Petiolule Length (cm)	Angle of petiolule (o)	Leaflet Area (cm^2)
RRII 5	24.70	2.42	20.50	485.21
RRII 105	20.40	1.21	19.80	341.19
RRII 118	22.02	1.01	18.41	353.29
RRII 203	23.70	1.07	21.72	371.14
RRII 208	19.64	0.63	17.19	216.56
RRII 300	17.72	1.54	20.70	313.41
RRII 308	16.90	0.51	16.68	304.78
RRIM 600	21.56	1.06	17.21	214.20
RRIM 703	22.06	1.12	18.00	299.08
C. D.	4.258	1.19	N. S.	90.197

Table - Bot. 5. **Seed size of nine modern clones**

Clone	Mean length (cm)	Mean width (cm)	Mean thickness (cm)	Volume (cm^3)
RRII 5	2.77 ± 0.071	2.19 ± 0.054	2.15 ± 0.040	8.00 ± 0.632
RRII 105	2.73 ± 0.042	2.12 ± 0.029	1.95 ± 0.022	5.70 ± 0.153
RRII 118	2.31 ± 0.087	2.05 ± 0.224	1.88 ± 0.034	4.17 ± 0.307
RRII 203	2.48 ± 0.017	2.10 ± 0.036	1.79 ± 0.027	5.16 ± 0.0166
RRII 108	2.26 ± 0.034	1.92 ± 0.025	2.0 ± 0.013	5.75 ± 0.250
RRII 300	2.76 ± 0.037	2.27 ± 0.037	2.02 ± 0.019	6.20 ± 0.199
RRII 308	± 2.81 ± 0.046	2.14 ± 0.030	1.96 ± 0.037	7.81 ± 0.133
RRIM 600	2.60 ± 0.021	2.32 ± 0.025	1.66 ± 0.022	5.52 ± 0.167
RRIM 703	2.47 ± 0.029	2.10 ± 0.020	1.87 ± 0.030	5.28 ± 0.096

Table - Bot. 6. **Range, mean and genetic parameters for test incision yield and girth at 18 months**

	Range	Mean	CV (%)	GCV (%)	PCV (%)	h^2 (%)
Test incision Yield	0.11-0.36 gm	0.23±0.01	53.96	22.17	50.70	19
Girth	8.01-15.08 cm	11.43±0.29	25.82	15.35	25.12	37

The GCV as well as heritability for yield and girth shown in the above table is medium to low which implies that response to selection will be limited in this population at this age. In order to assess the genetic parameters in the mature phase a trial was laid out at H. B. S. S., Nettana during 1990 planting season with open pollinated progenies of 12 clones and their parents.

6. Cytogenetical investigations

The growth attributes and floral characteristics of the spontaneous and synthesized triploid were studied. The chlorophyll content of both the triploids was estimated by acetone method. The growth attributes are given in Table-Bot. 7. Significant variations were observed for all the characters except length of male flower and foliar index. The spontaneous triploid exhibited more vigour. Behaviour of chromosomes during meiosis was also studied and the chromosome association is depicted in Table Bot. 8. Significant variation was noticed with respect to number univalents and trivalents.

7. Floral biology and fruit set

Five female parents were crossed in different combinations involving 15 male parents and fruit set was recorded. The observation revealed wide variation in fruit set among the crosses. RRIM 600 was found to be a favourable female parent, having produced high rates of fruit set success when crossed with eight different male parents. Fruit set in crosses involving RRII 105 as the female parent was also reasonably high and comparable with RRIM 600. The influence of the female parent on fruit set is evident from the Table-Bot. 9.

Table - Bot. 7. **Growth attributes of synthesized and spontaneous triploids**

Parameter	Synthesized	Spontaneous	't' value for comparison of means
Plant height (cm)	169.80±2.230	216.80±7.330**	8.54
Stem diameter (mm)	15.68±0.290	20.83±0.329**	14.47
Number of flushes	4.73±0.066	6.20±0.200*	9.53
Number of leaves per flush	11.20±0.306	16.40±0.305**	14.74
Female flower length (mm)	1.02±0.145	11.99±0.067**	20.63
Female flower size (mm^2)	33.59±0.200	70.70±0.990**	45.89
Male flower length (mm)	7.80±0.05	7.81±0.06	0.,19
Male flower size (mm^2)	22.930.400	30.11±0.480**	14.25
Total chlorophyll (mg/g fresh wt of leaf)	3.39±0.275	4.07±0.470**	1.58
Leaf area (mm^2)	75.33±0.605	86.77±0.870**	12.91
Stem index	0.0654±0.00034	0.0703±0.00035**	12.37
Petiolar index	0.0168±0.00026	0.0181±0.00021**	4.82
Foliar index	0.0056±0.00004	0.0068±0.00006**	20.70

*Significant at P<0.05 **Significant at P<0.01

Table - Bot. 8. **Chromosome association in synthesized and spontaneous triploids**

Chromosome association	Synthesized	Spontaneous	't' value
Trivalent	11.06 ± 0.236	12.44 ± 0.245**	4.05
Bivalent	6.11 ± 0.205	5.76 ± 0.226	1.14
Univalent	8.72 ± 0.415	6.22 ± 0.297**	4.90

**Significant at P<0.01

8. Anatomical (general) investigations

Data collected on stomatal characters of drought tolerant and susceptible clones at the juvenile age were summarised. Small stomatal aperture was observed as a character of drought tolerant clones.

Studies on the interclonal variability of leaf anatomical traits were continued. Paraffin block preparations of leaf were sectioned, processed and data collected. The data are being summarised.

9. Bark anatomical investigations:

Investigations on bark anatomical characters and their practical implication were continued. Bark study of 11 clones at the fourth year of planting was done and data collected for estimating the correlations of bark anatomical characters at that age with those traits at mature age.

Table - Bot. 9. **Influence of female parent on fruit set success.**

Female parent	No. of pollinations	Fruit set	
		Total no.	%
RRII 105	2580	97	3.76
RRII 118	665	1	0.15*
RRIM 600	2857	124	4.34
IAN 873	3312	49	1.48*
PCK 1	1523	41	2.69*

* Chi- square value for comparison with RRIM 600 significant at P<0.05

For comparing anatomical characters of the virgin and renewed bark, the data collected earlier were processed. On quantitative basis, virgin and renewed bark differ significantly for certain characters. Reduced quantity of laticiferous tissue and highly zigzag orientation of laticifers were observed for the renewed bark.

10. Wood anatomy

Studies on the wood quality of stimulated rubber wood are under progress. Ethrel applications were continued.

11. Propagation techniques

Budding trial being carried out at Tripura to find out the optimum time for budding in the northeastern region was completed and the data are being summarised.

Girth and other secondary characters of the plants in the field trial of benchgrafted plants were recorded. Girth data were summarised and ground budded plants of RRII 118 recorded the maximum girth at the age of three years. Girth and other secondary characters of the plants during the 4th year in the study on depth of planting were recorded. Girth data were summarised. As in the previous years the control exhibited maximum vigour.

A field trial was laid out on deep planting of bag plants at Central Experiment Station, with bud union buried upto 5 cm, bud union buried upto 10 cm, bud union buried upto 15 cm and normal planting as the treatments. The design adopted was R. B. D. with 5 replications. For the study on comparison of polybags, samples of bags were collected after keeping them in the nursery for one year to assess their degradation due to weathering.

12. Genetic basis of stock-scion relationship

Annual recording of girth and secondary characters was carried out in the trial with 14 different stock-scion combinations, laid out during 1984. Among the different stock-scion combinations, RRII 203 budgrafted on clonal root stock of RRII 203 as well as on assorted stock recorded the highest girth (39.67 cm and 39.16 cm respectively) at the age of six years. At the Central Experiment Station, Chethackal a new trial was laid out incorporating nine different treatments, in a randomized block design with three replications. A polybag nursery was established for the supply of casualties during the 1991 season.

13. Horticultural manipulations

Proper maintenance of the plants in the trial on crown budding of polybag plants is being done and their growth is being observed. Seedlings required for the comparative study of twin stocks and single stocks were raised in polybags and in the ground nursery. Twin grafting was done wherever necessary. Green budding of single stocks and twin stocks was also carried out.

14. Early evaluation

Data on juvenile yield of 13 selected clones at an age of three years revealed RRII 6, RRII 118, RRII 105, RRIM 600, PB 311 and GT 1 to record higher juvenile yield than the general mean (Table Bot. 10). All these clones except RRII 118, are high yielders in the mature phase also. RRII 38 recorded the lowest yield followed by HP 20, both low yielders in the mature phase.

15. Studies on inbreeding

Seedlings raised from selfed and monoclonal seeds and those resultant of open pollination belonging to four clones were maintained in the nursery and subjected to recording of test-tap yield ($^1/_2$ S d/$_2$ system for 10 days), height and number of flushes at the age of 2 years. Inbreeding depression, expressed as per cent decrease/increase in the mean value over the open pollinated progenies was observed in almost all the characters both in selfed and monoclonal seedlings. Clonal difference was also noticed. Monoclonal and selfed seedlings of clone Tjir 1 exhibited less inbreeding depression.

16. Genetic divergence, prepotency and inbreeding depression

Observations on wintering and flowering attributes were recorded from 42 clones included in the study on genetic divergence and are being summarised.

Assessment of prepotency of twenty promising clones through seedling prog-

Table - Bot. 10. Mean yield of clones

Clones	Mean yield	S.E.
RRII 6	3.91	.26
RRII 118	3.57	.27
RRII 105	3.09	.26
RRIM 600	2.84	.28
PB 311	2.80	.26
GT 1	2.63	.28
RRII 300	2.48	.27
Tjir 1	2.44	.30
RRII 208	2.35	.29
RRIM 612	1.80	.28
RRIM 501	1.79	.29
HP 20	1.32	.29
RRII 38	.89	.28
General Mean	2.49	

eny analysis was attempted. Progenies differed significantly with respect to foliar traits and juvenile yield on test incision at the age of one year. The mean performance of superior progenies with respect to juvenile yield revealed AVT 73 to be the best with 45% of the seedlings being high yielders. Progeny of RRII 105 also displayed high mean juvenile yield with 37% of the seedlings showing high yield. Associations among the juvenile traits studied and data (Table-Bot. 11) indicated highly significant positive correlation of juvenile yield with girth, number of flushes and number of leaves. For the study on inbreeding depression, selfed and open pollinated progenies of the clones assessed for prepotency were raised in a nursery.

Table - Bot. 11. **Associations among juvenile traits and yield**

	Height	Girth	Flushes produced	Flushes retained	No. of leaves
Girth	0.8102**	—	—	—	—
Flushes produced	0.4525**	0.3804**	—	—	—
Flushes retained	0.5129**	0.4833**	0.6064**	—	—
No. of leaves	0.6374**	0.4761**	0.3234**	0.5836**	—
Juvenile yield	0.5562**	0.6289**	0.0913	0.2641*	0.4661**

* Significant at P = 0.05 ** Siginficant at P = 0.01

GERMPLASM DIVISION

The Germplasm Division concentrated its research activities 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

The collection of older and elite cultivars of indigenous and exotic origin, being conserved *in situ*, were properly maintained and their evaluation is being continued.

A schedule for the bilateral exchange of clones with IRCA was prepared and preliminary steps were initiated to procure import/export permits.

1.2 Wild germplasm from IRRDB explorations

Maintenance of the genotypes introduced and further introduction of Brazilian germplasm were continued. Out of the 800 genotypes introduced from the Malaysian IRRDB germplasm centre in 1989-90, only 591 survived (Table - Gplm 1). The budgrafts of these genotypes were raised in polybags and subsequently transplanted in source bush nursery.

2. Evaluation of germplasm

2. 1. *In situ* conservation gardens

Field evaluation of Wickham materials from secondary diversity centres was continued. Girth and yield data of clones conserved in the germplasm gardens were collected. In addition observations on wintering, flowering and floral morphology of certain genotypes were also being recorded. A large number of trees were severely damaged by wind. The stumps of the affected trees were pollarded and the sprouts are retained. In the first germplasm garden among the 51 clones, PB 215, PB 235 and PB 28/83 recorded a higher average yield than RRII 105. A high rate of brown bast incidence was noted in RRIM 703, a component clone in the second garden.

The germplasm gardens are being utilized by other research divisions for various experiments.

Table - Gplm. 1. 1989 - 90 Introduction

Provenance	No. introduced	No. survived
Acre	445	309
Rondonia	250	192
Mato Grosso	100	86
Mixed seedlings	5	4
Total	800	591

2. 2. Nursery evaluation, juvenile characterisation and cataloguing

Juvenile characterisation and preliminary evaluation of 200 genotypes belonging to different groups were carried out. Data on girth, bark thickness, total height, height of first branching, leaf area, etc., were collected. Data on test tapping yield was also collected. The results are being statistically analysed. Bark samples of the selected genotypes were collected for anatomical studies.

2. 3. Field evaluation of Brazilian germplasm

Cultural operations were carried out in the evaluation trial laid out in 1990. About 60% of the plants sprouted and notching was given to the stumps where buds still remained in the dormant stage. Preparation of planting materials for gap filling was also carried out.

Table - Gplm. 2. 1990 - 91 Introduction

Provenance	No. introduced	No. survived
Acre	137	101
Rondonia	95	68
Mato Grosso	35	27
Ortets	15	10
Total	282	206

MYCOLOGY AND PLANT PATHOLOGY DIVISION

Crop protection is the main activity of this Division carried out by Plant Pathology, Mycology and Entomology sections. Microbiology section is engaged in improving soil fertility and reducing pollution from rubber processing factories using microbes.

1. Abnormal leaf-fall disease

This disease, caused by *Phytophthora* spp., has been causing serious damage to the health of rubber plants in the traditional rubber growing areas of Kerala and Karnataka. For the past three years, the disease has appeared in a severe form in Kanyakumari District of Tamil Nadu also, warranting prophylactic control measures.

1. 1. Clone-wise and region-wise spraying trials

Experiments were conducted in the low rainfall area in Punalur and high rainfall area in Trichur on the clone RRII 105. Four dosages of copper were tested from 2 kg to 10 kg of copper oxychloride (COC) 56% oil dispersible powder (ODP) per hectare. Lower dosage were tested at Punalur. Absolutely no difference in leaf retention was found, in low rainfall area, between protected plots and control. In high rainfall area, significant difference was noticed within treatments and also between treatments and control. Ten kg COC per hectare was found to be essential to get satisfactory leaf retention. (Table - Path 1).

1. 2. Testing of new formulations of fungicide and spray oil

One sample each of COC 56% ODP formulated by three manufacturers and two samples of 'Dithane' M-45 ODP were subjected to preliminary screening. These products were found to be suitable for large scale testing. One COC sample was subjected to largescale testing but was found to be unsatisfactory. A new spray-oil sample supplied by Indian Oil Corporation was found to retain more copper in small scale trials but in large scale field testing the leaf retention was found to be on par with that of the normal spray oil.

Table - Path. 1. **Leaf retention in clone RRII 105 in high rainfall area (Chemoni Estate)**

Treatments	Leaf retention (%)
COC 56% 4 kg/ha	42 (40.41) b
„ 6 kg/ha	57 (49.03) b
„ 8 kg/ha	51 (45.05) b
„ 10 kg/ha	77 (61.89) a
Control (unsprayed)	19 (24.79) c

P = 0.05 S. E 5.07 C. D. 11.5

Figures in the brackets are arc sine transformed values

1. 3. Spray volume trials under aerial spraying

No apparent difference was found in leaf retention, between the spray volume recommended by RRII and those used by some private estates.

1. 4. Survey of leaf-fall in the clone RRII 105 due to abnormal leaf fall disease

A survey was conducted in ten regions of the rubber growing area of Kerala. Out of the 119 holdings surveyed, leaf fall above 50 per cent was recorded in 12 holdings and in another 12 holdings leaf-fall above 25 per cent was observed. The survey will be repeated next year also.

2. High volume spraying

High volume spraying is done in nearly 65,000 ha, mostly small holdings. Reduction in the cost of spraying and improving its efficacy forms the objective of the experiments in high volume sparying.

The experiment conducted at Chemoni estate, Trichur on the spray fluid requirement in the tolerant clone RRII 105 indicate that a minimum spray volume of 30001 per hectare only can provide satisfactory leaf retention in this region. (Table - Path 2).

Table - Path. 2. **Spray volume and leaf retention**

Treatments	Leaf retention (%)
Control (unsprayed)	13.0
1% Bordeaux mixture 1000 1/ha	29.0
„ 2000 1/ha	50.0
„ 3000 1/ha	71.0
t test (P = 0.05)	Significant

The HDP motorised high volume sprayer, when field tested by spraying 1% Bordeaux mixture indicated that it is only as efficient as that of the rocker sprayer in protection. But the area covered per day could be almost three times that by the rocker sprayer.

3. Evaluation of panel protectants and wound dressing compounds

Bark rot disease is not very serious in India except in some regions. Protection of tapping panel with wound dressing compounds ensures faster bark regeneration and protection from pathogen which infect through the wounds in tapping panel. The effect of application of petroleum wound dressing compounds on renewed bark region was evaluated for the products sopkot and furnace-oil, in clones RRIM 600 and PB 217. In RRIM 600, better bark regeneration was obtained with sopkot compared to that with furnace oil. But in clone PB 217 no difference was noticed. The experiment is being repeated.

Three new wound dressing compounds were field tested.

4. Crown budding for disease resistance

Crown budding is a good technique to resist the attack of disease occurring on leaves and twigs. High yielding trunk clones can be crown budded with a resistant crown. Eventhough some difficulties are encountered, this technique has to be exploited for control of major diseases.

The third year girth of PB 311 - crown budded plants showed considerable reduction compared to control. In order to overcome the reduction in girth and canopy size, an extra doze of fertilizer application was done.

5. Pink disease

Pink disease is the most important stem disease or rubber during its growth period from third to twelth year. The disease is widespread in high rainfall areas and in certain clones like RRII 105 and PB 217.

Two field experiments were conducted to evaluate the efficacy of prophylactic spraying of Calixin 0.1%, Thiride 0.2%, Cobox L-1% and Bordeaux mixture 1%.

With either of the stickers, Triton AE or Fevicol DDL, in clones PB 217 and PB 311. Two rounds of spraying were given. The results indicate that there is marginal reduction in disease incidence under certain treatments. But it does not compensate for the additional cost involved.

A survey was conducted to assess the damage due to pink disease in clone RRII 105 in fifty five small holdings. The details of the data obtained are furnished in Table - Path. 3.

Table - Path. 3. Incidence of pink disease on RRII 105 in small hodlings

Age (years)	No. of trees examined	% diseased trees	Percent trees completely lost
2	3,540	18.49	1.62
3	1,990	27.47	0.56
4	3,465	12.87	0.12
5	1,665	9.91	0.60
6	2,630	5.21	0.15
7	9,618	6.13	0.64

The data indicate that maximum incidence of the disease occurs in the third year and it is not alarming.

6. Powdery mildew disease

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

In a field trial conducted in immature area, it was found that four rounds of spray application of Carbendazim 0.025% applied as a mixture with wettable sulphur 0.1% was equally effective as that of four rounds of systemic fungicides like Carbendazim 0.05%. The results of the experiments are furnished in Table - Path. 4.

7. High pressure injection for disease control

High pressure injection of fungicides, insecticides and chemicals is being tried for the control of diseases and rubber wood preservation. Planks of the small tree injected with copper sulphate remained considerably free from fungal and insect attck even after three years. In 30 years old tree the effect lasted for eighteen months. The treated wood is under evaluation.

8. Minor leaf spot disease

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

The field trial carried out at Manikal estate, Mundakayam, against *Gloeosporim* leaf spot disease confirmed the effectiveness of 'Dithane' M-45. The results are furnished in Table - Path. 5.

9. Yield loss due to diseases

The experiment to assess yield loss due to abnormal leaf fall disease in clones RRIM 600, RRII 105 GT 1 and RRII 118 was continued for the second year. Spraying

Table - Path. 4. Intensity of powdery mildew disease

Treatments	Fungicide concentration (%)	Mean disease intensity (%)
Carbendazim (Bavistin)	0.05	20.71 (27.03)
Carbendazim (Sten)	„	26.75 (31.13)
Benomyl	„	28.67 (32.36)
Bitertanol	0.025	21.59 (27.68)
Triademefon	„	25.13 (30.08)
Wettable Sulphur	0.20	28.42 (32.19)
Carbendazim + Wettable Sulphur	0.025 + 0.1	19.96 (26.54)
* Carbendazim and Wettable Sulphur	0.05 0.20	35.88 (36.75)
Water spary control	0.0	47.80 (43.73)
Unsprayed control	0.0	50.58 (45.35)
S. E. (d) 2.09	C. D. 4. 39	

*Alternate round of Carbendazim and Wettable Sulphur. Figures in parentheses indicate arc-sine transformed values.

Table - Path. 5. Control of *Gleosporium* leaf spot disease

Treatments	Mean disease intensity
Control (unsprayed)	63.33 (52.78)
Baycor 0.025%	35.83 (36.72)
Bavistin 0.05%	28.33 (32.14)
Delan 0.2%	32.50 (34.75)
Dithane M-45 0.2%	27.50 (31.58)
Bordeaux mixture 1%	44.17 (41.64)
Instant Bordeaux mixture	39.17 (38.73)

S.E. (d) = 1.44 C.D. = 4.44

Figures in parantheses indicate arc sine transformed values

was carried out during May in protected plots. Marked difference in leaf retention was observed only in RRIM 600 (31%) between sprayed and unsprayed plots.

10. Over summering of *Phytophthora*

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

A specific medium has been standardised for isolation and quantitative estimation of *Phytophthora* in soil. Pure colonies could be obtained on the medium from soil artificially infested with oospores.

11. Host parasite relations

Attempts were made to study the changes in the contents of total phenols upon infection of *Phytophthora meadii* in clones RRIM 600 (susceptible) and RRII 33 (tolerant). In RRII 33, initial phenol level was found to be higher and it increased upto 24 hours and then decreased. But in RRIM 600, the initial phenol level was lower and the increase was noticed only from 24th hour and this trend was continued upto the third day.

The growth of *Phytophthora* in culture was tested in the presence of three phenols viz. cinnamic acid, catechol and hydroxy benzoic acid, at five different concentrations from 1 mg to 5 mg per litre. The fungus has grown well in all, at all the concentrations tried.

12. Epidemology of diseases

Dew formation was recorded during the powdery mildew disease season. As the disease incidence was very poor, the relation between dew formation and severity of the disease could not be studied.

The incidence of abnormal leaf-fall disease caused by *Phytophthora* repeatedly occurred for the third time in Kanyakumari District of Tamil Nadu. In this region the minimum required congenial climatic factors occured for the triggering of disease. Eventhough the severity of the disease was high in susceptible clones like RRIM 600 and PB 86, refoliation to the extent of upto 50% has occurred in most of the areas indicating that there was no severe shoot-rot and die-back, as occuring in Kerala and Karnataka. This year's meteorological observations also indicated that in Kanyakumari, the disease is triggered at slightly higher (one degree centigrade) temperature conditions compared to Kerala and Karnataka. The other climatic requirements such as humidity, rainfall, cloudy days etc remained the same.

13. Regional isolates of fungal pathogens

A large collection of fungal pathogens of rubber is being maintained for various studies. These cultures are purified and revived periodically.

Morphological studies on an isolate

of *Phytophthora* from Tripura was made. The sporangia of the isolate have short stalks and chlamydospores were found in plenty. Eighteen new isolates were added to the stock cultures.

14. Root diseases

Investigations on root disease control was continued. Attempts on artificial inoculation of *Fusarium solani* was unsuccessful. A new root disease observed on rubber seedlings is under investigation.

15. Multidisciplinary evaluation of clones

Field observation on occurence of diseases in the two trials are continued. Mild incidence of shoot rot and Gloeosporium leaf diseases were observed in some of the clones.

16. Early prediction of diseases

Among 35 germplasm genotypes screened for resistance to *Phytophthora* by artificial inoculation three genotypes showed tolerance. A total of 121 HP seedlings were also screened for resistance to this disease.

17. Physiological specialisation of *Phytophthora*

Physiological specialisation of pathogens can cause development of resistant strains which cause problems in control. Information on this aspect is essential in breeding for resistance.

Four isolates of *Phytophthora* were repeatedly screened by inoculating them on susceptible and tolerant clones. No significant difference in infectivity was observed, indicating absence of races.

18. Biological control of plant pathogenes of rubber

In the context of the increasing concern about the environmental hazards due to agrochemicals used in disease control, biological control methods offer an alternative.

Attempts were made to isolate antagonistic microorganisms which are effective in the control of plant pathogens of rubber. An isolate of *Trichoderma* is found to be promising antagonist of *Phellinus noxius* which causes root disease in rubber.

19. Microbiology of leguminous cover crops

Establishment and maintenance of leguminous cover crop in rubber plantation is an important cultural operation. The leguminous plants used at present dry up in summer and are palatable to cattle which are undesirable characters. Hence identification of more suitable cover crops is necessary.

Onfarm trials to study the effect of inoculation in the two *Rhizobium* isolates on *Pueraria phaseoloides* were carried out in 11 estates in one hectare plots. In all these areas, *Rhizobium* inoculation augmented the nodule number and biomass production. But there were wide variations in the effect.

Treatment with concentrated sulphuric acid is superior to hot water and abration treatments for the germination of *Pueraria phaseoloides*.

The population of *Beijerinckia* spp. and nitrogenous activity were found to be more in soils under *Mucuna bracteata*.

20. Rhizosphere studies of rubber plants

Root region of plants known as rhizosphere is the region of intensive microbial activity. Both associative and antagonistic activity among microorganisms and between plants and microbes take place in this region.

The solubilisation of mussoorie rockphosphate by an efficient phosphate bacteria collected from rhizosphere of rubber was maximum at pH 7, within five fays from inoculation. Among four carbon sources (glucose, sucrose, starch and carboxymethyl cellulose), glucose was found to enhance solubilisation of rock phosphate. The phosphate solubilisation was observed in RRII isolate. This isolate when inoculated to soil was found to increase in population and promote the growth of *Pueraria phaseoloides*.

21. Antagomistic microorganisms

A study was carried out to isolate antagonistic actinomycetes in the rhizosphere soils of rubber and test them against major pathogens of rubber.

In a study of the bark healing property induced by antagonistic actinomycetes of *Corticium salmonicolour*, the actinomycetes treated wounds healed faster than those treated with Bordeaux paste.

The phosphate solubilising bacteria collected from Rhizobium was found to have antagonistic activity against *Phellinus noxius* and *Corticium salmonicolor*.

22. Biological control of white grubs

The infectivity of *Beauveria brongniartii* to adult beetles, which are responsible for the abundance and distribution of white grubs in rubber nurseries was evaluated. The study confirmed that this fungus was readily pathogenic to adults of *Holotrichia serrata F.* and significantly reduced there longivity (Table - Path 6). Males which had copulated with contaminated females recorded 100 per cent infection by this fungus. On the other hand untreated males and females which had mated with one another were not infected. This study confirmed that *B. brongniartii* spread from contaminated adults to non-treated adults through copulation.

23. Vertebrate and non-insect pests

Rat burrows in an area of 1 ha of rubber nursery fields were treated with brodifacoum baits at 0.005% concentration. The rodent population was estimated by counting the number of live burrows of respective species before control operation.

Table - Path. 6. Susceptibility of adult *H. serrata* (F.) to field infection by *B. brongniartii*

Date of collection of beetles	Treatments	Number of beetles used	Per cent infection	Mean period to death (days)
March 20	Inoculated	F 60	100	13.1 a (11-15)
		M 60	100	16.1 b (14-18)
	Control	F 60	0	24.5 a (14-28)
		M 60	0	26.5 b (22-28)
April	Inoculated	F 60	100	9.0 c (7-12)
		M 60	100	7.8 d (7-9)
	Control	F 60	0	21.0 c (16-25)
		M 60	0	27.2 d (26-29)

a, b, c, d : Days followed by the same letters are significantly different (t-test, P=0.05)

: Maximum-minimum days given in parenthses

: F : Female, M : Male

The success in nursery sites was 93.65 per cent. The control with respect to the species of rats encountered are given in Table - Path 7.

Studies on the faunal composition revealed that over 56.50 per cent of the rodent populations were represented by *Bandicota bengalensis* followed by *B. indica* (27.30 per cent) and *R. meltada* (16.20 per cent) at the Central Nursery, Karikattoor.

Table - Path. 7. Efficacy of Brodifacoum in controlling odent pests in nurseries.

	Rattus meltada	Bandicota bengalensis	Bandicota indica	Total
Pre-control census	40	95	70	205
Post-control census	5	0	8	13
Control success (%)	87.50	100.00	88.57	93.65

24. Termites

Plots treated with aldrin at 0.1% followed by aldrin 0.05% and chlordane 0.1% were superior to control in checking termite infestation on young rubber at Regional Research StationFarm, Kamakyia Nagar (Orissa).

25. Slugs

Application of aldicarb-maida slurry at 0.01% concentration was superior to snail kill baits at 2.5% concentration for the control of slugs.

26. Wood preservation

In preliminary evaluation of rubber wood preservation, the combination of boric acid, borax and sodium pentachlorophenoxide (5 : 7 : 5 : 0.5) was found to be effective for protection of rubber wood from fungal moulds as well as insect borer when treated by means of diffusion process.

27. Nematodes infesting rubber seedlings

Root-knot nematodes (*Meloidogyne incognita*) accounted for 12-14 per cent loss of seedlings in a patch of area of Perumpulickal and Kadackamon rubber nurseries.

28. Minor pests

Severe incidence of leaf-feeding caterpillars (*Tiracola plagiata*) infecting *Mucuna bracteata* was effectively controlled by the application of carbaryl 50 w.p and HCH 50 w.p at 0.2 per cent concentration at Palampra Estate.

A new mite sp. *Eutetranychus anneckai* infesting rubber seedlings was identified.

29. Mushroom culture

Six more species of oyster mushroom were obtained from North Eastern region and studied for their growth and yield on rubber wood saw dust and compared with *Pleurotus florida*, *P.flabellatus* and *P.sajor-caju* were found to grow well. But they are inferior to *P.florida* with respect to growth and yield of mushroom. Studies on cellulolytic enzyme production by different species of *Pleurotus* shows that the yield of mushroom is related to the cellulose enzyme production.

PLANT PHYSIOLOGY AND EXPLOITATION DIVISION

The Plant Physiology and Exploitation Division undertakes research on biochemistry, crop physiology, stress physiology, expolitation, intercropping of medicinal plants, etc. The Division also evaluates commercial products used in tapping, rainguarding and stimulation.

1. Physiological and biochemical subcomponents of yield

Latex diagnosis parameters were analysed in clones PB 217, PB 235, RRII 105, Ch 4 and Pil B 84 under $^1/_2$S d/$_2$ 6d/7 tapping system in panel BO2. The parameters estimated were latex yield, dry rubber content, sucrose, thiols, phosphate and magnesium (Table - Phy. 1). Sucrose contents and magnesium did not show any relation with yield. Thiols and phosphate were high in high yielding clones. These parameters are being studied in more clones, employing different tapping systems in different seasons.

2. Early prediction of yield and stress tolerance

Latex diagnosis parameters were estimated in latices obtained by test tapping of 28 HP clones. Maintenance of better plant moisture status was found to be an important attribute of drought tolerance. Two proteins with molecular masses 63.1 KD + 79 KD were identified in the latices of high yielding clones. Stimulation did not result in the production of the proteins in the low yielding clones.

3. Lipid metabolism and latex production

Lipid analysis in the rubber cream and bottom fractions was continued. Higher levels of triglycerides were observed in the rubber cream fraction of clones PB 260, PB 217 and PB 235 when compared to clones RRII 105, RRIM 600 and GT 1 (Table - Phy 2). Phospholipid content in the bottom fraction was also higher in the PB clones (Table-Phy. 3).

4. Clone identification by protein mapping/isoenzymes

Electrophoretic patterns of acid phosphatase (AP), isocitrate dehydrogenase (IDH), alcohol dehydrogenase (ADH), diaphorase (DIA), phospho gluco dehydrogenase (PGD), esterase (EST) and peroxidase were studied in 20 clones. Isozyme patterns of esterase, peroxidase, diaphorase and isocitrate dehydrogenase were compared in diploid, triploid and tetraploid plants of clone RRII 105. Marked variations were observed in the banding patterns

Table - Phy. 1. **Latex yield, DRC and contents of surcrose, thiols, inorganic phosphate and magnesium**

Clone	Latex volume ml tree^{-1}tap	DRC	Sucrose mg/100 g fresh wt	Thiols mg/100 g fresh wt	Pi (mg/100 g)	Magnesium (mg/100 g)
PB 235	316	42.20	132.9	1.67	55.90	50.30
RRII 105	338	38.68	167.67	3.06	33.25	101.26
PB 217	333	32.07	389.21	2.27	62.36	79.30
Ch 4	138	33.15	174.64	1.73	25.38	50.19
Pil B 84	115	35.87	168.39	1.40	16.13	54.30

Table - Phy. 2. **Lipid content in the rubber cream (mg/g dry weight) in latices**

Clone	Total lipids	Sterols	Triglycerides	Phospholipids
RRII 105	47.78	4.77	9.13	7.27
PB 260	58.21	5.35	18.51	6.05
RRIM 600	41.89	3.85	5.61	5.85
PB 217	60.32	4.11	24.34	5.66
GT 1	40.47	4.72	9.16	6.13
PB 235	56.53	4.99	18.57	6.98

Table - Phy. 3. **Lipid content in the bottom fraction (mg/g dry weight) in latices**

Clone	Total lipids	Sterols	Triglycerides	Phospholipids
RRII 105	140.56	25.03	35.50	19.77
PB 260	139.87	18.62	42.12	26.40
RRIM 600	124.65	21.13	39.83	14.44
PB 217	152.42	17.82	36.51	30.51
GT 1	131.76	23.19	49.29	19.63
PB 235	143.94	22.17	50.28	30.39

among cytotypes. Esterase showed a decrease in the mean number of bands as the ploidy level increased (Table Phy 4). An enhancement in the mean number of bands was observed in IDH and DIA with increase in the ploidy level (Table Phy 5 and 6).

5. Yield constraint analysis

Monitoring of growth, yield, latex flow characteristics, turgor pressure, solute potential and soil moisture status in clone GT 1 was continued in New Ambadi estate (Kanyakumari area) and Kinalur estate (Calicut area) of the traditional rubber growing region. Collection of rainfall data was also continued. Monitoring of thiols and sugars was started. The per tap yield continued to be higher in New Ambadi estate (15.68 kg tap^{-1} $tree^{-300}$) where rainfall pattern is more favourable, compared to

Table - Phy. 4. **Esterase isozyme pattern of four cytotypes of *Hevea***

	Rf values								
Cytotype	0.33	0.40	0.43	0.48	0.53	0.59	0.63	0.67	0.72
Diploid	+	+	+	+	+	+	+	+	+
Synthesized triploid	+	-	+	+	+	-	-	-	-
Spontaneous triploid	-	-	-	+	-	-	-	-	-
Tetraploid	+	-	+	+	+	-	-	+	-

+ presence - absence

Table - Phy. 5. **Isocitrate dehydrogenase pattern of four cytotypes of *Hevea***

	Rf values				
Cytotype	0.22	0.28	0.34	0.42	0.51
Diploid	-	-	+	+	+
Synthesized triploid	-	-	+	-	+
Spontaneous triploid	-	-	+	-	+
Tetraploid	+	+	+	+	+

+ presence - absence

Table-Phy. 6. **Diaphorase isozyme pattern of four cytotypes of *Hevea***

	Rf values			
Cytotype	0.40	0.48	0.53	0.67
Diploid	+	+	-	-
Synthesized triploid	-	+	-	-
Spontaneous triploid	-	+	-	-
Tetraploid	+	+	+	+

+ presence - absence

that in Kinalur (7.82 kg tap^{-1} tree^{300}) estate where the dry season is longer though total rainfall is much higher. Latex thiols and sugars were also found to be lower in the trees at Kinalur estate.

6. Physiological evaluation of clones

Data collection on growth and other physiological parameters were continued in the multilocation trial comprising Depchari in Maharashtra (prolonged dry season), Mudigere in Karnataka (high elevation) and Central Experiment Station, Kerala (traditional region). At CES among the twelve clones, in all except PR 107 and in Dapchari among the nine clones in all except GT 1, PB 235 and Tjir 1 more than 70 per cent of the trees attained tappable girth. Tapping was commenced in both the locations in March 1991 on all the trees which attained tappable girth. At Mudigere tapping was not started due to poor girth.

7. Performance of clones at high elevations

Girth recording was continued in all the 16 clones of 1982 planting. Only 30 per cent of the trees had attined tappable girth.

8. Exploitation systems and yield

The trial started in 1985 to evaluate the effect of exploitation systems on the yield of modern *Hevea* clones was continued and the yield obtained during the experimental period is presented in Table Phy 7. Yield from trees under $^1/_2$ S d/3 system of exploitation was slightly higher than the yield obtained from the trees under $^1/_2$ S d/2 system during 1990-91. Tapping panel dryness was highest under $^1/_2$ S d/2 system.

In the large scale estate trial the second year yield from $^1/_2$ S d/3 system was around 25 per cent lower when compared to the yield from $^1/_2$ S d/3 system. Tapping panel dryness was found to be higher under $^1/_2$ S d/2 system of tapping. Yield performance of trees under $^1/_3$ S d/2 system was better than that of trees under $^1/_2$ S d/3 system of tapping.

9. Comparison of yield stimulants

The experiment at CES was continued. Cumulative yield data of three years indicated 25 per cent yield increase under ethephon treatment and 34 per cent under calcium carbide treatment.

10. Tapping systems for small growers

The experimental tapping was continued during the third year. The yield pattern was comparable to that of the previous year.

Table-Phy. 7. **Dry rubber yield *(kg ha^{-1}) under different exploitation 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)	1990-91 (12 months)	Total (69 months)	Brown bast (%)
1/2 S d/2	1027.25	1491.00	2030.50	3328.79	2206.57	1944.09	12028.20	30.00
1/2 S d/3	845.50	1246.98	1737.28	2631.95	2190.04	2009.48	10661.23	17.50
2 x 1/4 S d/2 (t,t)	704.00	1201.03	1374.82	2169.39	1389.15	1217.32	8055.71	14.17

* 300 trees ha^{-1}.

11. Effect of ayurvedic oil on tapping panel dryness

The large scale estate trial involving prophylatic monthly and bimonthly applications of the ayurvedic oil was continued. The data on the incidence of tapping panel dryness was collected during the period.

12. Controlled upward tapping

A large scale statistically laid out trial on controlled upward tapping (CUT) comprising seven exploitation systems was started in CES in clone RRIM 600 (under last year of tapping in panel B1-1). There are three replications for each treatment, each replication comprising of 90 trees. Upper panel is tapped using long handled modified gouge knife. Tappers were trained to use the knife for CUT. Cumulative dry rubber yield from 10th November 1990 to 31st March 1991 is given in Table Phy. 8. The mean monthly bark consumption is also given in the table. Under Indian conditions upward tapping of high panel is difficult during rainy season. A package for using skirt type of rainguards with 60 cm width, second support cut, rainguard lifter and panel change was formulated for evaluation.

Table-Phy. 8. **Dry rubber yield and bark consumption**

Treatments	Cumulative dry rubber yield (300 trees) from 10th Nov. 1990 to 31st March 1991	Monthly bark consumption on high panel (cm)
1/2 S d/2 6 d/7	1293.63	—
1/3 S ↑ 1/2 S d/2 (9 m, 3 m) 6 d/7	2226.80	3.40
2 x 1/2 S ↑↓ d/2 6 d/7	2819.17	3.68
1/4 S ↑ + 1/2 S d/2 6 d/7	2419.37	3.24
1/3 S ↑ + 1/2 S d/2 6d/7	2705.07	3.34
2 x 1/2 S ↑↓ d/3 6d/7	2117.77	2.92
1/3 S ↑ + 1/2 S d/3 6d/7	1905.17	2.71

13. Intercropping of medicinal plants

The studies on intercropping of medicinal plants in mature *Hevea* stands were continued. New experiments were started to find out the light requirements of promising medicinal plants.

RUBBER CHEMISTRY, PHYSICS AND TECHNOLOGY DIVISION

1. Solar drier for sheet rubber

In order to modify the existing drier of 800 kg capacity, the area of heat collectors was increased by 50% by adding one more collector or 8 m^2 area, the volume of the drying chamber was reduced by 25% and the trollies were strengthened. Construction of a solar drier, of 200 kg capacity, has been initiated.

2. Sulphuric acid as alternative latex coagulant

Further observations on the corrosion aspects of using sulphuric acid, showed that weight loss of aluminium pans used for coagulation was nearly identical in the case of both sulphuric acid and formic acid.

3. Epoxidation of NR

The design of a pilot plant for the production of ENR has been finalised. Properties of vulcanizates of ENR-25 and ENR-50 at different loadings of ISAF black and precipitated silica have been evaluated using a semi-EV vulcanizing system. The formulation of the compound and properties of the correspoding vulcanizates are given in Tables Chem. 1 and Chem. 2 respectively.

Table-Chem. 1. **Formulation of compounds**

Ingredients	Parts by weight
ENR-25 or ENR-50	100
Filler	variable
Sodium carbonate	0.3
Zinc oxide	5.0
Stearic acid	2.0
Antioxidant HS*	2.0
Sulphur	1.5
2-Morpholinothio-benzthiazole	1.5
PVI 50**	0.2

* Polymerised 2, 2, 4-trimethyl-1, 2-dihydroquinoline

** N-cyclohexylthio phthalimide (50% active)

Ageing resistance of both ENR-25 and ENR-50 has been found to be very poor. The raw rubber is found melting on prolonged exposure to elevated temperature. Work is in progress to improve PRI and ageing resistance.

4. Compression set of NR vulcanizates

This study has been concluded. The major factors contributing to compression set (C. S) at elevated temperatures are those involving changes in network structure while at subzero temperatures. C. S. is contributed mostly by low temperature crystallization. Peroxide curing is advantageous at elevated temperature while a conventional sulphur cure is found better at subzero temperatures, where low C. S. is important. Although C. S. is increased by the presence of fillers like carbon black, precipitated silica and china clay, the superiority of the conventional system at subzero temperature is still maintained. Naphthenic oil and antioxidant PBNA are found to increase C. S. throughout the temperature range studied.

5. Development of chemical resistant NR compounds

Ageing studies of chloroprene rubber gum vulcanizates were conducted in phosphoric acid and distilled water. The strength properties were not affected by ageing in phosphoric acid whereas a drop in strength was observed during ageing in distilled water.

6. Preparation and properties of depolymerized NR

Trials with CV rubber showed that presence of hydroxylamine salts did not

Table-Chem. 2. **Properties of ENR vulcanizates**

Property	ENR-25				ENR-50	
ISAF black, phr	30	50	-	-	30	-
Precipitated silica (Insil VN3)	-	-	30	50	-	30
Optimum cure time at 150°C, min.	8.5	9.5	13	10	10	9.25
Hardness, Shore A	46	62	52	73	55	55
Tensile strength, MPa	21.4	22	17.5	19.2	24.2	22.8
100% Modulus, MPa	1.54	2.9	1.5	1.82	1.89	1.89
200% Modulus, MPa	3.1	6.4	2.6	2.93	3.8	3.35
300% Modulus, MPa	5.13	10.5	4	4.41	6.4	5.23
Elongation at break, (%)	855	597	878	865	707	841
Compression set (22 h at 70°C), %	16.3	18.6	21.6	-	30	34
Tear strength, N/mm	50.5	70.3	45.1	66	66	61.1
Goodrich heat buildup (ΔT) at 50°C, °C	27	39.1	36.4	40.5	31	29.7
DIN abrasion loss, mm^3	197	146	278	155	163	191
Resilience, %	49	45	-	-	38	-

influence the characteristics of the depolymerization reaction.

7. Degradation of natural rubber

The effect of physical strain on the ageing of NR vulcanizates is being investigated.

8. Transparency of latex vulcanizates

Physical properties of latex films prepared using transparent rubber band formulation, were compared with those of films made from a conventional rubber band formulation. The films were having comparable strength and ageing properties.

9. Development of NR based adhesives

The effect of plasticiser and antioxidant on bond strength of NR solution adhesives was studied. Bond strength increased with addition of antioxidant but decreased with the addition of plasticiser.

10. Studies on EPDM-SP rubber blends

This study was taken up with a view to developing formulations that will combine the ozone and ageing resistance of EPDM rubber with the processing advantages of superior processing rubber. The study includes; optimisation of blend ratio, selection of a suitable cure system, effect of filler loading and finalisation of a compound for weather strips.

11. Blends of NR and ethylene vinyl acetate copolymer

Studies on blending of NR and ethylene vinyl acetate (EVA) showed that EVA improves tear strength and abrasion resistance of NR but adversely affects compression set and resilience. A mixed cure system consisting of dicumyl peroxide and sulphur was found to give better technological properties for the blends containing

higher proportions of NR. Thermal ageing and radiation resistance of the blends were better when the proportion of EVA in the blend was higher. Complete protection against ozone attack was obtained for the blends containing 40% or more of EVA.

12. Kinetics and heat transfer in the vulcanization of NR

The effects of three retarders viz. benzoic acid (BA), N-nitrosodiphenylamine (NDA) and N-(Cyclohexylthio) phthalimide (CTP) on the kinetic parameters of vulcanization and physical properties of NR compounds containing MBTS or MOR as accelerator were evaluated. The study indicated that NR compounds containing CTP as retarder required higher activation energy for vulcanization and the first order rate constant of the compound containing BA is lower than that of compounds containing CTP or NDA. Both BA and CTP prolonged the optimum cure time of the compounds and this effect was more pronounced in the case of CTP. Higher dosages of NDA and CTP affected some of the physical properties of MOR accelerated compounds.

13. Short fibre-rubber composites

Short sisal fibre-natural rubber composites having different volume loadings of the fibre were evaluated for processing characteristics and physical properties. It is observed that acetylation of the fibre improved the strength of the composites considerably. In this particular case, a dry bonding system consisting of resorcinol and hexamethylene tetramine was found to be better than the normal tricomponent dry bonding system consisting of resorcinol, hexamethylene tetramine and silica.

14. UNIDO project on NR based precured tyre retreads

Evaluation of road performance of 72 precured retreaded cross ply tyres received from MRPRA, UK have been completed. Results indicated that all the experimental compounds had similar wear performance and were inferior to the control (SBR/BR compound) by about 10 to 15%.

15. Development of 'flex seal' compound for VSSC

A project was undertaken for developing a rubber compound for flex seal for use in rockets under the GSLV programme of the Indian Space Research Organization. Flex seal is an important component of the flexible nozzle of the rocket and has to meet a set of critical parameters. Different compounds were screened and a selected one was sent to the Vikram Sarabhai Space Centre, Trivandrum for evaluation at their end.

AGRICULTURAL ECONOMICS DIVISION

The Agricultural Economics Division undertakes studies relating to economic aspects of natural rubber cultivation, processing and marketing, intercropping, ancillary products etc. The problems pertaining to small growers are given utmost priority. The Division evaluates the development schemes of the Rubber Board. It further analyses the economic viability of the findings of other scientific divisions. The Division monitors the position of natural rubber in the light of the developments in the Indian economy.

1. Commercial evaluation of planting materials

The third report of the study, which is under publication, covers 21 prominent planting materials. RRII 105 recorded the highest performance with 1412 kg/ha during the first five years and 1556 kg/ha during the first ten years. A classification of clones according to yield and consistency also put RRII 105 at the foremost position (high yield with medium consistency). Other promising planting materials with proven commercial yield were PB 28/59, GT 1, RRIM 600 and PB 5/51. The region wise analysis showed that different planting materials had shown varying commercial performance in different regions.

A survey on the use of planting materials in the estate sector has been conducted covering 95 estates and the data are being processed.

2. Production and utilization of rubber wood

The production and utilization of rubber wood were estimated based on the survey done among major rubber wood consuming units in Kerala, Tamil Nadu, Karnataka and Andhra Pradesh. The rubber wood production for 1989-90 was estimated to be 1,26,000 cubic metres. Out of the round log major share (60 per cent) is used for making packing cases. Rubber wood is also used by plywood, safety match and furniture industries.

3. Production and utilization of rubber seed oil

The production and utilization of rubber seed oil was estimated using the data collected from various production and processing centres. During 1989-90, the average price was around Rs. 12/- per kg. The oil is used predominantly by soap, paint and leather tanning industries. It was also estimated that the production of rubber seed cake during the period was 7800t. A delegation from Vietnam was given all the necessary information regarding Indian rubber seed oil sector.

4. Commercial production of honey

The production of rubber honey was estimated at 3400t in 1989-90 by visiting all the major honey producing centres. This accounted for approximately 45 per cent of the total honey production in India.

5. Management of rubber small holdings

The study analysed the extent and pattern of resource use of small growers during the immaturity period in relation to the levels of external funding and asset holdings. The results showed that the institutional finance channelised through the schemes of the Rubber Board had been able, to a certain extent, in filling up the resource gap caused by the lower levels of asset holdings. It was also seen that as the size of the holding increased the impact of

institutional funds on resource use declined. A positive relationship was observed between the level of asset holding and the accessibility to institutional funds. Altogether it was reported that during the first, second and third years of planting 36, 18 and 4 per cent respectively of the rubber area had been intercropped.

6. Census of unregistered small holdings in a village in Meenachil taluk

The study revealed that 34.5 per cent of the rubber area was unregistered. It was observed that as the size of the holding increased, the extent of unregistration declined. It was also noticed that during the recent years though not officially recommended the growers were planting PB 311 upto a quarter of the rubber area. The main reasons for unregistration were found to be the limits with regard to interplanting and area prescribed by the Rubber Board for granting subsidy.

7. Study of rubber small holdings

The study assessed the response as well as net gain on the growers to the input subsidy schemes of the Rubber Board through rubber producers' societies (RPS). In the post-scheme period there was a remarkable shift to straight fertilizers and their application based on soil and leaf analysis effecting reduction of Rs. 304/ha in unit fertilizer cost. The group spraying programmes of RPS changed the consumption pattern of plant protection chemicals in favour of copper oxychloride. During the pre-scheme and post-scheme periods the application of panel protection materials was found to be confined to predominantly to fields planted with RRII 105. A comparison of rainguarding during the two periods revealed its non-neutrality to resources. A remarkable rise of 67 per cent was observed in the use of plastic latex collection cups. The input subsidy was estimated to be Rs. 681.67/ha during 1988-89 and the additional employment generation was found to be 34.19 mandays/ha.

8. Other studies

Studies on brown bast incidence in RRII 105, adoption of improved planting and processing method by small rubber growers, profit maximization/utility maximization of rubber growers, transportation of rubber and the reclaimed rubber industry in India are also in progress.

CENTRAL EXPERIMENT STATION

The Central Experiment Station of the RRII, established in 1966, at Chethackal, Ranni (Pathanamthitta District), is about 50 km away from the Institute. The Station is spread over an area of 254.8 ha. Long term field experiments on clone evaluation, exploitation studies, evaluation of Brazilian germplasm, pests and diseases management, intercropping of medicinal and other cash crops, etc., have been laid out in the station by the Botany, Plant Physiology and Exploitation, Germplasm, Mycology and Plant Pathology and Agronomy and Soils divisions of the RRII. Over 4000 wild genotypes received from the Malaysian germplasm centre are established and maintained in the station for screening purpose.

During 1990-91, an area of about 12 ha. was planted for different experimental purposes. The total crop production during the peirod under report was 209 t.

The total rainfall received during the period under report was 3132.7 mm. (Table-CES. 1) compared to 3952.4 mm during 1989-90.

The strength of the permanent workers and temporary causal workers on the rolls were 201 and 220 respectively. The total mandays engaged for different operations in the station during 1990-1991 were 67450.

Table-CES. 1. **Rainfall (1990-91) distribution at CES.**

Month	Rainfall (mm)
April	187.4
May	412.6
June	550.5
July	589.3
August	272.5
September	111.0
October	428.1
November	343.0
December	8.2
January	32.5
February	14.5
March	183.1
Total	3132.7

A medical camp was organized at the station in January 1991. Experts from the medicine, gynaecology and community medicine departments of Medical College, Kottayam, participated. 179 patients availed the facility in the camp. Besides, 11722 patients from CES farm and Central Nursery, Karikattoor utilized the services of the CES dispensary during the period under review.

Two teams of RPS members, one batch of estate management trainees, one batch of newly appointed junior field officers and a team from Vietnam visited the Station.

REGIONAL RESEARCH STATION, ASSAM

The RRII has a Research Complex for North-East Region, which concentrates on evolving agromanagement technology specific to the region. The Complex has its headquarters at Guwahati and three Regional Research Stations, one each in Tripura, Meghalaya and Mizoram, in addition to the one in Assam.

The thrust areas of research at the Regional Research Station, Assam are multidisciplinary evaluation of clones through location specific trials, assessment of nutritional requirements under different fertility status of soil, diseases and pest management, agroclimatological parameters and biotechnology. The station is undertaking field experiments as well as on-farm trials.

1. Multidisciplinary evaluation of clones

In the 1985 clone trial, PB 235, RRIM 600 and RRII 118 recorded more than 40 cm girth, the figures being 41.90 cm, 41.22 and 40.49 cm respectively, while Gl 1 recorded the minimum (31.22 cm). In the 1986 clone trial girth ranged from 30.29 cm (RRII 105) to 34.32 cm (RRII 118).

Severe *Oidium* leaf fall disease was observed in 1985 clone trial during the last two years, which has affected growth. In addition to leaf fall disease severe scale insect attack was also observed during 1989-90.

2. Nutritional studies - immature phase

The two on-farm trials to ascertain the optimum requirements of fertilizers, one at Mendipather and the other at Nayekgaon, were continued. In both the experiments, highest level of nitrogen gave maximum girth. It was also noticed that higher doses of phosphorus gave a depression in girth, though highest dose continued to be more beneficial in girth increment. No trend was found in case of K. Pretreatment soil samples were analysed. Posttreatment soils and leaves were collected for further assay. Efforts are now being made to assay soil moisture stress and plant nutrient uptake.

The trial initiated at Bargang in 1989 was also continued. A combination of four levels of N, P (both soluble and insoluble) and K are being tried.

3. Interaction between potassium and magnesium

The trials initiated in two locations (Sarutari and Nayekgaon) in 1987 with clone RRII 105 were continued. The treatments consisted of combinations of three levels of potassium (0, 20 and 40 kg/ha) and three levels of magnesium (0, 7.5 and 15 kg/ha) laid out in a randomised design with three replications.

The pretreatment potassium status of Sarutari and Nayekgaon were 380 kg/ha and 43.4 kg/ha, respectively, which revealed that potassium levels for Sarutari soils is very high whereas that for Nayekgaon low. From the girth data (Table-NEA. 1) it was noticed that there is a decreasing trend in girth increment with increasing levels of potassium in Sarutari whereas the trend was reversed for Nayekgaon. This may be due to the presence of high levels of potassium at Sarutari. The higher doses of applied magnesium was more effective for girth increment at Sarutari farm. Highest dose of Mg was comparatively more effective at Nayekgaon. It is, however, too early to draw conclusions.

Table - NEA. 1. **Effect of potassium and magnesium on girth in cm**

Treatments	Sarutari, June '90	Guwahati Dec. '90	Nayekgaon, June '90	Dubri Dec. '90
Levels of K				
0	16.09	19.20	11.91	15.87
20	15.40	18.78	12.76	16.71
40	12.82	16.71	13.04	16.47
SE	0.89	0.53	0.40	0.42
C.D.	2.19	NS	NS	NS
Levels of Mg				
0	13.41	17.54	12.40	16.07
7.5	15.92	18.75	12.65	16.21
15.0	15.00	18.41	12.67	16.76
SE	0.89	0.53	0.40	0.42
C.D.	NS	NS	NS	NS

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

The trials initiated in two locations of Assam (Sarutari and Nayekgaon), to compare the efficiency of different sources of phosphatic fertilizers and their combination used for rubber in its immature phase were continued. Pre-treatment soil has been analysed. Post-treatment soil and leaf samples were collected and are now being analysed.

5. **Anther culture and plantlet regeneration**

Among the five clones subjected to anther culture, somatic embryos were regenerated from PB 5/51 and RRII 105. Only one embryo regenerated into a complete plant. Malformations in shoot growth were observed in the other embryos with roots.

6. **Culture of mature and immature zygotic embryos**

Attempts were made to culture immature and mature zygotic embryos. Plants were regenerated from 50 per cent mature zygotic embryos without cotyledonary leaves. The response of immature embryos was not positive.

7. **Plant regeneration from tissues of cover crops**

Root, stem and leaf explants of *Pueraria phaseoloides* were subjected for callus induction and all produced calli. However wide variations were observed from among the regenerated plants. Plantlet regeneration was achieved from stem derived callus only and a few plants were established in pots.

8. **Genetic transformation of *Hevea* cells by *Agrobacterium***

Eight new strains of *Agrobacterium tumifaciens* were obtained from the University of Washington and were tested for their virulence on large number of Wickham and Brazilian germplasm materials.

A. tumefaciens strain harbouring WHR (wide host range) to plasmid Ag 162 transformed about 60% genotypes, whereas strain A 136, a Ti plasmid cured derivative of WHR strain C 58, showed no response. Other strains showed varied response.

9. Survey of diseases and pests

Pest and disease survey was carried out in 65 different locations of rubber growing tracts in Assam, Meghalaya and Mizoram, the damage caused by them were assessed by visual scoring.

Powdery mildew disease caused by *Oidium heveae* was found on tender leaves in all stages on growth of rubber plants in all the locations surveyed. Intensity of the disease was very high during March-April in some of the plantations in Assam and Meghalaya, at the altitude of 120 to 300 metres, causing repeated defoliation and die-back of twigs and branches. Flowers were also affected resulting in a considerable loss in seed production.

Secondary leaf fall caused by *Gloesporium alborubrum* was noticed during June to September on new flushes of leaves in all the plantations surveyed. High intensity of disease was noticed in some plantations of Assam and Meghalaya causing repeated defoliation and die-back of twigs and branches.

Leaf spot caused by *Corynespora cassiicola* and bird's eye spot caused by *Bipolaris heveae* are also important diseases in nursery plants, but the former was found more serious.

Brown root disease caused by *Phellinus noxius* was noticed at Sarutari farm and in a few locations of rubber growing tracts in Assam and Meghalaya.

Scale insect (*S. nigra)* was noticed by the end of March and the attack increased gradually till August. Thereafter it started decreasing due to the activity of an entomophagous fungus (*Hypocreallax* sp.) which controlled insect population biologically. Infestation of termites, slugs and snails was also noted. Observation on a new insect pest, which voraciously feed on rubber leaves, is in progress.

10. Isolation, identification and maintenance of pathogens

Routine isolation of fungal pathogens was made from diseased samples of rubber collected from different locations of North East. Forty fungal isolates associated with various diseases were maintained as stock cultures.

Eleven isolates were identified by the International Mycological Institute. Studies on their virulence are in progress.

11. Characterisation of the agro-topo-climate

Based on the meteorological data collected from NE India and surrounding regions the climatic characteristics of the region were brought out and water availability periods were delineated. The results were utilised in scheduling climate dependent agronomic and cultural operations for rubber cultivation in the region.

Climatic analogue studies revealed that rubber can be successfully cultivated in the plains and midlands of NE India but adequate precautions should be taken against wind damage in cyclone affected areas of Tripura State. For this purpose, wind shelter belts should be established along with rubber plantations. Cyclones and hailstorms are some of the limiting factors in the area, which can cause great damage to rubber plants.

12. Quantification of agrometeorological parameters

For crop-weather modelling and for estimating the performance of rubber in the sub-tropical NE India, data from the five stations in North East and one in West Bengal are being regularly collected and a data bank has been established at NERC,

Guwahati. Data collected are also being communicated to the national data centre of IMD, Pune.

Rainfall received in the year 1990 at Sarutari (Assam), Ganolgre and Darachikgre (Meghalaya), Taranagar (Tripura) and Kolasib (Mizoram) were 142, 224, 315, 228 and 200 cm respectively. Number of rainy days varied from 128 to 148. On an average 57% and 28% of the annual rainfall have been received during the SW monsoon (June to September) and summer (March to May) seasons respectively. Mean daily relative humidity recorded at the stations in the year ranged from 60 to 90%. Bright sun shine hours were comparatively less during the SW monsoon periods at all the stations with mean monthly values less than 5 hr day^{-1}. Wind speeds recorded in the month of April at Taranagar and Ganolgere were of the order of 9.3 km h^{-1} and 10.9 km h^{-1} respectively. At all the other stations winds were relatively calm.

During winter season (December-February) of 1990-91 the coldest temperature of 1.8°C was recorded at Ganolgere in January. At this station, during this coldest period, daily minimum temperature remained well below 5°C continously for 6 days.

13. **Effect of irrigation on rubber microclimate**

Soil temperature variations due to irrigation in seedling nurseries were studied during the winter seasons of 1990-91. Significant decrease in soil temperature were observed throughout the day due to irrigation at 5, 10 and 20 cm depths, over nonirrigated control plots. There was no appreciable difference in girth of the seedlings in the treatments and control plots.

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

Soil temperature variations with respect to control were significant due to all the three mulch treatments at 1320 IST at depths 5 cm and 10 cm. Significant differences in soil temperature were observed between organic and black polyethylene and white and black polyethylene mulches. The seedlings mulched with black polyethylene recorded the maximum girth in the winter season.

15. **Effect of shade on soil microenvironment**

Observations on the effects of shades created by rubber plantations on soil temperature variations have been made. It was observed that the soil temperature inside five years old plantations varied from 2.5 to 5.5°C, 1.6 to 3.3°C and 0.4 to 1.6°C at 5, 10 and 20 cm depths respectively at 1325 hrs IST. The effect of shade had been found to affect the diurnal air temperature extremes, relative humidity, etc.

16. **Effect of aspect on the rubber microclimate**

Wide variations have been observed in the physiochemical properties of the soil on hill slopes of different aspects in the subtropical NE India. These changes have been caused by the difference in microclimate experienced in these slopes. Significant difference in temperature of the soil had been noticed on slopes having different aspects (orientations). During the winter season, soil temperature inside rubber plantations on a south facing slope was found to be considerably higher than that on a north facing slope. On an average at 1325 hr IST, the soil temperature difference ranged from 5°C to 9°C. At 0625 hr IST, the range was from 1.2°C to 4.8°C. Investigations are in progress to quantify the changes in growth performance of the *Hevea* trees planted on slopes of different orientations.

REGIONAL RESEARCH STATION, TRIPURA

The Regional Research Station, Tripura started in 1979 with its office and laboratory at Agartala, has a research farm located at Taranagar, Mohanpur, about 20 km away from Agartala, at 23° and 53' latitude and 91° 15'E longitude, altitude being 16.6 metres above mean sea level. The entire area available in the farm has been brought under various trials besides budwood nursery with 5800 points and a seedling nursery in about 1.5 ha. About 14 ha are under tapping, the trees first opened in the year 1989. The laboratory has been equipped to undertake advanced research work on the disciplines of agronomy, soil science, plant physiology, bio-chemistry and plant breeding. The library attached to the station has 860 volumes of scientific books besides regular subscription of 25 journals. The station also has a mobile soil and tissue testing laboratory to offer discriminatory fertilizer recommendation to the growers of this state. A meteorological observatory also is set up in the farm at Taranagar.

1. Nutritional studies on rubber

1.1 Immature phase

The trees under the experiment were opened in April 1989. The data collected indicated a positive response to higher levels of nutrients.

1.2. Immature phase (polybag plants)

The data on girth and girth increment during the period have been summarised from the trial laid out in 1986.

1.3. Seedling nursery

The trial in the seedling nursery was taken up to evolve new fertilizer recommendation for seedling nurseries in Tripura. The trial was laid out in 72 factorial combinations of N, P, K and Mg. This trial has been carried out during 1989-90 season. Data on number of buddable plants and morphological parameters were recorded. The data generated are pooled for analysis.

2. Density-cum-nutritional trial

2.1. Immature phase

The trial was started in 1987 with two clones, RRII 105 and RRII 118, having three densities (420, 606 and 824 plants per hectare) and three levels of fertilizers. The clones have been laid out as the whole plot treatment and densities and manurial treatment as sub-plot. Recording on girth, plant height and number of whorls had been made.

3. Multiple cropping and mixed farming

This trial, laid out in the year 1990 was well maintained. Another trial has been laid on an observational basis in the research farm at Taranagar to monitor the growth of rubber with the perennial inter crops, coffee and pepper. Cover crop also has been established in the intercrop area. There was no appreciable difference in the girth increment of the trees.

4. Studies on planting technique

This trial was laid out during the year 1981 with five treatments in a randomised block design having five replications with a view to comparing three types of budded stumps and polybag plants of two stages of growth as planting material. The clone was RRIM 600. Considering the early growth the 14 months old polybag plants had highest girth. The result from the comparative studies on different plant-

ing techniques on the growth of *Hevea* suggests that polybag plants in this region have high initial rate of girth and also the consequent capacity to tide over stress period during the initial year as evidenced by girth increment of polybag plants during winter stress periods. The data collected so far are under publication. Two trials were laid out in the polybag nursery during the year 1990-1991 to study the optimum time for raising polybag plants with different cultural practices in Tripura. Observation on the sprouting of budded stumps were also recorded.

5. Agromanagement practices for *Hevea*

5.1. Ground cover and soil moisture depletion

The trial was laid out and the cover crops have been established. The observations of moisture depletion pattern under three ground cover management situations such as *Pueraria phaseoloides, Mucuna bracteata* and natural cover, treatmentwise are being recorded.

5.2. Effect of shade

The trial was taken up with a view to monitor the influence of shade on the growth of seedling at nursery stage. It was also attempted to monitor the reduction in frequency of irrigation due to provision of shade. Shade was taken up as a whole plot treatment and frequency of irrigation as sub-plot treatment in a split-plot design with six replications. Observation from the field trials have shown that provision of partial shade (40% light cut) can reduce the frequency of irrigation from once in three days to once in 10-12 days. It has also been observed that provision of shade with frequency of irrigation 10-12 days also helped in making available more plants for green budding and also a higher percentage of buddable plants per seedling bed. The data generated hitherto has been analysed statistically.

5.3. Effect of mulching

This trial was laid out in the year 1989 with a view to monitor the influence of different mulch materials on soil temperature and growth of rubber seedlings. The data on stem diameter, height and number of whorls of *Hevea* seedlings grown under different mulches are summarised in Table-NET. 1. The results suggest that the black polythene bags used as mulch material has increased the soil temperature and subsequently the growth of *Hevea* seedlings.

6. Forms and placement of fertilizers

6.1. Phosphatic fertilizers (immature phase)

This field experiment was taken up to compare the efficiency of different sources and combination of phosphatic fertilizers being used in rubber. The growth attributes were recorded.

6.2. Phosphatic fertilizers (seedlings)

The trial was laid out in seedling mursery at Regional Research Station, Taranager in 1987-88 with four treatments (one treatment with no phosphorus and the others comprising three sources of phosphorus). Apparently no significant difference was noticed in 1988-89 season. The trial is being repeated during this season (1990-91) with five sources of phosphorus and a control with no phosphorus. Soil and leaf samples have been collected for assessing the nutrient status treatment wise.

6.3. Mode of fertilizer application (Mg)

The trial was laid out as an on-farm trial in Mohanpur in 1988 with clone RRII 105. The objective is to compare three methods of application, broad casting, in

Table - NET. 1. **Effect of different mulch materials on growth of *Hevea* seedlings**

Treatments	Mean height (cm)		Mean stem diameter (mm)		Mean no. of whorls	
Organic mulch	95.13	(6.47)	12.89	(6.88)	4.86	(3.62)
White polythene mulch	97.65	(9.29)	13.36	(10.78)	4.97	(5.97)
Black polythene mulch	101.15	(13.21)	13.99	(16.00)	5.11	(8.95)
No mulch with irrigation	91.83	(2.77)	12.71	(5.39)	4.76	(1.49)
Control	89.35	-	12.06	-	4.69	-
S.E. ±	1.95		0.04		0.08	
C.D. (p = 0.01)	8.41		0.17		0.36	

Figures in pranthesis indicate percentage increase over the control

band and in pocket at two depths. To monitor the influence of magnesium on the growth of *Hevea*, magnesium treatment has been super-imposed. Soil and leaf samples were taken for assessment of nutrients.

6.4. Mode of fertilizer application (N and P)

The trial was laid out as an on-farm trial at Tulakona in a grower's field with budded stumps of clone RRIM 600 in 1990. The design is split-plot with methods of application as whole plot and forms of fertilizer as sub-plot treatment. Soil samples have been collected for initial mutrient assessment. Periodic recording of girth has also been undertaken.

7. Soil test crop response studies

7.1. Standardisation of soil extractants

This study was taken up as an extension of the incubation study and the pot culture studies with *Pueraria phaseoloides* with different sources of phosphatic fertilizers to assess their agronomic suitability. The trial was taken up in large size polybags (85 x 65 cm) with budgrafted stumps of clone RRIM 600 planted during July, 1990. Five forms of phosphorus which include two water soluble sources are being compared besides a control. To standardise the extractant, five extractants (Bray I, Bray II, Mechlich I, Mechlich II and Mechlich III) are also under comparison with respect to extraction as well as plant uptake. Morphological observation, stem diameter, height and number of whorls were recorded. Soils and foliar samples were collected for analysis.

7.2. Incubation studies

The study which was started in 1989, aims at assessing the agronomic suitability of various sources of phosphatic fertilizers. The results show that initial rate of availability of single super phosphate (SSP) was higher and in the pot culture experiment maximum biomass was for the treatment with SSP. Among the phosphate rocks, Mussoorie rock phosphate emerged as the best in terms of influence on biomass build up of *Pueraria phaseoloides*, number of nodules and leaf and stem phosphorus concentration. The poorest performance was the treatment with Maton rock phosphate. The data generated so far are being compiled.

8. Physico-chemical characteristics of soils

8.1. Elemental composition

The major work carried out under this project was the collection of profiles and processing the samples. Estimation of micronutrients was carried out in a few samples.

8.2. Applied potassium in soils

The study was initiated to monitor the dynamics of applied potassium inthe soils under *Hevea* in Tripura. The zone of application of the fertilizers is limited and the timing of application coincided with monsoon and this would accelerate loss through fixation and leaching. The fate of applied potassium is also influenced greatly by thermal regimes.

One control (no potassium) and two doses of fertilizer were applied in the column and water was added to simulate average daily rainfall during the time of fertilizer column. Translocation of potassium down the column, quantity leached, quantity fixed etc., were monitored. The samples were incubated at 5°C and 40°C to study the changes of K - concentration. Available potassium was continuously monitored using two extractants viz. water and morgan reagents. All analyses for the initial characteristics of the soil were carried out.

9. Ecological impact of *Hevea* cultivation

9.1. Soil physical properties

In this study all attempts were made to quantify the influence of rubber plantation on soil physical properties with special reference to moisture retention. It was observed that rubber plantations helped in the enrichment of organic matter which also improved physical properties like bulk density, soil porosity, moisture retention and infiltration. Moisture retained at field capacity (-0.033 MPa) was higher by 5.45 per cent. The moisture desorption pattern showed that at -0.5 MPa 90.34 per cent of the available moisture was desorbed from surface soils from the rubber plantation whereas from outside the plantation in the same layer only 67.38 per cent was desorbed. Infiltration studies revealed that flow rates initially and after attaining steady state were higher inside the plantation, compared to the field subjected to shifting cultivation.

9.2. Micro-climate

The stydy was initiated to monitor the influence of *Hevea* on micro-climate in Tripura. Continuous monitoring of soil and air temperature, humidity etc, within and outside the plantation is being done. Continuous monitoring of soil moisture was also made. The results show that the thermal climate inside and outside the platnation has wide variation in air temperature the differnece being as high as 4.1°C. Similarly, the soil temperature fluctuation have indicated that in the midday, observation on soil temperature, the variation is 10.6°C, the soil temperature of the plantation being lower than that outside. The humidity per cent was lesser outside the plantation. The study is being continued.

9.3. Commercial plantations

The study was initiated to compare three commercial plantations (rubber, teak and tea) with natural forest, on their influence on soil nutrient enrichment, physical properties and nutrient and biomass recycle. Samples were collected from different plantations and natural forest from the area Shibdun (Siliguri) and brought to the Regional Research Station, Tripura. While collecting samples an enumeration of biomass under these forest covers were made. The plant population under rubber, teak plantation and natural forest were assessed. The physical and chemical analysis of soil was carried out. Chemeical analysis of available nutrients (N, P, K, Ca,

Mg) of monocots, dicots, litter of different plantations and natural forest were also carried out. Soil moisture retention characters of different plantations and natural forest were studied. Further work is in progress.

10. Standardisation of analytical procedures

The study was initiated to monitor the monthly variation in leaf nutrients and also to evolve correction factor at various months, so that leaf samples collecttion can be optimised and apropriate month of collection of leaf sample can be recommended. During the stydy, monthly collection of leaf samples were carried out and major nutrients (N, P, K, Ca, Mg) were analysed. The results are not adequate to draw conclusions and the study is being continued.

11. Evaluation of planting materials

11.1. Clone trial (1979)

Girth data from this trial for a period of eight years were statistically analysed to study the genotype X environment interaction in the early growth phase. The results showed that increment in growth significantly reduced with age over the years irrespective of sesons (winter/sumer). Also there was much difference between the girth increment during summer and winter months (Table-NET. 2). GE interaction paramerers like ecovalence and stability variance (Table-NET. 3) show that clones studied have differential adaptability and the adaptability ranks in the order RRIM 600, PB 86, GT 1, RRIM 605, PB 235, RRIC 52, RRIM 703, RRII 203, RRII 118, Harbel 1, RRII 5, RRII 105, Gl 1, RRIC 105

Table - NET. 2. Average winter and summer performance of clones

Clones	Mean girth increment in percentage*					
	Winter+			Summer+		
RRIC 52	7.11	(15.01)	a	20.46	(25.55)	a
PB 86	6.94	(14.80)	ab	27.89	(23.91)	a
RRII 105	7.07	(14.65)	ab	18.33	(23.58)	a
PB 235	6.50	(14.34)	ab	18.73	(23.99)	a
RRII 118	6.71	(14.27)	ab	18.66	(23.89)	a
GT 1	6.46	(14.13)	ab	17.70	(23.24)	a
RRII 5	6.62	(14.08)	ab	19.10	(24.25)	a
RRIC 105	6.54	(14.06)	ab	20.00	(24.80)	a
RRIM 600	6.30	(13.94)	abc	18.64	(24.03)	a
RRIM 703	6.06	(13.69)	abc	17.24	(22.64)	a
PB 5/51	6.18	(13.50)	abc	18.94	(24.07)	a
RRII 203	5.58	(13.34)	bc	19.42	(24.59)	a
RRIM 605	5.81	(13.31)	bc	19.58	(24.29)	a
Gl 1	5.66	(13.29)	bc	18.69	(24.18)	a
Harbel 1	4.93	(12.44)	c	17.72	(23.08)	a

*Numbers in parantheses are arcsin transformed values

+Means followed by the same leter in the same column are not significally different at the 5% probability level as determined by DMRT

and PB 5/51. The data suggests that clones RRIM 600, PB 86 and GT 1 can be called as widely adapted genotypes showing more genotypic flexibility and those like RRII 105 which show partial adaptability to seasons can be called as specifically adapted genotypes with less genotypic flexibility.

The area came under tapping in 1989. Yield and yield components such as plugging index, d.r.c., total solids, turgor pressure etc. are recorded periodically.

11.2. Clone tiral (1987a)

Periodical recording of girth (150 cm height) was carried out and the percentage increment in girth worked out, during summer months and winter months.

11.3. Clone trial (1987b)

Physiological parameters were recorded in different seasons and clonal differences were observed (Table NET. 4). Highest photosynthetic efficiency was recorded in RRIM 600 during October as well as February. Girth recording at quaterly intervals was carried out. During summer months PR 107, PB5/51, PB 86, SCATC 88-13 recorded more girth increment whereas during winter months Haiken 1, GT 1, RRII 118 and RRII 208 showed more girth increment.

11.4. Clone trial 1987c

Physiological parameters were recorded during the different seasons and the mean data on photosyntheses, transpiration rate and conductance are presented in Table-NET. 5. The clones SCATC 88-13, and SCATC 93-114 showed better performance during winter along with RRIM 600 which recorded highest photosyntetic efficiency.

12. Mother tree selection

From the ortet selected from a seedling plantation, multiplication was done. Periodic recording of girth, plant height

Table - NET. 3. **Stability parameters of genotypes over winter and summer**

Clones	Winter+		Summer+	
	Ecovalence (Wi)	Stability variance	Ecovalence (Wi)	Stability variance
RRIC 52	8.36	1.25	22.61	3.38
PB 86	3.87	0.51	74.73	11.97
RRII 105	13.83	2.16	6.53	0.72
PB 235	7.26	1.07	71.79	11.48
RRII 118	11.22	1.73	49.29	7.77
GT 1	5.94	0.86	11.81	1.60
RRII 5	12.50	1.94	24.68	3.72
RRIC 105	16.94	2.67	22.45	3.35
RRIM 600	1.12	0.06	18.92	2.77
RRIM 703	9.82	1.50	14.60	2.06
PB 5/51	21.83	3.48	11.65	1.57
RRII 203	10.76	1.65	35.07	5.43
RRIM 605	6.44	0.94	60.16	9.57
GI 1	15.02	2.35	16.55	2.38
Harbel 1	12.13	1.88	6.85	0.78

Table - NET. 4.Traspiration rate (E), stomatal diffusive conductance (gs) and photosynthetic rate (A) in different season (1990-91) at RRS, Agartala

Clone	Transpiration (U mol/m²/Sec)		Conductance (u mol/m²/Sec)		Photosynthesis (u mol/m²/Sec)	
	October	February	October	February	October	February
RRII 105	7.01	3.25	0.38	0.18	11.88	7.63
RRII 118	10.99	4.30	0.48	0.11	11.85	7.02
RRII 203	9.68	5.66	0.39	0.14	12.41	6.39
RRII 300	9.95	5.19	0.50	0.13	10.76	5.20
RRIM 501	6.14	3.86	0.36	0.14	12.91	7.38
RRIM 600	9.64	4.02	0.53	0.23	13.97	8.69
RRIM 605	8.47	5.55	0.39	0.16	10.09	7.98
RRIM 612	9.53	5.46	0.48	0.12	8.32	4.98
RRIM 703	9.75	5.08	0.47	0.10	10.05	6.15
PB 5/51	9.31	3.95	0.45	0.11	8.93	5.04
PB 86	10.06	4.16	0.44	0.11	9.56	5.16
PB 235	8.38	2.98	0.33	0.13	13.12	7.96
Gl 1	10.02	4.05	0.48	0.18	8.20	6.13
GT 1	6.93	2.96	0.33	0.10	8.30	6.10
Tjir 1	9.27	4.90	0.50	0.15	8.03	5.24
PR 107	8.24	3.38	0.44	0.13	11.71	5.36
Mean	8.96	4.29	0.44	0.14	10.63	6.40
SE	0.33	0.22	0.02	0.009	0.49	0.30
CV (%)	14.84	21.12	15.90	28.57	18.53	19.22

Table - NET. 5.Traspiration rate (E), stomatal diffusive conductance (gs) and photosynthetic rate (A) in different seasonS (1990-91) at RRS, Agartala

Clone	Transpiration (m ml/m²/Sec)		Conductance (mol/m²/Sec)		Photosynthesis (u mol/m²/Sec)	
	October	February	October	February	October	February
RRII 105	6.58	2.39	0.36	0.16	11.55	6.30
RRII 118	9.18	5.30	0.46	0.12	11.06	6.82
RRII 208	8.16	4.73	0.38	0.20	9.36	5.04
RRIM 600	8.96	3.92	0.51	0.24	13.80	8.56
SCATC 93-114	7.13	3.46	0.33	0.17	12.66	7.32
SCATC 88-113	9.83	4.32	0.40	0.21	13.45	7.85
Haikern - 1	8.26	4.16	0.45	0.20	8.84	5.31
PB 86	9.38	4.25	0.43	0.12	8.89	5.24
PB 5/51	8.90	4.30	0.46	0.13	9.05	5.36
Gl 1	9.90	4.85	0.49	0.20	8.86	5.90
GT 1	7.08	3.40	0.34	0.12	8.65	5.95
PR 107	7.90	4.08	0.52	0.21	10.98	5.67
Mean	8.44	4.09	0.43	0.17	10.59	6.27
SE	0.31	0.22	0.02	0.01	0.55	0.33
CV (%)	13.03	18.58	21.50	23.53	18.13	18.02

and number of whorls were carried out and the vegetative progenies will be field planted during the coming planting season for evaluation.

13. **Performance of polyclonal seedlings**

This project, aimed at studying the performance and suitability of polyclonal seedlings in Tripura, was planted in 1987. Morphological parameters were recorded periodically. Studies are being carried out to select promising seedlings from among the population.

14. **Flowering and fruit development**

The study was initiated during 1987-88 and continuous recording of wintering and flowering signified that variations had been existing in almost all the events leading to the floral induction among different clones. Clones such as RRII 105, RRII 118 and Harbel 1 were found to exhibit distinct wintering span.

15. **Recombination breeding and selection**

This programme was designed to make critical evaluation of the recombination values of the clones with respect to the development of potential recombinants owing to the narrow genetic base of the available clones.

Open pollinated half sib progenies belonging to ten maternally derived families were raised. The individual progenies were multiplied and would be evaluated for their performance along with their parents in a field trial. For full-sib progeny evaluation programme, work was initiated during the present flowering season by controlled crossing of the selected clones for evaluating the hybrids for the direct estimation of genetic values of different cross combinations.

16. **Germplasm conservation, evaluation and maintenance**

A total of 29 domesticated clones were being maintained in the budwood nursery. These clones were being utilized in various clonal evaluation experiments in the farm. A collection of 361 wild clones from Brazil were also being maintained in the station. These clones would be utilized for detailed characterisation and field evaluation for characters relating to stress tolerance and their genetic variability would be utilised in future recombination breeding programmes.

17. **Relationship between girth and biomass**

This experiment was started in 1987 with two clones (RRII 118 and RRIM 600) laid out in RBD to derive regression formulae for calculation of biomass from girth as well as height measurement at different ages. Destructive harvests were made periodically and height, girth and biomass were calculated. A general regression equation for three year old trees has been evolved.

18. **Environmental and physiological parameters on growth**

This trial was started in 1987 with clones RRII 118, RRII 105, RRIM 600, GT 1 and PB 235, laid out in RBD to study the various aspects of the interaction between agrometeorological factors and growth of *Hevea*. Physiological parameters were recorded during different seasons and clonal differences were observed (Table-NET. 6). RRIM 600 performed better during winter also. Investigations are being continued.

19. **Exploitation system**

This experiment was laid out in a nearby plantation at Taranagar with RRIM

Table - NET. 6. **Photosynthetic rate (A), Transpiration rate (E) and stomatal diffusive conductance (g 5) in different seasons (1990-91) at RRS, Agartala**

Clone	Transpiration (m mol/m²/Sec)		Conductance (mole/m²/Sec)		Photosynthesis (u mol/m²/Sec)	
	October	February	October	February	October	February
RRII 105	6.46	2.20	0.32	0.12	11.67	6.22
RRII 118	7.92	2.28	0.43	0.11	12.05	6.89
RRIM 600	7.35	3.65	0.54	0.12	15.14	8.24
GT 1	7.85	3.51	0.47	0.18	10.87	6.29
PB 235	7.33	3.34	0.46	0.14	13.35	7.47
Mean	7.38	2.99	0.44	0.13	12.62	7.02
SE	0.26	0.31	0.04	0.01	0.75	0.38
CV (%)	10.84	23.41	18.18	13.08	13.23	12.10

600, as an on-farm trial during November 1989 to find out a suitable exploitation system along with rest in winter, if necessary, for this region. The results indicate that tapping rest upto two months during winter (Dec. and Jan.) may not reduce annual yield per block in case of clone RRIM 600. This experimental farm with the clone RRIM 600 and RRII 105. Detailed studies are being programmed.

REGIONAL RESEARCH STATION, MEGHALAYA

The Regional Research Station, Tura, has been established in 1985 with two experimental research farms (Ganolgre 600 m MSL and Darechikgre, 1100 m MSL). During the year 1990, a trial on intercropping with banana, pineapple with cover crop covering about 5 ha area was started at NRETC, Jenggitchakgiri. The clone used is RRII 105. A seedling nursery was maintained at Ganolgre farm. To notice the response of *Hevea* clones to cold weather four ployhouses were constructed in the farm.

1. Field experiments at Ganolgre farm

1.1. Multidisciplinary evaluation of clones

Girth measurements of the 1985 trial with ten clones showed that RRII 118 (34.79 cm), RRII 203 (34.73 cm) and RRIM 605 (34.17 cm) have attained the maximum girth during the year, while PB 5/51 (29.38 cm) and GI (29.687) have attained the minimum. Generally it has been observed that in all the clones maximum growth was observed during the period May to September. In the trial started in 1986, RRII 208 (25.73 cm) showed maximum girth followed by RRII 118 (22.03 cm).

The growth of RRIM 600, under block planting (1987), was found satisfactory.

1.2. Assessment of potential intercrops

The growth of rubber continued to be better between banana plants. An amount of Rs. 236 has been obtained from selling banana and pineapple fruits. Damage to banana by elephants and to pineapple by rodents was observed.

1.3. **Rubber based cropping system**

The growth of tea was better than orange. But growth of coffee was not satisfactory. 62.15 kg. tea leaves were harvested, which fetched an amount of Rs. 148.50.

1.4. **Intercropping trial, NRETC**

A new intercrop trial has been started during the year 1990 at NRETC, Jenggitchakgiri. Under this trial budgrafted plants of RRII 105 were planted along with banana, pineapple and cover crop. Growth parameters of *Hevea* clone are being recorded at different time intervals. It has been noticed that growth of RRII 105 was better between the banana plants.

2. Field experiments at Darechikgre farm

2.1. **Multidisciplinary evaluation of clones**

Establishment of rubber was very difficult and the survived plants showed very poor growth. Even the growth rate of surviving polyclonal seedlings was comparatively very poor. The mean height and girth of four year old plants were 107.46 cm and 3.72 cm respectively.

3. Research programmes in Plant Pathology

3.1. **Mushroom culture**

Studies pertaining to mushroom culture are in progress. The mushroom is fruiting well on banana pseudostem, maize stem and dried Mucuna. A total of 64.05 kg of mushroom was harvested fetching a net income of Rs. 1,932.00.

3.2. **Plant diseases**

Occurrence of powdery mildew and leafspot disease was noticed. However, the percentage disease incidence was very negligible. A comparative study on the soil microflora under different rubber plantation in the region was initiated.

4. Research programmes in plant physiology

4.1. **Budsprouting in polyhouses**

Four polyhouses, with different gauges, were constructed at 600m MSL in Ganolagre farm and during the month of November and four clones (RRIM 600, RRIM 605, GT 1 and RRII 118) were planted. In December and January only three clones were planted. Planting was done outside the polyhouse also. It has been noticed that maximum sprouting percentage was recorded when stumps were planted in polyhouses during November than in December. In January budded stumps of only RRIM 600 sprouted, that too in polyhouses.

Observations on sprouting of Novmber planting indicated about 46% sprouting success in poyhouses, compared to less than 15% outside.

4.2. **Physiographic aspects on growth**

A trial was taken up in 1985 to study the effect of slope on the grwoth performace of ten clones of *Hevea*, at 600m MSL. girth was recorded at two month intervals. It has been noticed that all clones showed maximum girth in the bottom of the slope. RRIM 605 (38.10 cm), and RRII 203 (38.06 cm) has attained the maximum girth in the bottom, while Gl 1 (32.68 cm) recorded minimum girth. Similar trend was noticed in the middle of the slope. At the top maximum grith was recorded in RRII 118.

REGIONAL RESEARCH STATION, MIZORAM

The Regional Research Station, Mizoram continued to concentrate on field trials. The station, established in 1985 has an experiment farm of 50 ha, at Tuichuan, about 13 km away from Kolazib town.

1. Multidisciplinary evaluation of clones

Observations were continued in the trial laid out in 1985 with ten clones. Girth recorded in March 1991 showed that RRII 118, RRIM 605 and PB 235 are the most vigorous with mean girth of 37.26 cm, 35.87 cm and 35.60 cm respectively. Gl 1 recorded the minimum girth (26.13 cm). Girth increment from January 1990 to March 1991 was maximum for PB 235 (11.24 cm), followed by RRII 118 (10.82 cm).

2. Studies on intercropping

The area of intercropping trial is being planted with cover crops so as to reduce landslide damage. The growth of plants with cover crops is satisfactory. Maximum diameter was recorded for rubber plants with banana as intercrop.

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

The average girth of rubber plants in the trial laid out in 1987 was recorded. The results revealed that growth of plants on the eastern slope was satisfactory.

4. Rubber based cropping systems

Due to uncontrollable local factors vacancies in the tiral area (1987) could not be filled.

Girth of the different clones in the polyclonal seed garden laid out in 1988-89 was recorded. The clones were planted in three position on the slope. The results revealed that the clone RRII 118 performs well in the foothill, while the growth of GT 1 in the midhill and hill top is good.

5. Irrigation in seedling nursery

This trial was started in 1989 to study the effect of partial shade and frequency of irrigation on the growth of *Hevea* seedlings in the nursery. Budding was undertaken in July-Aug. 1990 and the percentage of budding success had revealed that shading has a beneficial effect on budtake.

6. Weed management

The observation trial laid out in 1990, was concluded. The percentage control of *Imperata cylindrica* 180 days after spraying was recorded.

From the data generated, it has been observed that chemical weed control especially with Glycel at 5 l and 7.5 l/ha gave very good control even 6 months after spraying. Economic analysis of the treatments shows that Glycel at 5 l/ha enables saving of about Rs. 944/ha.

REGIONAL RESEARCH STATION, WEST BENGAL

The Regional Research Station, Nagrakata, West Bengal concentrated on evaluation of clones and investigations on nutritional requirement of *Hevea* under leguminous cover crops. A seedling nursery, a polybag nursery and polyclonal nursery were raised to cater to the demands of the local entrepreneurs.

1. Nutritional trial

The preliminary girth data from nutritional trial indicated that application of nitrogen has a significant influence on the increment of girth. The highest girth (9.40 cm) and height (3.43 m) were recorded at the levels of 30 kg/ha. No significant response was noticed for phosphorus and potassium. However, interaction with nitrogen and potassium was found to be significant. Pretreatment soil samples were collected plotwise and are being analysed for assaying the nutritional status of the soil.

2. Multidisciplinary evaluation of clones

Two clone trials have been laid out in randomised block design with three replications, during 1990 in order to evolve the best suitable clones in the agroclimatic conditions of North Bengal. Eighteen clones are included in this study. The morphological parameters are found to be more or less same both the clone trials. In the clone trial with eleven clones, maximum height was recorded by clone PB 235 (148.7 cm) whereas maximum girth (5.5 cm) was recorded by clone Haiken 1. In the second trial which was planted with seven clones, the performance of clone PB 86 was better in respect of girth and height in comparison with other clones.

REGIONAL RESEARCH STATION, MAHARASHTRA

The Regional Research Station, Maharashtra started in 1981, continued its research programmes aimed at identifying appropriate agrotechnology for rubber cultivation in the Konkan region.

1. Irrigation systems

The irrigation experiment was continued. Basin irrigation was provided at the rate of 212.5 l/tree/ frequency while quantity of drip irrigations were 10, 20 and 30 l/tree/day (seasonal mean) during 1990 dry season. During the 1990 dry period the quantity of basin irrigation was increased to 400 l/tree/ frequency while mean seasonal drip irrigations were 22,44 and 66 l/tree/day. During 1990 dry season irrigation has resulted in promotion of growth at 1.00 ETc to a maximum of 50% of that of 1989 wet season growth and improved physiological performance of the plants. In unirrigated control plants, due to severe soil and atmospheric stress reduced growth was observed with negligible girth increment and reduced physiological activity. Irrigation during 1990 dry period maintained better water relations of the plants and brought the soil moisture of the plant basin area near to field capacity.

Six year old plants of clones RRII 105 and RRII 118 were irrigated at 1.00, 0.75, 0.50 ETc using hoses and sprinklers and growth was periodically monitored. During 1990 dry period the plants were provided with 319 litre water while during 1991 dry period the quantity was 600 l/

irrigation. Yield and yield components are under observation.

2. Physiological evaluation of clones

The ongoing physiological evaluation trial was continued. Irrigation was discontinued from 1988 dry period onwards. The growth of *Hevea* plants of different clones is not significantly different with each other showing only 11-15% of growth over a period of one year. The growth of clones RRIM 600, RRIM 501 and RRIM 612 were comparatively better. Predawn and afternoon water potentials, latex vessel turgor potential and other physiological parameters of the leaf are continuously being monitored in different seasons. Photosynthetic rate, stomatal diffusive resistance, transpiration, and other physiological parameters were monitored during summer period of 1990. Among all these clones, RRIM 600 has maintained a better physiological status with higher photosynthetic activities which is also evident from the diurnal variation exhibited by the clone. One hundred and ten matured plants of different clones have been tapped during March 1991 from which yield and yield components are regularly being monitored.

3. Contact shading

The trial on contact shading was continued in the third year. The girth and leaf chlorophyll contents were higher in all contact shaded plants and the control with shade was comparable to the other control plants without shade and spray. The physiological performance of all the china clay sprayed plants were high while control plants with and without shade maintained poor physiological performance. Ten per cent china clay spray appears to be optimum registering higher photosyntheses, transpiration, diffusive stomata conductance and water use efficiency. China clay spray can effectively replace conventional shading and is three times cost effective.

4. Dry farming

Treatments including those under dry farming techniques, were imposed on one year old plants of clone RRII 105. The initial girth observations indicated that the three treatments under dry farming were not very effective. At the initial stages of growth deep irrigation at 156 l/10 days and 20 days were effective in showing higher girth over other treatments. Plants receiving irrigation (with sub-soil injector) at 2 l/day/tree have shown comparable growth to that of pit irrigation treatment (50 l/20 days). During dry period of 1990 deep irrigated plants have shown high stomatal diffusive conductance over other treatments.

5. Clone trial

The clone trial laid out during 1985, in order to evaluate the performance of different clones in non-traditional area was continued. The data on girth and girth increment showed that RRII 208, RRII 6, RRIM 605 and RRII 105 have registered comparatively higher girth.

6. Polyclonal trees for selection

Polyclonal seedling population were maintained properly. Growth attributes of these plants were recorded.

7. Cost evaluation trial

The trial was initiated in 1987 to estimate the cost of cultivation of *Hevea* under irrigated and unirrigated conditions in non-traditional area. A block of 250 plants of clone RRII 600 were irrigated from January to May in accordance with their evaporation demands. During 1990 dry season the plants were provided 220 l/irrigation and during 1991 400 l /irrigation. Another block of 250 plants were maintained without irrigation. The management inputs and irrigation costs are being monitored.

REGIONAL RESEARCH STATION, ORISSA

The Regional Research Station, Orissa concentrated its activities on experimental plantings, polyclonal seedlings and irrigation.

1. Nurseries

The seedling as well as budwood nurseries were maintained properly.

2. Experimental plantings

The growth of plants in the clone evaluation trials as well as polyclonal seedling trial was good. A new clone trial was laid out incorporating ten clones (RRIM 600, RRIM 701, RRII 5, RRII 208, RRII 300, SCATC 88/13, SCATC 93/114, Haiken 1, PCK 1 and PB 310.). Another trial to study the irrigation requirement under the prevailing sub-tropical conditions in the area was laid out using 700 plants of RRIM 600. A spacing density trial was also started.

3. On-farm trials

The performance of plants in the on-farm trials is satisfactory.

HEVEA BREEDING SUB-STATION, KARNATAKA

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

1. Trial on growth, yield and exploitation systems

Two trials have been laid out, one in 1987 and the other in 1988. Both the trials are being maintained properly.

2. Small scale trials of selected ortet clones

The trials laid out during 1988 with a total number of 46 clones including three controls employing a randomised block design with three replications and five plants per plot were under proper care. Girth recording was carried out regularly.

3. Large scale trials

Some casualities were noted during the summer season and gap filling was done during 1990 planting season in the 1989 trial with 14 clones.

Five second selections from 1954 hand pollination progaramme (HP 185, 187, 204, 223 and 372), four popular clones and four parents of second selection were laid out in a randomised block design with three replications and 25 plants per plot, during 1990. The trial is being maintained.

4. Estimation genetic parameter

Twelve parent clones and their respective progenies (seedlings) were field planted during 1990. The design of the trial is randomesed block with three replications and a plot size of 15 plants. The trial is being maintained.

Since the area experiences severe drought, casualties are high due to sunscorch. During 1990, pot irrigation was attempted. Since this operation was found to be labour intensive and expensive, in 1991 sub-soil injectors were procured and irrigation was done with satisfactory results. Besides, trunk of all trial plants were protected with areca leaves and leaf sheath.

5. General

A power fence was erected at the

station to provide adequate protection of experimental trees from damages due to wild animals. Fence lines were erected on stone pillars and they run to a distance of 4.0 km. The power fence is operated by two 12 volt batteries and imported energiser unit and is working properly.

The station has awell equipped meteorological observatory. Total rain fall during 1990 was 4942 mm with a maximum of 1346 mm during August, followed by June (1216 mm) and July (1110 mm). The highest temperature recorded during summer was 36°C during March-April.

HEVEA BREEDING SUB-STATION, TAMIL NADU

The station is located at Paraliar, about 40 km from Nagercoil and has an area of 23.1 ha. Two breeding orchards established, one durng 1987 and the other in 1988, are being maintained. As a part of the stability analysis project, a large scale clone trial using 15 popular clones was laid out during 1990. The design of the experiment is randomised bock with three replications and a plot size of 25 plants. The tiral has an area of approxiamately 4.5 ha.

AGROMETEOROLOGY UNIT

1. Weather conditions at experiment stations

The general weather conditions during 1990 at RRII and four of the Research Stations were summarised in table agromet. 1. The total rainfall varied from 1618 mm (Keeriparai, Tamil Nadu) to 5098 mm (Nettana, Karnataka). Except in the Kanyakumari region, SW monsoon was vigorous. The rainfall during October and November was quite satisfactory in the traditional areas.

Temperature conditions in the traditional areas varied from 19-35°C. At Agartala temperature during January to March varied from 11-30°C. During this period evapotranspiration demand was low and the marginal drought conditions experienced were comparable to that of traditional areas. At Nettana, however, the temperature during January to April varied from 14 to 36.5°C, coupled with drought conditions. Also, during January the minimum temperature recorded was as low as 8-10°C for five days.

2. Agroclimatic aspects of rubber cultivation

Meteorological data base was developed to undertake agroclimatic modelling. Inorder to evaluate the climatic suitability of different parts of India for rubber cultivation, an index has been developed incorporating temperature and rainfall distribution.

The estimated weekly reference evapotranspiration at Kottayam during January to April varied from 3.3 - 6.5 mm d^{-1}. The climatalogical water balance conditions at Dapchari indicate an annual moisture deficit of 1200 mm. In the absence of rainfall during November to May, frequent irrigations shall be essential to reduce immaturity period.

3. Crop weather relations

Data on rainfall pattern in different

Table - Agromet. 1. Meteorological conditions recorded in different Rubber growing regions during 1990

	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
	a.	Rainfall (mm)										
Agartala	0	37	77	298	376	266	319	355	333	184	25	10
Nettana	3	0	0	14	444	1314	1111	1346	298	509	59	0
Kottayam	31	6	49	32	489	578	694	220	122	410	239	19
Chethackal	42	0	157	187	413	550	589	273	111	428	344	8
Keeriparai	26	70	101	106	312	156	134	49	20	235	396	13
	b.	Maximum temperature (°C)										
Agartala	25.1	27.8	30.3	32.2	33.3	33.0	31.7	33.1	32.6	31.1	30.8	26.6
Nettana	34.0	34.6	36.2	36.5	32.5	27.9	27.1	26.3	30.7	31.2	31.8	32.8
Kottayam	31.9	33.9	34.7	34.3	31.4	29.8	28.9	29.2	30.6	31.0	30.9	32.9
Chethackal	33.5	35.1	33.9	33.4	30.6	28.9	29.0	28.9	30.7	31.7	30.7	32.8
Keeriparai	32.3	34.1	34.3	34.0	31.2	29.8	29.6	30.2	32.6	31.6	30.4	31.4
	c.	Minimum temperature (°C)										
Agartala	11.0	18.7	17.1	20.5	23.3	24.3	25.1	25.3	24.7	21.4	19.1	12.4
Nettana	14.1	15.1	19.1	23.3	22.6	21.7	21.4	21.4	21.9	21.6	20.1	16.7
Kottayam	20.5	22.3	23.8	25.1	23.8	23.1	22.3	23.0	23.1	22.9	22.6	22.6
Chethackal	19.5	19.6	22.3	—	23.0	22.8	22.4	23.0	22.4	22.2	21.7	20.0
Keeriparai	17.9	18.2	21.3	23.7	23.4	23.5	22.7	23.7	21.9	21.9	22.2	21.2

agroclimatic regions of the traditional rubber growing locations are given in Table-Agromet. 2. No association has been observed between cumulative rainfall and annual yield in different agroclimatic regions. Correlation sudies between monthly rainfall and yield in different years of planting in two agroclimatic zones were undertaken.

At Dapchari, diurnal variations in temperature, humidity, light and radiation inside immature plantation were recorded and compared with open conditions. Significant changes in microclimate were noticed. Mulching the plant basin in dry period induced a reduction in soil temperature by 15-18°C upto 10 cm. Heavy mulch in the basin could, however, further decrease the temperature by 2-5°C. At a depth of 20 cm soil is cooler by 7-9°C under mulch when compared to bare soil.

4. Establishment of agrometerological observatories

A meterological observatory was estabilished at Regional Research Station Orissa, Kamkhya Nagar.

Table - Agromet. 2. **Rainfall (mm) pattern in the rubber growing regions of South India**

Station	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
	a. **Kanyakumari region**											
Keeriparai (15)	19	44	62	119	169	306	146	124	167	259	370	73
Kulasekharam (37)	22	34	61	172	220	216	148	88	141	286	211	70
Pechipara (37)	30	37	37	176	228	284	194	137	182	316	271	84
	b. **Quilon, Trivandrum and Pathanamthitta region**											
Punalur (31)	14	42	74	228	294	460	434	295	242	355	217	37
Lahai (30)	31	80	120	284	366	662	704	513	440	502	329	94
Koney (38)	20	57	114	249	301	504	513	362	294	401	227	58
	c. **Kottayam, Alleppey, Idukki and Ernakulam region**											
Kottayam (30)	19	32	59	162	268	598	606	421	311	293	205	54
Alleppey (26)	24	52	50	135	312	576	566	366	303	313	191	70
Thodupuzha (28)	18	42	86	260	308	695	803	558	395	425	248	84
	d. **Palghat and Trichur region**											
Palghat (31)	3	6	25	77	153	427	544	358	155	227	153	25
Palapilly (39)	4	7	23	108	264	716	776	459	296	298	136	31
	e. **Malapuram, Calicut and Cannanore region**											
Perinthalmanna (31)	2	8	22	82	19	711	808	456	262	270	174	31
Balusserri (38)	10	11	29	129	327	1021	1176	710	362	416	259	48
Kasaragod (21)	0	0	6	39	225	887	1106	690	318	175	89	22

* No of years of data is given in paranthesis

LIBRARY AND DOCUMENTATION CENTRE

The total collection of books has reached 20463 and that of bound periodicals 14482. The library subscribed to 283 periodicals. Among the journals, 200 were received as gift and 21 as exchange.

Both bibliographic searches and general information work were carried out. Three issues of Documentation list, containing 69 abstracts and two issues of Rubber Alert, containing 124 indexes on NR publications, were compiled and issued. Requests for photocopies of articles from local/overseas universities, institutions and scientists were appropriately entertained. As part of the information dissemination, about 1.6 lakh photocopies and about 80,000 duplicating copies of different information materials were made by the reprographic section. The library and documentation centre also organised translation of articles, news cliping service etc. for the better dissemination of natural rubber information. Database development of the library was taken up. Up to the end of the year, 3,500 documents have been indexed. The library actively participated in the sales promotion of the *Indian Journal of Natural Rubber Research*, and the books *Rubber wood Production and Utilisation* and *Plant and Soil Analysis*.

The facilities and services were also extended to planters, manufacturers and others connected with the natural rubber industry. Research scholars and students from universities and colleges also utilized these services. Scientists from other national research institutions visited the library for consultation and reference.

CONFERENCES AND SYMPOSIA

NATIONAL SYMPOSIUM ON NEW TRENDS IN CROP IMPROVEMENT OF PERENNIAL SPECIES, 30 AUGUST 1990, KOTTAYAM, INDIA.

A national symposium on new trends in crop improvement of perennial species was organized by the Botany Division on 30 th August 1990. The symposium was attended by over 150 delegates working on various aspects of perennial crop improvement. Two invited lead papers and ten contributed research papers pertaning to perennial species like tea, coffee, cardamom, rubber and forest trees were presented. A panel discussion which was organized as part of the symposium provided an ideal forum for the interaction of scientists and planters with experts in the field of parennial crop breeding as well as for the exchange of innovative ideas among plant breeders working on various perennial species.

BUDGET

(Rs in lakhs)

Sl no	Head of account	Approved budget	Actual expenditure
	Non Plan		
1.	General Charges	155.39	147.65
2.	Schemes	5.00	8.02
3.	Projects - CES	44.89	56.79
		205.28	212.46
4.	DOT 4.72	4.49	
	Total Non Plan	210.00	216.95
	Plan		
5.	General Charges	17.00	25.51
6.	Schemes	95.00	69.19
7.	NERDS Research Component	100.00	166.35
	Total Plan	212.00	261.05
	Grosss Total	422.00	478.00

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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
Sanjeeva Rao Popuri, M.Sc., Ph.D.	Meteorologist
S. Thankamony, M.Sc.	Entomologist
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
Annakutty Joseph, M.Sc.	Junior Scientist
Kochuthresiamma Joseph, M.Sc.	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
N. Usha Nair, M.Sc. (Ag.)	Biochemist
Molly Thomas, M.Sc., Ph.D.	Assistant Biochemist
K. U. Thomas, M.Sc., Ph.D.	Assistant Physiologist
R. Rajagopal, M.Sc., Ph.D.	Junior Scientist
S. Sreelatha, M.Sc.	Junior Scientist
A. S. Devakumar, M. Sc. (Ag.)	Junior Scientist
Modem Suhasini, M.Sc. (Resigned w.e.f. March '90)	Junior Scientist
P. K. S. Panicker, B.Sc.	Development Officer
Vidyalakshmy, M.Sc. (upto 5-2-91)	Junior Scientist
S. Visalakshi Ammal, B.Sc.	Senior Scientific Assistant
G. Gopinathan Nair	Assistant Farm Superintendent

Rubber Chemistry, Physics and Technology Division

N. M. Mathew, M.Sc., LPRI, Ph.D.	Deputy Director
Baby Kuriakose, M.Sc., LPRI, Ph. D.	Deputy Director
N. M. Claramma, M.Sc.	Rubber Chemist
K. T. Thomas, M.Sc., LPRI, M.Tech.	Rubber Technologist
K. Mariamma George, M.Sc.	Junior Scientist
N. Radhakrishnan Nair, M.Sc., M.Tech.	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., LPRI.	Senior Scientific Assistant

Accounts Section

M. G. Gopi	Assistant Director of Finance
Joy Cyriac, B.Sc., A.C.A.	Assistant Accounts Officer
N. Vijayamma	Section Officer

Admimistration Section

R. Soman	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

Library and Documentation Centre

V. K. G. Nair, B.Sc., D.Lib.Sc., ADI.Sc.	Documentation Officer
P. J. Lukose, B.A., B.Lib.Sc. (Retired on 30-4-90)	Senior Librarian
Mercy Jose, B.Sc., M.L.I.Sc.	DocumentationOfficer
Accamma C. Korah, B.Sc., M.L.I.Sc.	Librarian (Documentation)

Statistics Section

G. Subbarayalu, M.Sc.	Statistician
A. Malathy, M.Sc.	Assistant Statistician

Experiment Station at RRII

M. D. Issac	Assistant Farm Superintendent

Maintenance Wing

S. Mohanachanadran Nair, B.Sc. (Engg)	Electrical Engineer
T. K. Somanatha Pillai	Assistant Estate Officer
Sheela A. John, B.Tech.	Assistant Engineer (Civil)

Security Wing

A. K. Ramakrishna Pillai	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.
R. Harikrishnan, B.Sc., A.C.A.	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 Farm Superintendent

Hevea Breeding Sub Station, Tamil Nadu

T. A. Soman, M.Sc., M.Phil	Junior Scientist
S. Suma	Junior Scientist

Regional Research Station, Maharashtra

T. Mohanakrishna, M.Sc., Ph.D.	Plant Physiologist
T. R. Chandrasekar, M.Sc.	Assistant Botanist
K. Prathapan, M.Sc., (Ag.)	Junior Scientist
Lalith Mohan Nath	Assistant Section Officer

Regional Research Station, Orissa

Arun K. Nair, M.Sc. (Ag.), Ph.D.	Agronomist
P. Abdul Salam	Assistant Section Officer
R. Raveendran	Assistant Farm Superintendent

Regional Research Station, Assam

Radha Raman Sinha, M.Sc. (Ag.) Ph.D.	Deputy Director
Gopal Chandra Mandal, M.Sc., Ph.D.	Plant Pathologist
Ramphool Sing, M.Sc. (Ag.)	Junior Scientist
S. A. Saseendran, M.Sc.	Junior Scientist
Krishna Das, M.Sc. Ph.D.	Junior Scientist
Debasis Mandal, M.Sc.	Junior Scientist
Dilipkumar Daimari, M.Com.	Assistant Accounts Officer

Regional Research Station, Meghalaya

A. P. Thapliyal, M.Sc., Ph.D.	Plant Physiologisst
Hiranya Kumar Dekha, M.Sc., Ph.D.	Junior Scientist
Mohan Ram Rao, M.Sc.	Junior Scientist
K. R. Manjunath, M.Sc. (Ag.)	Junior Scientist

Regional Research Staton, Agartala

A. K. Krishnakumar, M.Sc. (Ag.), Ph.D.	Deputy Director
P. Mallinath Priyadarsan, M.Sc., Ph.D.	Plant Breeder
N. Dhurjati Chaudhari, M.Sc. (Ag.)	Plant Physiologist
Rajeswari Meenattoor, M.Sc. (Ag.)	Junior Scientist
D. V. K. Nageswara Rao, M.Sc. (Ag.)	Junior Scientist
Y. A. Nanja Reddy, M.Sc. (Ag.)	Junior Scientist
K. Chandra Gupta, M.Sc. (Ag.)	Junior Scientist
K. K. Vinod, M.Sc. (Ag.)	Junior Scientist
Jiban Chakrabrothy, B.Com.	Assistant Accounts Officer

Regional Research Station, Mizoram

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

High Altitude Research Station, Wynad

N. Reghunathan Nair, B.Sc. (Ag.)	Senior Superintendent

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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 Divison are investigations of 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 cytogentetic 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), Kamakhynagar (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 RRII has been 368 during the period under review. This inculdes 152 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

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