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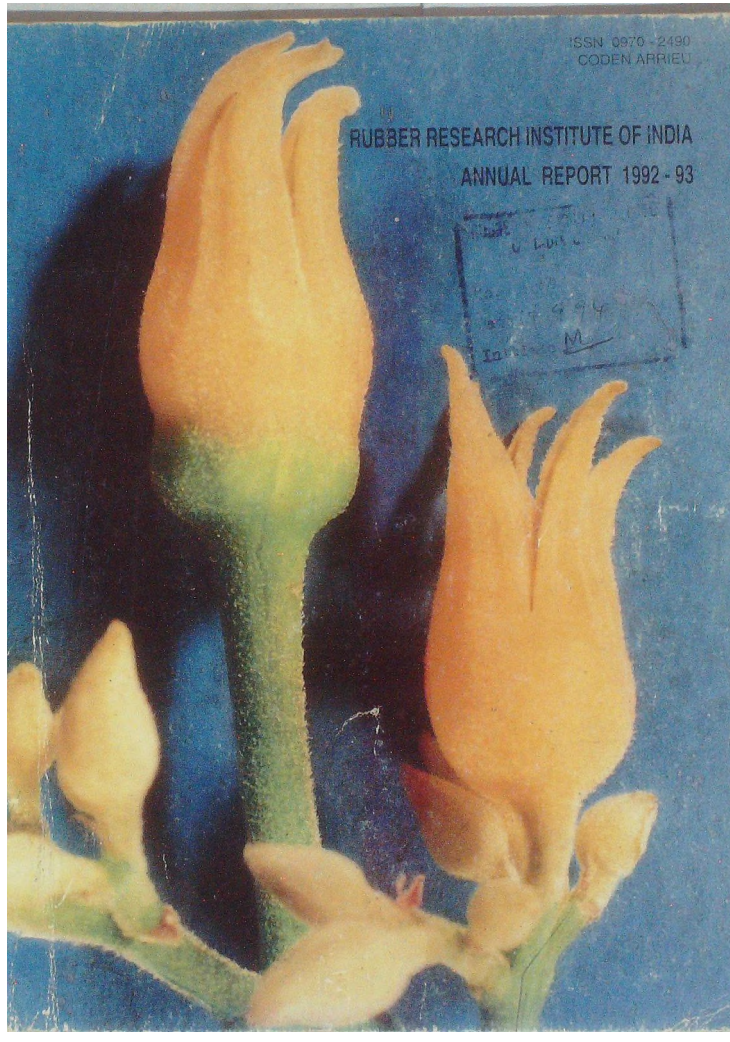
RUBBER RESEARCH INSTITUTE OF INDIA

ANNUAL REPORT 1992 - 93



Rubber Research Institute of India

Annual Report 1992-93

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Publisher

Dr. M. R. Sethuraj

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Cover

Female and male flowers of *H. brasiliensis*

Photograph

Mr. K. P. Sreerenganathan

July 1994

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) 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 ecouraging scientific, technological and economic research and dissemination of knowledge to the NR industry are the statutory functions of the RRII.

Organ isation

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

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KOTTAYAM-686009, 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 exercises control over all departments of the Board. The Rubber Research Institute of India works under the administrative control of the Board, the Director being the head of the institution. Besides RRII, there are five departments under the Board, viz. Administration, Rubber Production, Processing & Product Development, Finance & Accounts and Training.

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Processing & Product Development Department
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DIRECTOR'S REVIEW

The period under report represents a phase of changing research priorities. In the beginning of the last Five Year Plan period, the priorities of the Rubber Research Institute of India (RRII) were oriented towards attaining self-sufficiency by extending rubber cultivation, though with many enviormental and socio-economic constraints. Efficiency of productivity or cost of production under these varying situations with manifold constraints were given secondary importance to the primary objective of attaining self-sufficiency. The experimental results in our Regional Stations have given evidence to the magnitude of constraints resulting in heavy casualty during establishment, long gestation period and comparatively lower productivity. In most of these non-tradtional areas, the wage structure was low compared to the labour wages in traditional area. But with the advent of sweeping social changes this disparity is fast disappearing. With the introduction of the concept of liberalised global market economy, the sustainability of plantations would depend on the economic efficiency of the units. India has vast potential for export of finished rubber goods and the raw material price will become critical in determining the cost competitiveness of such industrial units. Therefore, our present research priorities are focused on increasing the efficiency of each unit, whether of a small farmer or of a corporate sector. Our research programmes are being reorganised towards addressing these objectives. In the technology scene, our past thrust was to conserve NR, but now with opening up of tremendous opportunities for export of finished rubber goods, R&D efforts on new products as well as on quality competitiveness become inevitable.

These conceptual changes are being translated into structural changes in our research priorities. Though the present annual report may not fully reflect this change adequately, because these are results of our past programmes, the future annual reports would be indicative of such changing priorities.

The Agronomy and Soils Division concentrated its research activities on nuturitional requirements, irrigation and water requirement, soil conservation, weed management and intercropping of rubber at various stages of growth in different agro-climatic regions. Studies were also in progress to refine foliar diagnosis through Diagnostic and Recommendation Integrated System (DRIS) approach. Based on soil and leaf sample analyses, fertilizer recommendations were also given to farmers.

The priority areas of research activities of the Botany Division continued to be breeding and selection of planting materials, anatomy, propagatation and cytogenetics. Special emphasis was given for evaluation of clones having comparable or better yield/yield attributes than

those of the clone RRII 105. Nine prepotent clones were selected. Due attention was also given to ortet selection programme. Laticifer area index showed the highest direct effect and highly significant positive correlation with yield. The Biotechnology Division continued its research efforts on shoot tip culture, somatic embryogenesis and isozyme studies. The Germplasm Division concentrated on research activities related to the introduction, collection and conservation of germplasm. A total of 4709 genotypes of Hevea brasiliensis is being manintained in the source bush nurseries. Emphasis was given to the evaluation, characterization and cataloguing of the germplasm. A programme for collection, conservation and evaluation of Ceara rubber (Manihot glaziovii) was also initiated, with a view to assessing its potential as an alternative minor source of NR.

The Mycology and Plant Pathology Division gave emphasis on crop protection aspects and the area of research activities were mycology, pathology, microbiology and entomology. Studies on pink disease were also in progress. For controlling shoot rot a new systemic fugicide Akomin was tried which gave better result than Bordeaux mixture. Rhizobium culture, which augumented the biomass production in Pueraria, were marketed to the planters in packets. Studies on the introduction and management of Apis mellifera colonies in rubber plantations were initiated.

The Plant Physiology and Exploitation Division continued its research activities in exploitation, crop physiology, stress physiology, bochemisttry and introduction of medicinal plants for intercropping. Multi-disciplinary research on Tapping Panel Dryness (TPD), as part of the international programme under the International Rubber Research and Development Board (IRRDB) was also in progress. Priority was given for popularising Controlled Upward Tapping (CUT) and investigations on TPD. The major research programmes of the Rubber Chemistry, Physics and Technology Division were primary processing, chemical modification of natural rubber, rubber techonology and product development. Studies on improving the solar drier system and use of sulphuric acid as an alternative latex coagulant were also in good progress.

The Regional Research Stations of RRII continued their activities on location specific research in Assam, Tripura, Meghalaya, Maharashtra, Mizoram, Orissa and West Bengal. The major thrust area has been the evaluation of clones suited for local conditions and developing agro-management techniques specifically suited for the respective region.

Volume 5 of the Indian Journal of Natural Rubber Research was brought out during the year. This contained thirty three scientific contrications, of which twelve were related to rubber chemistry and technology. The international contribution from outside India numbered eleven, the contributing countries being France, Indonesia, Malaysia, Nigeria, Sri Lanka and UK. The panel of advisers was revised to have global representation of experts on natural rubber research. The research programmes on TPD initiated by the IRRDB continued to be co-ordinated by the RRII. The institute also maintained academic linkages with several universities and other institutions of research and learning.

The Department of Training organised training courses for planters, product manufacturers, estate supervisors and scientific personnel and technical staff of the Rubber Board in which the scientists and officers of the RRII have served as faculty members. Progress in research programmes was explained to the farmers who visited the institute for familiarisation and on the spot study.

AGRONOMY AND SOILS DIVISION

The Agronomy and Soils Division concentrated on investigations on nutritional requirements, irrigation and water requrements, soil moisture management, soil conservation, intercropping and weed managment of rubber at various stages of growth in different agroclimatic regions. Attempts to refine foliar diagnosis through Diagnosis and Recommendation Integrated System (DRIS) approach, to improve fertilizer use efficiency through different forms and methods of fertilizer application and to characterise the rubber growing soils in the traditional region were also in progress. In addition to the Central Laboratory at RRII, eight regional laboratories are functioning under the Division to offer site specific and situation specific fertilizer recommendation to rubber growers.

1. Nutritional studies (immature phase)

1.1 The three experiments located in three estates (Mundakayam, Shaliacary and Kanthimathy) in different agroclimatic regions to assess the fertilizer requirement of modern high yielding clones were concluded. The optimum doses of N, P_2O_5 and K_2O were found to be 30, 30 and 20 kg ha^{-1} yr^{-1} respectively for the experiments at Shaliacary and Kanthimathy. In the case of the experiment at Mundakayam the responses were highly inconsistent.

1.2 The three experiments laid out in the three locations to assess the fertilizer requirement of clone RRII 105 were in progress. In the experiment at Kodumon Estate, Pathanamthitta district, the highest girth (December 1992) and girth increment (January 1991 to December 1992) were obtained by the combined application of 60 kg N, 30 kg P_2O_5 and 40 kg K_2O ha^{-1}. However, there was no significant difference between this treatment and the application of N, P_2O_5 and K_2O at the rate of 30, 30, and 20 kg ha^{-1}. (Table-Ag. 1).

1.3 The two experiments laid out at Koney Estate and RRII Farm in 1988 and 1989 respectively to evaluate the nutrient requirement of RRII experimental clones were continued. In the experiment at Koney estate, significiant clonal differences were noticed in the case of girth (1993). Clones RRII 203 and RRIC 100 were superior with highest girthing, compared to the other clones (Table-Ag. 2).

Table-Ag. 1: **Mean girth and girth increment**

Levels of NPK (Kg ha^{-1})			Girth (cm)	Girth increment (cm)
0	0	0	20.51	12.35
30	30	20	26.11	16.03
30	30	40	25.00	15.53
30	60	20	24.46	15.44
30	60	40	22.37	13.54
60	30	20	22.18	13.23
60	30	40	26.15	16.65
60	60	20	23.94	14.70
60	60	40	22.88	13.49
90	30	20	23.51	13.79
90	30	40	22.19	13.09
90	60	20	23.11	13.63
90	60	40	21.42	12.63
SE			1.05	0.85
CD			3.052	2.48

Table-Ag. 2. **Mean girth**

Clone	Girth (cm)
RRII 5	39.33
RRII 105	36.24
RRII 203	46.29
RRII 208	36.86
RRII 300	35.55
RRII 308	31.96
PCK 1	34.26
PCK 2	38.41
PB 311	39.24
RRIC 100	45.49
SE = 1.57	CD = 5.02

2. Nutritional studies (mature phase)

2. 1 Clonal/regional requirements

Seven field experiments in four locations on three high yielding clones were in progress. In the experiment at Vaniyampara Estate with clone RRII 105, application of N at 20 kg ha^{-1} and that of P at 40 kg ha^{-1} resulted in significant increase in girth 1992 (Table-Ag. 3).

Table-Ag. 3. **Mean girth (cm)**

N (kg ha^{-1})	P_2O_5 (kg ha^{-1})			Mean
	0	20	40	
0	60.47	60.55	64.76	61.93
20	63.52	64.20	66.59	64.70
40	63.98	63.94	64.12	64.01
Mean	62.59	62.89	65.16	
SE = 0.62				CD = 1.82

In the same experiment N, P_2O_5 and K_2O applied at the rate of 20, 20 and 30 kg ha^{-1} recorded the maximum yield of 90.31 g tree^{-1} tap^{-1} which was 38 g more than that of the control plot (Table-Ag. 4) during 1991.

2. 2 Micronutrient experiments

The field experiment started during 1991 in Cheruvally Estate (Erumely) to evaluate the effect of 'Boracol BSF-F', a micronutrient mixture containing Fe, Zn, Cu, Mo and B on the yield of rubber was continued. Observations on yield and girth of the trees are being summarised.

3. Density of planting, growth and yield

The experiment on density of planting at Shaliacary Estate was in progress. Observations on growth and yield were recorded and the data are being processed.

4. Irrigation and moisture management

4. 1 Immature rubber

The experiment comparing basin and drip methods of irrigation in Manjoor

Table-Ag. 4. Mean yield (g tree^{-1} tap^{-1})

Levels of nutrients (kg ha^{-1})	K_2O									Mean
	O			30			60			
	P_2O_5			P_2O_5			P_2O_5			
	0	20	40	0	20	40	0	20	40	
0 N	51.89	57.57	53.53	80.97	72.33	49.24	41.86	68.82	81.52	61.97
20 N	68.75	77.67	58.40	50.77	90.31	73.22	78.06	67.69	87.85	72.53
40 N	59.64	61.42	71.63	58.03	57.51	49.47	69.72	69.12	71.53	66.45
Mean	60.09	65.55	61.19	63.26	73.38	67.31	63.22	68.54	80.30	66.98
SE 1.56		CD 4.57								

Estate was continued. The trees attained tappable girth and observations on yield are being recorded.

4. 2 Water requirement of immature rubber (lysimeter technique)

Regular monitoring of water balance was done. The mean evapotranspiration of the two year old plant was found to be 3.51 mm per day.

4. 3 Soil and water conservation

The experiment started in 1988 has been in progress. No run off was collected in any of the plots. There was no significant difference in girth of the trees in January 1993 also and all the treatments appear to be effective in conserving soil and soil moisture.

5. Weed management systems

Attempts were made for the biological control of the weed *Chromolaena odorata* by the larvae of field reared *Pareuchaetus pseudoinsulata*. However the eggs of the third generation did not hatch.

6. Intercropping in rubber

6. 1 Immature rubber (CES, Chethackal)

Growth of the rubber was found to be affected in the intercropped plots. Among the intercropping treatments, maximum girth was recorded in the plot where black pepper alone was planted as intercrop.

6. 2 Mature rubber (CES, Chethackal)

Intercropping with coffee did not adversely affect the growth of rubber. Coffee had started yielding during 1991-92 onwards.

7. Forms and methods of fertilizer application

7. 1 Effect of methods of application of nitrogeneous fertilizers

Girth data obtained was statistically analysed. No significant differences were noticed between broadcast, ring and pocket methods of application during the fifth year.

7. 2 Effect of water soluble and insoluble forms of phosphatic fertilizers on the growth of rubber

This experiment was started in 1989 in two locations (Vaniyampara, Trichur district and Kinalur, Calicut district) to evaluate the efficiency of different sources of N and P_2O_5. Girth increment data during the period 1989 to 1993 are furnished in Table-Ag. 5.

No significant difference was obtained between water soluble and insoluble forms of P-fertilizers. However, response to

Table-Ag. 5. Girth increment (cm)

Treatments	Vaniyampara	Kinalur
40 kg P_2O_5 (RP)+40 kg N(AS)ha^{-1}	19.4	23.6
40 kg P_2O_5 (RP)+40 kg N(urea)ha^{-1}	19.6	23.5
40 kg P_2O_5 +40 kg N (AP 20:20)ha^{-1}	19.8	23.6
40 kg P_2O_5 (SSP)+40 kg N(AS)ha^{-1}	20.0	23.4
40 kg P_2O_5 (SSP)+40 kg N(urea)ha^{-1}	19.5	24.5
Control (no manuring)	16.9	20.3
CD	2.3	2.8

RP - Mussorie rock phosphate, AS - Ammonium sulphate, AP - Ammonium phosphate, SSP - Single super phosphate

applied fertilizers was obtained in both locations. The pH of the soil in these two locations ranges from 5.0 to 5.1

7. 3 Sources of phosphorus for rubber and associated cover crops

The field study on immature rubber initiated in 1988 to evaluate the effectiveness of bowl sludge, a waste product from latex centrifuge factory, was being continued. Results indicated that the sludge as a phosphatic source was comparable to two other sources assessed viz., superphosphate and Mussorie rock phosphate. The potential savings by using the sludge as a source of phosphorus was estimated to be Rs.22.30 lakhs per annum.

7. 4 Dynamics of K in rubber growing soils and other related studies

A fertilizer experiment on RRIM 600 with graded levels of K_2O (0, 15, 30, 45, 60, 75 and 90 kg ha^{-1}) was started in 1990. After the continuous application of treatments for two years the yield data indicates that the dry rubber yield is the highest with 60 kg K_2O ha^{-1} application followed by 30 kg K_2O ha^{-1}. Application of K_2O at 75 or 90 kg ha^{-1} did not increase the volume of latex or the dry rubber content.

8. Physico-chemical properties of rubber growing soils

8. 1 Effect of continuous cultivation of rubber on soil properties

In order to investigate the effect of continuous cultivation of rubber, profiles were taken from estates in four locations (Nilambur, Chemoni, Mundakayam and Vithura) where rubber was cultivated for three consecutive cycles. Samples were taken from adjoining forest also. Soil samples were analysed for physico-chemical properties. Significant reduction in pH was observed due to rubber cultivation. Total and available P, total iron, sesquioxides and DCB extractable iron were significantly high in rubber cultivated area. High iron content indicates advanced stage of weathering due to rubber cultivation. Moisture retention assessments indicated significant reduction in available moisture in the rubber cultivated area.

8. 2 Subsoil acidity and aluminium toxicity in rubber growing soils and its amelioration

The distribution of exchangeable Al concentration in soils of major rubber growing tracts was studied. Soil samples upto a depth of 150 cm at 25 cm interval from the surface were collected from four locations and their exchangeable Al content was estimated.

The results (Table-Ag. 6) indicated that there was significant difference in Al concentrations between depths and also between locations. Nilambur and Vithura had the highest values followed by Chemoni and Mundakayam. At Nilambur, Mundakayam and Vithura the highest concentrtion was noticed at 50-75 cm layer whereas at Chemoni the zone of higher Al concentration was the 100-125 cm layer.

Table-Ag. 6. **Distribution of aluminium (meq 100 g)**

Location	Depth (cm)						Mean
	0-25	25-50	50-75	75-100	100-125	125-150	
Nilambur	0.36	0.99	2.23	1.35	1.33	0.65	1.15
Chemoni	0.68	0.75	0.58	1.11	1.23	1.03	0.90
Mundakayam	0.48	0.50	1.35	0.46	0.24	0.38	0.57
Vithura	0.90	0.74	1.64	1.38	1.18	0.98	1.14
Mean	0.61	0.75	1.45	1.08	1.00	0.76	

CD for comparison of places = 0.28 CD for comparison of depths = 0.34
CD for comparison of place x depth = 0.68

8. 3 **Distribution of S in rubber growing soils**

Horizonwise samples were collected from four profiles of conventional rubber growing areas (Kanyakumari, Kottayam, Trichur and Calicut) and from a non-traditional region (Dapchari, Maharashtra). The samples were analysed for mechanical composition, organic carbon, pH, total sulphur and avilable sulphur. It was found that total sulphur content was the highest in Dapchari soil and avilable sulphur in Calicut soil. The lower horizons contained lesser amount of available as well as total sulphur.

9. DRIS approach for interpretation of foliar analytical data and diagnosis of nutrient balances

A computer programme was developed for the calculation of DRIS indices for individual sample analytical values for the nutrients N, P, K, Ca and Mg, keeping the general DRIS norms developed as standard values. For a large number of samples nutrient indices were calculated and the DRIS diagnosis were compared with the sufficiency range approach. Simple agronomical trials on mature rubber were inititated to compare the fertilizer recommendation based on DRIS with the present discriminatory fertilizer recommendation system and blanket recommendation.

10. Collaborative studies

The Division is collaborating in the Institute project on tapping panel dryness, to study the possible role of nutrition. In this connection 72 soil, 122 leaf, 36 bark and 40 latex samples were analysed for macro and micro nutrients. In the project on medicinal plants in rubber plantations the Division analysed 42 soil and 18 leaf samples.

11. Advisory work

Analyses of 7415 soil and 1686 leaf samples were conducted at the regional laboratories for offering fertilizer recommendations. In the central laboratory at RRII, 887 leaf and 1118 soil samples were analysed and fertilizer recommendations offered.

BIOTECHNOLOGY DIVISION

The primary responsibility of the Division is to develop different procedures in biotechnology with a multidirectional approach in order to facilitate the main objective of rubber crop improvement

1. Somatic embryogenesis

The integumental tissue of the immature fruits were the explant source. Callus was induced on this tissue and from this callus mass, localized white and friable tissue formation occurred. Embryogenesis was confined to this friable callus where they appeared in asyncroneous fashion, first globular in shape subsequently turning into the shape of miniature zygotic embryos. These embryos regenerated into plants. However, extensive procedural refinements are warranted to improve this plant regeneration pathway. This pathway may prove very useful in developing a system for large scale propagation of rubber once a commercial level protocol is developed.

2. *In vitro* propagation by shoot tip/ meristem culture

This is an ongoing effort to generate plants every year, utilizing the experimental plant regeneration pathway developed previously. About 250 plants were generated. One of the major constraints to enhance the production number is the lack of a plant hardening facility where temperature, humidity and light are controlled.

3. Isozyme study

Polymorphic isozyme expression caused among a population of bud-grafted RRII 105 clone was investigated. The results showed remarkable variations within a clone in the isozymic banding pattern of aspartate amino transferase, leucine amino peptidase, acid phosphatase, alkaline phosphatase and glucose phosphate isomerase. This variation noticed within a clone may be due to the polymorphic rootstock genome influencing the scion.

BOTANY DIVISION

The thrust of investigations of the Botany Division is on genetic improvement through hybridization and clonal selection. Emphasis is also being given for ortet selection, propagation and genetic studies. Investigations on anatomy of bark and wood and cytogenetics are also in progress

1. Evolving high yielding clones for traditional area

1. 1 Hybridization and clonal selection

Secondary characters and annual girth were recorded from 565 hybrid clones planted in 26 small scale trials covering an area of 20 ha. Monthly yield recordings were done from all mature trials. Sixty three clones from 1982 hybridization programme were opened for tapping and data on yield components were recorded. Evaluation of 23 hybrid clones resultant of the cross RRII 105 x RRIC 100 of the 1985 small scale trial at the age of 54 months revealed significant clonal variation for yield and yield attributes (Table-Bot. 1).

Ten clones were selcted from among the progenies of the 1988 hybridization programme and a small scale trial was laid out employing a randomised block design. Juvenile yield and growth of 10 families at 24 months in the nursery showed that RRII 105 x Haiken progenies from the parental combination RRIM 600 x PB 5/51 gave the highest yield followed by RRII 105 x Haiken 1, RRIM 600 x RRII 203, RRIM 600 x RRII 203 and RRII 105 x PB 260. There was significant difference between the families for plant height, girth and juvenile yield (Table-Bot. 2).

Among the 18 families resultant of 1989 hybridization programme, juvenile yield at three years revealed that the

Table-Bot. 1. **Yield and yield attributes in hybrid clones 54 months after planting**

Characters	Mean	Range	Variance ratio**
Mean annual yield (g tree^{-1} tap^{-1})	11.41	4.35 - 10.90	1.37
Peak yield (g tree^{-1} tap^{-1})	22.51	7.40 - 40.57	7.18
Summer yield (g tree^{-1} tap^{-1})	2.88	1.27 - 5.26	5.36
Yield following ethrel stimulation (g tree^{-1} tap^{-1})	36.68	8.14 - 61.25	6.96
Initial flow rate/unit length of tapping cut (ml min^{-1} cm^{-1})	0.07	0.022 - 0.136	5.31
Total volume of latex (ml tap^{-1})	30.17	4.42 - 61.83	2.46
Plugging index	7.03	2.50 - 13.68	4.79
Girth at opening (cm)	35.42	31.34 - 39.82	2.60
Girth increment on tapping (cm)	5.06	3.47 - 7.25	4.73
Number of latex vessel rows	5.57	3.67 - 8.22	2.76
Bark thickness (mm)	5.58	5.09 - 6.34	2.76

**Significant at 1% level

Table-Bot. 2. **Juvenile attributes in hybrid families**

Family	Height (m)	Girth (cm)	Juvenile yield (g10 tap^{-1})
RRII 105xRRII 203	4.05	12.57	1.75
RRII 105xPB 260	5.00	15.40	2.48
RRII 105xPB 311	4.75	12.80	2.07
RRII 105xHaiken 1	3.60	13.17	2.95
RRII 105xRO/J/5/33/80	4.00	12.50	0.92
RRIM 600xRRII 203	4.35	12.83	2.54
RRIM 600xPB 235	4.47	12.05	1.82
RRIM 600XPB 260	4.33	13.34	1.75
RRIM 600XPB 5/51	4.88	13.64	3.83
RRIM 118xRRIM 600	4.70	14.13	2.01
General mean	4.41	13.24	2.21
Variance ratio	3.49**	2.03*	2.12*
CV %	16.18	16.84	77.71

combination RRIM 600 x PB 242 is the best (1.98g). The seedlings of the 1990 hybridization programme resultant of cross combination involving the newly introduced Brazilian germplasm were subjected to nursery evaluation. Among the 12 cross combinations juvenile yield at 2 years was the highest (2.22g) in RRII 105 x RO/JP/3/22/6. Of a total of 130 seedlings test tapped, 16 recorded juvenile yield above 2g. Incorporating 22 and 45 clones each of materials from the 1986 and 1988 hybridization programmes, field experiments for clonal nursery evaluation were laid out, with RRII 105 as control. Early growth vigour of ten months old polybag plants revealed that eight and fourteen clones respectively recorded substantial differences in girth and plant height in comparison to the control. During 1993 flowering season 8000 controlled pollinations were carried out incorporating 20 different cross combinations among parent clones selected based on yield components.

1. 2 Ortet selection

Annual girth recording three years after planting in the small scale trial at Mundakayam Estate revealed that out of 49 ortet clones, 34 clones showed relatively better girth when compared to RRII 105 and 15 clones exhibited better girth than GT 1. Casualties were supplied in the samll scale trial of 47 ortet clones planted at Koney Estate. The immature trial comprising 61 clones at Cheruvally Estate was maintained properly.

At CES, Chethackal, a trial comprising ten ortet clones selected from various small holdings was laid out in a randomised block design. Thirteen ortets from Kodumon Estate were multiplied and raised in polybags along with two controls (RRII 105 and RRIM 600). Five high yielding ortet clones from small holdings were multiplied

1. 3 Special techniques in breeding

Monthly yield recording and annual girth measurements were continued in the trials of the polyploid population and clones developed from seed irradiation. Five promising clones were multiplied and raised in polybags for further evaluation. A trial was laid out at CES incorporating seven selected clones from the irradiated population and RRII 105 as control.

2. Evaluation of clones

2.1 Large scale trials

In the two large scale trials of nine and eight modern clones planted at Central Experiment Station during 1989, girth data during the third year showed that PB 312 and PB 235 in trial 1 and RRIM 600 and KRS 25 in trial 2 are the most vigorous.

In the two multidisciplinary evaluation trials of 13 clones each planted in 1989 at RRII Farm, mean annual girth during the third year was the highest in RRII 118

(33.78 cm) in comparison to 28.30 cm for RRII 105 in trial 1 and in PB 314 (28.87 cm) in comparison to 25.36 cm in RRII 105 in trial 2.

Mean yield of the selections from 1956 hybrid clones for 1991 showed that compared to the control PR 107 all the clones are performing well. Among the selections RRII 202, RRII 209, RRII 204 and RRII 203 are the top yielders (Table-Bot. 3).

Table-Bot. 3. **Yield of selections from the hybird clones evolved in 1956**

Clones	Mean yield during 1991 (g tree^{-1} tap^{-1})
RRII 201	56.41
RRII 202	78.58
RRII 203	68.81
RRII 204	72.17
RRII 205	47.98
RRII 206	66.28
RRII 207	54.72
RRII 208	63.34
RRII 209	73.59
PR 107	42.02
SE	2.89
CD	20.47

In the foreign clone trial laid out in 1971, RRIM 701 recorded the highest yield (66.20g/tree/tap) during 1991-92 season. Girth was the highest in the case of GT 1 (92 cm). During 1991 RRIC 100 and RRIC 102 were the highest yielders in the Sri Lanka clone trial. As in previous years RRIC 52 continued to be the most vigorous and *Oidium* tolerant clone. From the mixed clone trial laid out in 1981, RRII 45 and PCK 1 recorded the maximum yield (51.95g and 50.75 g/tree/tap respectively) during 1991. RRII 44 and PB 235 continued to be more vigorous than the others during 1992 also.

2. 2 On-farm evaluation

Among the 12 clones in block trial at Malankara, RRII 105 continued to be the highest yielder followed by RRIM 703. RRIC 102 recorded the lowest incidence of brown bast, wind damage and pink, powdery mildew and abnormal leaf fall diseases. In another block trial of 12 clones at Chithalvetty Estate, girth at the year of opening was the highest for PB 235 followed by PB 260. The trial was opened for tapping and monthly yield and DRC were recorded. Among eight clones in a trial at Manikkal estate PB 235 recorded the highest mean girth during the sixth year. A block trial of six clones was laid out at Shaliacary Estate and six clones were supplied for a block trial proposed for 1993.

3. Performance of clonal composites

With a view to studying the performance of clonal composites, an experiment involving varying proportions of selected clones was laid out at CES, Chethackal along with a control plot of RRII 105 during 1992 planting season. A similar experiment was also laid out at RES, Nagrakata, West Bengal. Arrangements were made to take up an on-farm trial on clone blending in one large estate during 1993 and the plants were raised in polybags. Observations on yield in one on-farm trial with six clones (RRII 105, RRII 300,PB 311, PB 235, PB 217 and RRIM 600) in blend showed an encouraging yield trend.

4. Polycross progeny evaluation

One hundred and fifty clones comprising polycross progenies of nine prepotent parents were multiplied and established in a polybag nursery for laying

out an experiment on evaluation of progenies of prepotent clones.

5. Breeding for clones with high yield and compact canopy

Growth attributes of the different morphotypes from the genetic variant, planted at CES, Chethackal were recorded. Significant variations were noted for all the parameters except diameter (Table-Bot. 4). A total of 625 seedlings rsultant of open pollination were raised in the nursery. Morphological characters were recorded at the age of 10 months. Among these seedlings seven per cent showed dwarf stature and 26 per cent, semidwarf stature. The seedlings showing vigour and dwarf stature were multiplied and raised in polybags along with RRII 105 for further evaluation. A total of 1300 hand pollinations were carried out incorporating the genetic variant and clones having high yield and vigour.

6. Breeding for drought tolerance

Observations on yield and girth of forty clones were recorded at monthly intervals.

7. Breeding for powdery mildew resistance

Sixteen selected clones were established in a polybag nursery for field planting in 1993 with a view to screening clones for their reaction to powdery mildew.

8. Evaluation of popular clones

A study was initiated in seven large estates for the evaluation of yield and secondary characters of popular clones such as PB 235, PB 217, PB 311, PB 260, PB 28/59, RRII 105, RRIM 600 and GT 1.

9. Estimation of genetic parameters

9. 1 Variability, correlation and heterosis for yield and yield components

Variability and genetic parameters for yield and five biochemical yield attributes viz., total solids content, thiols, sucrose, inorganic phosphorus and magnesium were assessed in seven hybrid clones of a cross of 'RRII 105 x PR 107 at the age of 54 months after field planting. The hybrids displayed significant variation for yield and yield attributes. Among the characters studied magnesium content exhibited the highest heritability of 82% with a GA of 118% (Table -Bot. 5). Correlation estimates revealed most of the characters to have significant positive correlation with yield. Except in the case of total solids content all other characters revealed positive association both at genotypic and at phenotypic levels (Table-Bot. 6).

Table-Bot. 4. **Growth attributes of the progenies of genetic variant**

Morphotypes	Height (cm)	Diameter (mm)	No. of leaves	Petiole length (cm)	Inter whorl length (cm)
Dwarf	61.64	10.45	29.40	4.39	5.36
Semidwarf	63.76	9.42	16.76	5.01	5.74
Intermediate	91.40	11.40	21.72	9.90	8.16
Normal	91.34	10.39	19.96	10.46	9.92
Control	102.84	11.65	22.24	15.48	11.92
General mean	82.24	10.66	22.02	9.05	8.22
S.E.	4.47	0.52	1.79	0.49	0.91
C.D.	13.40	—	5.37	1.47	2.73

Table-Bot. 5. **Genetic parameters for yield and biochemical attributes 54 months after planting**

Characters	Mean	Range	Variance ratio	Coefficient of variation Genotypic	Phenotypic	Heritability (H^2 %)	GA over mean (%)
Yield (g tree^{-1} tap^{-1})	20.06	6.67—49.61	6.745	63.82	78.74	65.69	107.06
TSC (%)	44.72	37.58—48.14	3.148	7.05	10.91	41.74	9.21
Thiol (µg/g)	104.68	29.43—204.15	6.241	48.52	60.85	63.60	78.96
Sucrose (µg/g)	9.96	6.61—13.95	5.217	21.53	28.17	58.00	33.65
Inorganic phosphorus (µg/g)	2025.91	561.30—5304.23	10.439	74.13	85.16	76.00	135.00
Magnesium (µg/g)	984.49	137.38—2147.87	14.767	63.08	69.84	81.50	118.18

Table-Bot. 6. **Genotypic and phenotypic correlation coefficients among yield and yield attributes**

Characters	Yield	TSC	Thiol	Sucrose	Inorganic P	Magnesium
Yield	1	-1.13	0.737	0.537	1.035	0.796
TSC	-0.711	1	-0.844	-0.679	-1.15	-0.918
Thiol	0.686	-0.719	1	0.813	0.813	0.929
Sucrose	0.392	-0.742	0.718	1	0.601	0.554
Inorganic phosphorous	0.903	-0.785	0.718	0.554	1	0.866
Magnesium	0.601	-0.739	0.775	0.644	0.734	1

Values above the diagonal show genotypic correlations and those below the diagonal phenotypic correlations

9. 2 Estimation of combining ability for parental selection

Test tapping and recording of monthly yield were continued in the 1987 trial. Girth was recorded 30 months after planting in the 1990 parent progeny trial laid out at HBSS, Nettana. Out of the 12 parental clones, GT 1, PB 235 and PB 5/51 recorded high girth (14.52, 13.67, 13.27 cm respectively) and PB 86 recorded the lowest girth of 9.57 cm. Among the progenies, those of RRII 105, PB 235 and RRII 203 recorded high girth (18.66, 18.56, and 18.05 cm respectively) and progenies of PB 213 recorded the lowest (15.06 cm). However, progenies of all the 12 clones excelled their respective parental clones with regard to girth, the progeny mean being 17.02 cm as against the parental mean of 11.71 cm.

9. 3 Genetic divergence, prepotency and inbreeding depression

The experiment was concluded during the period under report. Estimates of genetic parameters for yield and yield components at the fourth year of tapping (Table-Bot.7) indicated predominance of additive gene action for dry rubber yield and rate of latex flow and non additive gene action for dry rubber content, girth and bark thickness.

Seedling progeny analysis revealed

Table-Bot. 7. **Estimates of genetic parameters for yield and yield components at the fourth year of tapping**

Characters	Mean	Coefficient of variation		Herita-bility %	Genetic advance %
		Genotypic	Phenotypic		
Dry rubber yield (g tree^{-1} tap^{-1})	46.2	26.2	38.1	47.5	37.2
Yield depression under stress (%)	30.1	21.2	29.5	28.8	23.5
Volume of latex (ml tree^{-1} tap^{-1})	142.9	20.8	34.4	36.6	25.9
Dry rubber content (%)	34.8	8.5	10.3	67.8	14.4
Latex flow rate (ml minute^{-1})	4.7	22.3	31.4	50.5	32.7
Plugging index	4.4	17.7	27.2	42.6	23.8
Girth (cm)	72.9	9.0	12.8	49.5	13.0
Girth increment rate (cm year^{-1})	3.8	18.0	31.8	31.9	20.9
Length of tapping panel (cm)	42.5	7.0	13.5	27.1	7.5
Bark thickness (mm)	7.4	10.0	15.8	39.5	12.9
Total chlorophyll content (mg per g fresh weight)	3.3	10.9	23.3	21.9	10.5
Chlorophyll a:b ratio	1.21	9.2	42.3	4.9	4.2

that nine clones showed high performance indices and a high percentage recovery of superior seedlings in their progeny. These clones viz, RRII 105, AVT 73, PB 215, PB 217, PB 28/83, PB 242, PB 252, PB 5/51 and Ch 26 were identified as prepotents.

The study on inbreeding depression revealed a low fruit set under selfing when compared to open pollination. No significant inbreeding depression was observed in one year old selfed progenies of the clones studied.

10. Cytogenetical investigations

Pachytene and karyotype analyses, and pollen studies were initiated in popular clones. Morphological characters of stainable pollen grains from diploid, synthesized triploid and tetraploid were studied. The size of the pollen grains of tetraploid was the highest (Table-Bot. 8) followed by those of the triploid and diploid.

11. Floral biology and fruitset

To elucidate the causes of low fruit set in *H. brasiliensis* two popular clones were selected and hand pollinated. Fruits at different developmental stages were collected, processed and paraffin sectioning is being done. Structural aspects of aborted ovule are under study.

12. Bark anatomical investigations

12. 1 Variability, correlations and path coefficient analysis for yield in relation to anatomical characters with emphasis to tapping panel dryness, leaf diseases and drought tolerance.

Genotypic correlations of bark anatomical characters and girth at the time of opening of the tree for exploitation, with subsequent yield over three years were estimated from ten clones planted in RBD with three replications. The cause and effect relationships were studied. Laticifer area index showed the highest direct effect and highly significant positive correlation

Table-Bot. 8. Morphological characters of stainable pollen grains from diploid, triploid and tetraploid clones of *Hevea brasiliensis*

Parameters	Diploid		Triploid		Tetraploid	
	Mean	Range	Mean	Range	Mean	Range
Polar diameter (µm)	34.98 ± 0.48	29.70 - 36.30	46.50 ± 2.04	35.00 - 52.50	29.20 ± 3.26	45.00 - 62.50
Equatorial diameter (µm)	28.61 ± 0.49	24.75 - 31.55	37.90 ± 1.80	30.00 - 45.00	42.48 ± 2.37	30.00 - 50.00
Exine thickness (µm)	3.00 ± 0.24	2.50 - 4.50	3.33 ± 0.98	3.00 - 5.00	5.54 ± 0.41	3.00 - 6.00
Ora diameter (µm)	4.00 ± 0.31	3.75 - 5.80	4.50 ± 0.63	4.00 - 6.00	5.82 ± 0.27	5.00 - 7.00

with yield. The number of latex vessel rows showed significant positive correlation with yield but its direct effect was negative. Genotypic correlation between yield and girth was negative while girth, number of latex vessel rows and diameter of latex vessels contributed to yield via laticifer area index. The intensity of laticifer anastamosing showed positive direct effect on yield (Table-Bot. 9 and 10).

12. 2 Studies on bark renewal

In connection with the studies on the process of bark regeneration, microscopic observations and photomicrography of bark samples are under progress,

12. 3 Estimation of anatomical parameters of clones under different stages of evaluation

Bark thickness, number of latex vessel rows and the mode of latex vessel distribution of a tetraploid of RRII 105, suspected tetraploid of RRII 116, a synthesised triploid and the diploid control (RRII 105) planted in 1982 at the RRII Experiment Station, were studied at the year of opening for tapping (Table-Bot. 11). The tetraploid of RRII 105 recorded the highest bark thickness while the highest number of latex vessel rows was recorded for the triploid. Latex vessel rings were found distributed in groups in the triploid.

Bark thickness and number of latex vessel rows in the virgin bark of ten clones planted in a statistically laid out trial was estimated at the year of opening for tapping. The clones are PB 235, PB 260, PB 311, PB 310, PCK 1, PCK 2, RRIM 600, RRII 105, RRII 45 and RRII 44. PB 311 recorded the highest number of nine latex vessel rows while its bark thickness was low (4.83 mm).

13. Wood anatomical investigations

To study the effect of ethrel stimulation on quality of rubber wood, two

Table-Bot. 9. **Cause and effect relationships of girth and bark anatomical characters (at opening) on mean yield over subsequent three years**

Characters	Girth	Laticifer area index	Diameter of latex vessels	Density of latex vessels	Intensity of anastamosing	No. of latex vessel rows	Ray height	Ray width	Genotypic correlations
Girth	-0.4806	0.4971	0.3252	-0.0108	-0.0431	0.2296	0.0135	0.0858	-0.0336
Laticifer area index	-0.1304	1.8315	-0.3702	-0.0074	-0.0038	-0.6254	-0.0031	-0.0001	0.6910**
Diameter of latex vessels	-0.2398	1.0402	-0.6517	-0.0166	0.0253	-0.0271	0.0114	0.0616	0.2033
Density of latex vessels	0.1885	-0.4919	0.3928	0.0275	0.0866	0.1020	0.0022	-0.1268	0.1809
Intensity of anastamosing	0.0821	-0.0276	-0.0653	0.0095	0.2523	0.0917	0.0012	-0.0415	0.3022
Latex vessel rows	0.1327	1.3775	-0.0212	-0.0034	-0.0278	-0.8315	-0.148	-0.0227	0.5888**
Height of phloem rays	0.1303	0.1123	0.1481	-0.0012	-0.0059	-0.2461	-0.0499	-0.0349	0.0528
Width of phloem rays	-0.2359	-0.0013	-0.2297	-0.0200	-0.0599	0.1079	0.0100	0.1749	-0.2541

Residual = 0.5534

Table-Bot. 10. **Genotypic correlations of girth and bark anatomical characters (at opening) with mean yield over subsequent three years**

Characters	Girth	Laticifer area index	Latex vessel diameter	Latex vessel density	Intensity of anastamosing	Latex vessel rows	Ray height	Ray width
Yield	-0.0336	0.6910**	0.2033	0.1809	0.3022	0.5888**	0.0528	-0.2541
Girth	1	0.2714	0.4990**	-0.3922*	-0.1709	-0.2762	-0.2712	0.4909**
Laticifer area index		1	0.5680**	-0.2686	-0.0151	0.7521**	0.0613	-0.0007
Vessel diameter			1	-0.6028**	0.1002	0.0325	-0.2273	0.3524
Vessel density				1	0.3433	-0.1226	-0.0441	0.7254**
Intensity of anastamosing					1	-0.1102	-0.0233	-0.2376
Latex vessel rows						1	0.2959	-0.1297
Ray height							1	-0.1994

* Significant at 5% level ** Significant at 1% level

Table-Bot. 11. **Bark anatomical traits of certain cytotypes in *Hevea***

Materials	No. of latex vessel rows	Bark thickness (mm)	Mode of latex vessel distribution
Tetraploid of RRII 105	9.60 ± 0.47	6.24 ± 0.25	Distributed type
Triploid	10.55 ± 0.54	5.73 ± 0.19	Grouped
Suspected tetraploid of RRII 116	8.08 ± 0.29	5.27 ± 0.15	Distributed
Diploid of RRII 105	9.23 ± 0.44	5.71 ± 0.17	Distributed

popular clones (RRII 105 and RRIM 600) were selected and stimulant applications were continued as per the schedule.

14. Studies on propagation

Growth characters of the plants in the trial on depth of planting were studied. Bag plants continued to surpass all types of budded stumps with respect to girth. Among budded stumps, those budded 45 cm above the collar showed maximum girth. Among bag plants those crown budded below the third whorl and second whorl of leaves attained comparatively better growth. Data collected from the nursery trial on bench grafting were summarised (Table-Bot. 12). Growth of the trees in the field trial was also recorded. Bench grafts showed marginally better growth than nursery grafts. A nursery trial with green buddings was initiated.

Growth characters of the plants in the trial on deep planting were recorded. Plants with the bud union buried 10 cm deep were found to grow more vigorously than others. Deep planted plants in general showed better growth than normally planted bag plants. A comparative study of polyclonal and assorted seedlings was initiated and plants were raised in nursery. Seedlings were also raised in bags for destructive samplings of roots and shoots.

15. Genetic basis of stock scion relationship

Yield and secondary characters of the trees were recorded. The data on girth were summarised. Trees of clone RRII 203 budded on to assorted and own stock showed maximum girth (39.67 cm and 39.16 cm respectively), while the general mean was only 29.06 cm. Another field experiment on 3 x 3 stock scion combination is in progress. Growth characters of plants in the trial were recorded.

16. Studies on early evaluation

A field experiment of 10 selected clones coming under high, medium and low yield groups was laid out employing randomised block design. Growth attributes of one year old polybag plants of 10 clones coming under low, medium and high yielding categories showed that PB 235, RRII 105 and RRIM 600 are the vigorous clones.

General

Nucleus quantities of budwood of clones RRIC 102, RRIM 703, PB 280, PB 312, PB 314 and PB 330 were supplied to Shaliacary Estate for taking up block trials. Another set of nucleus material of clones RRII 5, RRII 203, PB 28/59, PB 217, PB 280, PB 314, RRIM 703, PCK 1, RRIC 102 and SCATC 88/13 were supplied to Gokul Rubbers, Vithura. Budwood of clones PB 28/59 and PCK 1 were supplied to Chemoni Estate for taking up trials on clone blend planting.

Table-Bot. 12. **Comparative performance of bench grafts and nursery grafts in nursery trial**

	Budding success (%)	Establishment success (%)	Plant height (cm)	Scion diameter (mm)	No. of leaves	No. of leaf flushes
Bench grafts	83.60	55.40	88.59	11.07	21.56	3.97
Nursery grafts	94.73	80.80	68.44	9.56	15.78	3.37
Variance ratio	_	_	61.97**	37.31**	115.69**	70.08**

** Significant at 1% level

GERMPLASM DIVISION

The Germplasm Division continued to concentrate on activities related to introduction, collection, conservation and evaluation of *Hevea* germplasm.

1. Introduction, collection and conservation of germplasm

1. 1 Wickham materials from the secondary diversity centres

Budwood materials of 12 clones of exotic and indigenous origin from the clone museum were supplied to the North East Research Complex for establishing a source bush nursery. Nucleus materials were supplied to Plant Physiology Division for the initiation of an experiment on rooting of cuttings. The clone museum has been maintained well.

Five IRCA clones already introduced from Ivory Coast were raised in polybags. 40 plants of each clone were planted in a statistically laid out trial for evaluation at the Central Experiment Station. Preliminary observations on the girth, height, total number of whorls and the number of leaves per whorl were recorded. Fifteen polybag plants of the clone IRCA 18, 109, 111, 130 and 230 were supplied to the Botany Division on request as nucleus materials, and action has been taken to conserve the IRCA clones in the budwood nursery.

1. 2 Wild germplasm from the 1981 IRRDB exploration

A total collection of 4709 genotypes is being maintained in source bush nurseries at CES. Routine cultural operations were carried out.

2. Evaluation of germplasm

2. 1 *In situ* conservation gardens

Evaluation of the Wickham materials *in situ* was continued. Girth and yield were under observation in all the three germplasm gardens.

Genetic divergence studies on 35 clones in germplasm garden were also continued. Observations were taken at intervals of three months for the characters viz bark thickness, plugging index, total volume of latex, dry rubber content and yield. Girth is being recorded every month. Bark samples of these clones were collected for anatomical observations.

A total of 43 trees belonging to different clones was either partially or severely affected by wind and some trees of 18 clones showed symptoms of dryness.

2. 2 Nursery evaluation, juvenile characterisation and cataloguing

Preliminary studies on the variation of the structure of bark of 100 genotypes from the 1981 IRRDB collection, belonging to Acre, Rondonia and Matto Grosso provenances and the control clones RRII 105 and GT 1 were carried out. The parameters studied were girth, bark thickness, number of latex vessel rows in stone cell free zones and those enclosed by stone cells, density of latex vessels per ring per 2 mm circumference of the plant, diameter of latex vessels, average distance from cambium to inner latex vessel row, average distance between latex vessel rows, distance from cambium to stone cells, distribution pattern

of stone cells, laticifer cross sectional area and test tap yield.

Wide variability was exhibited in the population for bark anatomical traits (Table-Gplm. 1). The genotypes from Matto Grosso were found to be better performers than Acre and Rondonia (Table-Gplm. 2). The genotypes MT 999 was found superior for total number of laticifers and density of laticifers.

High estimates of phenotypic and genotypic coefficients of variation were observed in the total number of laticifer rows, density, diameter, cross sectional area of laticifers and yield. Total number of latex vessel rows showed medium estimates of heritability and genetic advance whereas yield and cross sectional area of laticifers showed higher estimates of heritability followed by high genetic advance.

Yield was found to have a positive significant phenotypic correlation with girth, bark thickness, number of latex vessel rings, density, diameter and laticifer cross sectional area.

Seventy two genotypes planted during 1989 were randomly selected for assessing the nature and extent of variability, the degree of association among characters and their direct and indirect effects on juvenile yield. A wide range of variation was exhibited by the individual genotypes in the population for all the characters studied (Table-Gplm. 3). Provenance-wise comparison of wild genotypes indicated the superiority of the Matto Grosso genotypes (Table-Gplm. 4). Estimation of genetic parameters revealed that except for

Table-Gplm. 1. **Mean values of characters**

Characters	Population range		Population mean	Controls	
	Minimum	Maximum		GT 1	RRII 105
Girth (cm)	12.42 (RO 343)	18.25 (AC 655)	14.86	17.33	16.17
Bark thickness (mm)	1.83 (AC668)	3.08 (AC 685)	2.37	2.92	2.92
LVR in st. cell free zone	1.00 (AC624, 714)	3.50 (MT 1016)	2. 20	2. 83	2.33
LVR enclosed by st. cells	1.00 (24 genotypes)	3.00 (MT 999)	1.41	1.83	1.67
TLVR	2.00 (AC 714)	7.00 (MT 999)	3.62	4.66	4.00
DLV	10.17 (RO 319)	23.83 (MT 999)	19.15	18.33	19.17
Diameter (µm)	14.29 (MT 1030)	27.99 (MT 999)	22.01	21.98	22.16
Distance between cambium and inner LVR (mm)	0.26 (MT 1000)	0.55 (AC 630)	0.37	0.33	0.29
Av. distance between LVR (mm)	0.26 (MT999)	0.79 (AC 622)	0.43	0.47	0.47
Distance between cambium and st. cells (mm)	0.71 (AC 654)	1.34 (AC 685)	1.01	1.06	1.22
Laticifer C. S. area (mm^2)	0.63 (MT 1030)	8.82 (MT 999)	2.17	2.82	2.42
Yield (g)	0. 05 (RO 319)	2.98 (MT 1020)	0.57	6.25	6.53

Genotypes having maximum and minimum values are mentioned in parentheses

Table-Gplm. 2. **Provenance-wise means for the characters (1988 planting)**

Characters	Provenance		
	Acre	Rondonia	Matto Grosso
Girth (cm)	15.42	14.11	14.89
Bark thickness (mm)	2.31	2.25	2.58
No. of LVR in st. cell free zone	2.70	2.20	2.39
No. of LVR enclosed by st. cells	1.39	1.17	1.70
TLVR	3.48	3.38	4.08
DLV	19.36	17.99	20.09
Diameter (µm)	22.74	19.46	23.74
Dis. between cambium and inner LVR (mm)	0.34	0.39	0.38
Av . dis. between LVR (mm)	0.46	0.39	0.42
Dis. between cambium and st. cells (mm)	0.97	1.00	1.07
Laticifer C. S. area (mm^2)	2.05	1.61	2.90
Yield (g)	0.38	0.37	1.06

Table-Gplm. 4. **Performance of genotypes from different provenances (1989 planting)**

Traits	Rondonia	Acre	Matto Grosso
Total height (cm)	288.00	249.00	314.30
No. of flushes	12.00	10.00	13.00
No. of leaves in the 3rd flush	12.00	10.00	10.00
Girth (cm)	11.70	11.30	11.10
LAI	2.00	2.30	2.50
Total leaf wt (g)	193.60	224.80	243.50
Aerial biomass (g)	1153.50	1049.00	1096.00
Test tap yield (g)	0.16	0.18	0.17
LAR	18.00	22.70	23.40
Leaf wt/unit leaf area	0.01	0.01	0.01
Leaf shoot ratio	0.22	0.29	0.31

the characters height, number of whorls, number of leaves in the third whorl and girth, all characters had higher estimates of heritability and genetic advance. Association among the juvenile traits studied indicated highly significant positive correlation of juvenile yield with girth, leaf area

Table-Gplm. 3. **Range of variation among genotypes**

Traits	Wild genotypes		General	Control*
	Maximum	Minimum	Mean	Mean
Total height	411 (MT 1650)	171 (AC 2040)	276.9	289.6
Total no. of flushes	21 (RO 1324)	4 (AC 2124)	11.2	13.6
No. of leaves in third flush	18 (RO 1334)	6 (AC 2057)	11.0	9.6
Girth	16 (RO 1269)	8 (MT 1655)	11.4	12.1
LAI	4.3 (AC 2016)	0.59 (RO 1348)	2.2	2.6
Total leaf wt (g)	444.6 (AC 2016)	63.2 (RO 1348)	215.2	275.4
Aerial biomass (g)	2415.1 (RC 1269)	393.5 (AC 2040)	1106.5	1479.3
Test tap yield (g)	0.26 (MT 1650)	0.08 (RO 1243)	0.20	0.60
LAR	42.41 (AC 2124)	9.05 (RO 1558)	20.76	17.62
Leaf wt/unit area	0.012	0.008	0.01	0.011
L-S ratio	0.594 (AC 2124)	0.107 (RO 1334)	0.262	0.229

* RRII 105

index and total leaf weight. Path analysis of these characters on yield revealed that total leaf weight had maximum direct effect (0.75) on yield indicating the importance of leaf weight on yield in juvenile stage.

2. 3 Field evaluation of Brazilian germplasm

Observations on plant height, girth, total number of whorls and number of leaves per plant were recorded at quarterly intervals from the age of 12 months for 175 wild genotypes laid out in the 1990 evaluation trial. The data generated in the first four seasons were used to classify the genotypes based on their performance, making use of metroglyph and index-score analysis. When the overall performance among genotypes was compared over the seasons the genotypes were confined to the extreme classess (Score-1 and Score-3). This points to the presence of wide genetic base among these genotypes giving scope for selection in the wild genotypes. However, the distribution of the genotypes coming under the extreme classes for each character did not show much difference over the seasons, revealing that all the genotypes interact with the environment more or less equally in traditional rubber growing areas. The study also indicated that there are wild genotypes showing high score irrespective of the seasons, which could be of help in selection.

143 genotypes from the 1981 IRRDB collection were planted during the period under report in two experiments of 80 and 63 genotypes each, in simple lattice design with four replications and 2.5 x 2.5 m spacing, with RRII 105 as the check. The first set of quarterly observations were recorded for height, collar diameter, number of whorls per plant and number of leaves per whorl.

50 genotypes belonging to the budwood collection of the 1981 IRRDB expedition and designated as ortets, were planted for evaluation in five experiments with RRII 105 as control. Each experiment was laid out in a randomised block design with normal spacing. Quarterly observations on height, number of whorls, number of leaves per whorl and collar diameter were taken.

3. General studies

3. 1 Collection, conservation and evaluation of Ceara rubber germplasm

Search for an alternative source of natural rubber suitable for the non-traditional marginal lands points to the possibility of trying Ceara rubber *(Manihot glaziovii)*. An exploration to the hill tracts of Tamil Nadu resulted in the identification of a large population of *Manihot* genotypes growing wild. Preliminary observations on the performance of the trees were taken and action has been taken for further detailed studies. Germplasm of a few outstanding genotypes of *M. glaziovii* were collected and conserved in the clone museum at the RRII.

3. 2 Local exploration of *Hevea* germplasm

An unexploited wild tree of *Hevea brasiliensis* was identified at Shevroy Hills, Tamil Nadu, growing at a height of about 1250 m above MSL. Green budwood was collected, multiplied and conserved in the clone museum at RRII.

MYCOLOGY AND PLANT PATHOLOGY DIVISION

Studies on crop protection, basic investigations on pathogens, research on improvement of soil fertility with microbes and biological control of pollution are the major areas of research of the Mycology and Plant Pathology Division.

1. Abnormal leaf-fall disease

This most important leaf disease of rubber caused by *Phytophthora* spp. is confined to traditional rubber growing areas. In Kanyakumari district of Tamil Nadu, this disease has come to stay warranting prophylactic control measures. In the year under report, severe incidence of disease occurred in Karnataka, Kerala and Tamil Nadu.

The experiment to evaluate different dosages of copper oxychloride in both susceptible and tolerant clones under high and low rainfall areas was concluded during the year. The leaf retention recorded in this experiment is given in Table-Path. 1. The susceptible clone RRIM 600 in Kanyakumari region (low rainfall) was also included in this trial during the year.

A dosage of 2 kg/ha of copper oxychloride (COC) has given good protection in low rainfall area in clone RRII 105 and 8 kg/ha in clone RRIM 600. However, even the highest dose tried (10 kg/ha) could not ensure satisfactory protection in high rainfall areas for either clones.

The incidence of abnormal leaf fall disease in clone RRII 105 was assessed through a survey in the rubber growing regions of Kerala, Tamil Nadu and Karnataka states.

Table-Path. 1. **Percentage leaf retention** *

Treatments	RRII 105		RRIM 600	
	High rainfall	Low rainfall	High rainfall	Low rainfall
COC 56% ODP				
2 kg ha^{-1}	—	74.91	—	48.80 (44.25)
4 kg ha^{-1}	29.58 (32.91)	67.22	29.65 (32.94)	70.15 (57.13)
6 kg ha^{-1}	49.22 (44.82)	79.31	42.45 (40.56)	69.65 (56.61)
8 kg ha^{-1}	46.98 (43.50)	78.35	47.77 (43.67)	81.90 (65.10)
10 kg ha^{-1}	49.09 (44.44)	—	41.39 (39.98)	—
Unsprayed	21.21 (27.05)	56.24	—	37.08 (37.46)
CD (P = 0.05)	NS	15.96	5.65	10.46

* Values in parenthesis represent arc sine transformation.

Large scale multilocational field testing of three formulated products of 56 per cent oil based copper oxychloride and one improved spray oil sample were carried out. One of the products, Parkins 56 per cent copper oxychloride manufactured by M/s. Parikh Enterprises Ltd., Ahmedabad was provisionally approved for large scale use in rubber. Other products were not approved as they did not perform satisfactorily in the field trials.

Oil based mancozeb was subjected to field testing. In the preliminary trials about 35-40 per cent leaf retention was obtained when a dose of 3 kg/ha was used in clone RRIM 600.

2. High volume spraying

Cost of high volume spraying is steadily increasing due to increase in cost of copper sulphate and labour. Hence, determination of optimum dose of fungicide is essential. In continuation of previous year's experiment on tolerant clone (RRII 105) and susceptible clone (RRIM 600) for determining the dosage adequate for protection of leaves from abnormal leaf fall disease, spraying and assessment of its effect on leaf fall were carried out at Chemoni and Pudukkad estates. The results presented in Table-Path. 2 indicate that a miniumum spray volume of 3000 l/ha is essential even for RRII 105 in high rainfall areas.

Table-Path. 2. **Percentage of leaf retention**

RRII 105		RRIM 600	
Dosage l ha^{-1}	Leaf retention %	Dosage l ha^{-1}	Leaf retention %
1000	38.0	3000	50.0
2000	46.0	4000	78.0
3000	70.0	5000	44.0
Control	21.0	—	—

The experiment on comparison of 0.5 per cent Bordeaux mixture containing 0.5 per cent zinc sulphate with 1 per cent Bordeaux mixture was continued in clone RRII 105 and RRIM 600. The results are furnished in Table-Path. 3. The results indicate that the zinc sulphate mixture is as good as Bordeaux mixture alone.

For controlling shoot rot, a new systemic fungicide, Akomin, was field tested at two locations (Mundakayam and Palapilly). The percentage disease intensity recorded in the test chemical and check (Bordeaux mixture) is furnished in Table-Path. 4. Akomin gave better control of the disease.

Table-Path. 3. **Percentage leaf retention**

Treatments	RRII 105	RRIM 600
1% Bordeaux mixture	70.0	50.0
0.5% Bordeaux mixture + 0.5% Zinc sulphate	72.0	65.0

Table-Path. 4. **Percentage of disease intensity**

Location	Clone	Akomin	Bordeaux mixture
Mundakayam	PB 311	8.0	12.0
Palapilly	PB 235	11.0	16.0

3. Evaluation of panel protectants/ wound dressing compounds

Wound dressing compounds are essential for protecting the wounds due to natural causes or diseases. These compounds also promote renewal of bark on the tapping panel. The panel protectant compounds Tans rubber kote and Bituchem rubber kote were subjected to field testing and were approved for use in rubber plantations. One more product is under field testing.

4. Pink disease

This is the most important stem disease of rubber to which clones RRII 105 and PB 217 are highly susceptible. Severe incidence of the disease is present in young plantations which are adjacent to mature plantations of these clones. In an experiment to evaluate prophylactic spray protection of young rubber from pink disease incidence in clone RRII 105, two rounds of spraying with Cobox L and Bordeaux mixture were found to reduce the disease incidence by 40.40 and 35.35 per cent respectively. The results are presented in Table-Path. 5.

Prophylactic treatment by application of 10 per cent Bordeaux paste on the forking region of two year and three year old plants was compared with conven-

Table-Path. 5. **Incidence of pink disease in prophylactic control experiment**

Treatments	Disease incidence (%)
Calixin (Tridemorph) 0.1%	46.0
Thiride (TMTD) 0.2%	49.5
Cobox L (ammoniated Copper)1%	29.5
Bordeaux mixture 1%	32.0
Bordeaux paste 10%	40.5
Detection and treatment (control)	49.5

tional, curative treatment with Bordeaux paste. The results of the trial are furnished in Table-Path. 6.

5. Powdery mildew disease

The importance of this disease has considerably increased due to the indication in the crop loss studies that the loss can be upto 28.5 per cent. The experiment to evaluate integrated schedule of application of systemic and non systemic fungicide dusts for the control of powdery mildew disease laid out in Kanyakumari and Wynad districts was concluded. The disease incidence was assessed after three rounds of dusting. The results presented in Table-Path. 7 indicate that integrated application of the systemic fungicides tridemorph and carbendazim is as effective as their application *per se* but is definitely superior to application of sulphur dust alone.

Table-Path. 7. **Percentage disease incidence under different schedules of dusting for powdery mildew disease control**

Wynad		Kanyakumari	
Treatments	Disease index	Treatments	Disease index
T+S+T	17.50	T+S+S	30.45
C+S+C	15.95	C+S+S	28.95
T+T+T	14.65	T+T+S	21.90
C+C+C	15.75	C+C+S	23.75
S+S+S	23.65	S+S+S	48.45
Control	35.25	—	—
CD (P=0.05)	7.23	—	13.30

T = Tridemorph 1.5% (7 kg/ha/round); C = Carbendazim 1.5% (7 kg/ha/round); S = Sulphur 70% (12 kg/ha/round).

6. Yield loss due to disease

Yield loss studies are essential to

Table-Path. 6. **Severity of disease incidence**

Location	Infection Index		Severe infection which can lead to tree los		Additional cost in prophylactic treatment (Rs./ha)
	Prophy-lactic	Curative	Prophy-lactic	Curative	
Two year old plants					
Madukakunnu	5.95	40.25			
Kayyoor	1.70	15.56			
Pulikalkavala	1.00	12.85			
Mean	2.88	22.88	0.33	8.5	29.57
Three year old plants					
Chungom	4.00	8.85			
Kanjirappara	3.40	8.80			
Payappar	3.00	8.20			
Mean	3.46	8.62	0.50	1.5	270.56

evaluate economics of control operations and to impress upon the planters the benefits of disease control. 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. The crop loss recorded in the clones RRIM 600, RRII 105 and RRII 118 were 46.15, 6.52 and 16.33 per cent respectively.

Although the yield under different treatments included in the dosage trial was monitored in all the four locations in both RRIM 600 and RRII 105 a definite relationship between the disease control and yield could not be established.

7. High pressure injection for disease control

Rubber wood treated by pre-felling pressure injection of copper sulphate was found to be mostly free from borer beetle attack and showed only moderate attack of fungi, even after three years of storage.

8. Biological control

Biological control has an important role to play in sustainable agriculture. The biological control organisms isolated are being maintained.

Heart wood extracts of different wood species were tested in the laboratory by incorporation in agar growth media of the fungal pathogens *Phytophthora* and *Corticium salmonicolor*. The wood extracts were compared with rubber leaf and rubber wood extracts. The results furnished in Table-Path. 8 indicate that certain wood extracts like those of rosewood and teak wood considerably reduce the growth of *Corticium* and extracts of anjili and rose wood that of *Phytophthora*. Pink disease control by prophylactic application of leaf extracts of certain plants has been attempted. *Acasia* leaf extract gave good control. This has to be further confirmed by more field experiments.

Table-Path. 8. **Growth measurements of *Corticium salmonicolor* and *Phytophthora***

Treatments (Extracts from)	Mean growth (cm)	
	C. salmonicolor	*Phytophthora*
Rose wood	1.54	0.88
Jack wood	1.78	—
Teak wood	2.00	1.69
Anjili wood	2.14	0.78
Samania (*Entrolobium*) wood	2.25	0.70
Rubber leaf	4.00	5.65
Rubber wood	4.29	7.00
SE	0.04	0.06
CD	0.11	0.17

9. Host parasite interrelationship

Attempts are being made to study the effect of nitrogen on the *in vitro* production and activity of cellulase enzyme by *Corynespora cassiicola*.

10. Root disease

Severe infection of purple root disease was noticed in a poorly maintained nursery. Treatment with an organo mercurial fungicide did not give satisfactory results.

11. Multidisciplinary evaluation of clones

Observations were made on the clones in the two experiments laid out in RRII farm, on the susceptibility to abnormal leaf fall disease, pink disease, *Gloeosporium* disease and powdery mildew disease.

12. Screening of germplasm material/ HP seedlings

Powdery mildew incidence was re-

corded. A total of 11 HP seedlings were screened for susceptibility to *Phytophthora* by artificial inoculation.

13. Microbiology of leguminous cover croprs

The effect of inoculation of *Bradyrhizobium* in *Pueraria phaseoloides* was studied in 25 ha area. The interspace of rubber was covered in four months by inoculated plants whereas in unioculated plants it took seven months. Pelletisation of the culture with rock phosphate and calcium carbonate have the same effect on nodulation in *P. phaseoloides*. A type of clay was tested as a carrier for *Bradyrhizobium* culture. But the suvival was reduced to 50 per cent in 30 days.

Mass culture of the suitable *Bradyrhizobium* for *P. phaseoloides* using lignite as carrier was arranged with the Centre for Advanced Research and Development, Neyveli Lignite Corporation, Neyveli. 200 g packets of the culture will be marketed to the palnters during May-June 1993. Screening of 15 *Bradyrhizobium* isolates for *Mucuna bracteata* is in progress. One isolate is found to be very effective in nodulation, biomass production and nitrogenase activity.

A fast growing legume creeper *Mucuna aterima* was studied in comparison to *M. bracteata*. *M. aterima* showed more nodulation, biomass production and nitrogenase activity.

14. Mushroom culture

Ganoderma lucidum which has medicinal property was grown on rubber wood sawdust. It grew very slowly and did not produce sporocarp. Another mushroom, *Calocybe indica* was successfully grown on rubber wood sawdust.

15. Pollution studies

The laboratory model of floating areator was used to treat composite effluent from the crumb rubber processing factory. Eighteen hour detention was found to be essential to reduce the pollution load to the level recommended for irrigation. The results obtained are furnished in Table-Path. 9.

Table-Path. 9. **Performance of pilot plant**

Parameters	% reduction after		
	8 hr	12 hr	18 hr
BOD mg/l	34.8	45.1	77.8
COD mg/l	33.9	40.3	76.3
Suspended solids	50.0	57.0	82.0

16. Rhizosphere studies

Weed biomass was estimated in experimental areas inoculated with *Bradyrhizobium* and *Beijerinckia sp.* in *P. phaseoloides* either alone or together, after 15 months of establishment. The results are furnished in Table-Path. 10. Dual inoculation produced significant reduction in weed biomass.

From field collections of micorrhizal spores, eight isolates which showed better growth and infectivity were selected for further investigation. Using finger millet seedlings raised in sterile soil, spore multiplication is being done.

The effect of inoculation of phosphobacteria on growth of rubber seedlings applied with different levels of phosphate was studied. Three months after inoculation, population of phosphobacteria was estimated in the rhizosphers and rhizoplane. The population was found to be 105 bacteria/g of soil and 102 bacteria/g of root. The effect of inoculation on the girth and height of rubber seedlings is furnished in Table-Path. 11.

Table-Path. 10. **Effect of dual inoculation in *P. phaseoloides* on weed biomass**

Treatments	Weed biomass (kg/plot)
Uninoculated with	
50% N	12.6
75% N	13.0
100 % N	12.83
Rhizobium with	
50% N	10.47
75% N	10.73
100% N	11.10
Beijerinckia with	
50% N	10.17
75% N	9.97
100% N	9.87
Rhizobium + *Beijerinckia* with	
75% N	8.77
Rhizobium + *Beijerinckia* with	
100% N	8.37
CD (P = 0.05)	3.46

Table-Path. 11. **Effect of inoculation of phospho-bacteria on growth of rubber seedlings after one year**

Treatments			Girth at 2.5 cm (cm)	Height (cm)
25% recommended level rock PO_4			1.03	153.50
50%	,,	+ No bacteria	1.08	163.00
75%	,,	+ No bacteria	1.23	175.00
100%	,,	+ No bacteria	1.58	186.75
25%	,,	+ phospho bacteria	1.18	159.50
50%	,,	+ phospho bacteria	1.30	179.50
75%	,,	+ phospho bacteria	1.63	192.75
100%		+ phospho bacteria	1.60	194.25
CD			0.21	5.80

The results indicate that 75 per cent of recommended level of phosphate with phospho bacteria is equivalent to 100 per cent recommended level of phosphate alone.

17. Biological control of white grubs

The field trial on the compartive evaluation of biological and chemical control treatments against white grubs revealed that all the biological and chemical treatments proved to be effective in protecting rubber seedlings (Table-Path. 12). Among the entomopathogens, the application of *Beauveria brongniartii* recorded the highest plant survivial and lowest grub population. In chemical treatments, Isofenphos 5G proved to be most effective and HCH 10D proved to be least effective in terms of plant survial.

Studies on species composition revealed the incidence of four species of *Holotrichia* in rubber nurseries viz. *Holotrichia serrata, H. fissa, H. rufoflava,* and *H. bicolor.*

18. Vertebrate and non-insect pests

Rat burrows in an area of 1 ha of rubber nursery were treated with flocoumafen (Storm) baits at 0.005 percent concentration. The rodent population was assessed by counting the number of live burrows of respective species before control operation. The success in nursery sites was 97.28 per cent. The control with respect to the species of rats are presented in Table-Path.13.

Phorate 10G placed in porous plastic packets at two dosages (2.5 g/9.30 m^2 and 5 g/9.30m^2) area in nursey proved to be effective repellents against hares and rabbits damaging rubber seedlings.

19. Bee keeping

Two medicinal plants *Aegle marmelos* (Rutaceae) and *Syzygium cumini* (Myrtaceae) were identified as potential sources of nectar and pollen for off-seasonal bee management in rubber plantation- based apiaries.

A region-wise survey on the inten-

Table-Path. 12. **Comparative evaluation of different biological and insecticidal formulations for the management of *H. serrata***

Treatments	Dose + (kg/ha)	Mean percentage survival of plants/plot*	Grub population/ 30 cm^2
Beauveria brongniartii	1 x 10^{10}**	91.80 (73.36) a	0.00
Beauveria bassiana	1x 10^{10}**	86.60 (68.44) b	0.05
Doom dust (*Bacillus popilliae*)	2g/9.30m^2 plot	86.00 (68.03) b	0.05
Isofenphos 5G	25	80.40 (63.72) c	0.05
Phorate 10G	25	80.30 (63.65) c	0.10
Carbaryl + Lindane (Sevidol) 4:4G	25	80.10 (63.51) c	0.15
Carbofuran SR II 3G	25	62.58 (52.24) d	0.20
Carbofuran 3G	25	34.56 (35.97) e	0.25
Carbaryl 5D	10	34.28 (35.79) e	0.25
Carbaryl 4G	25	34.50 (35.97) e	0.30
HCH 10D	100	19.90 (26.49) f	0.40
Untreated check	-	8.40 (16.85) g	2.00
F test	-	Significant	-
SE of X	-	1.22	

+ For insecticides. *Mean for four replications, at eleven months after treatment. Figures in paranthesis are arc sine values. Mean values followed by the same letter do not differ significantly. P = 0.05 (DMRT); **Spores/g of soil

Table-Path. 13. **Effectiveness of Storm in controlling rodent pests in nurseries**

	Bandicota bengalensis	*Bandicota indica*	*Rattus meltada*	Total
Pre-control census	96	50	38	184
Post control census	0	2	3	5
Control success (%)	100.00	96.0	92.11	97.28

sity of incidence of bee disease affecting *Apis cerana indica* colonies is in progress. Studies on the introduction and management of *Apis mellifera* colonies in rubber plantations are also in progress.

20. Minor pests

Severe incidence of bark-feeding caterpillar, *Aetherastis circulata* affecting mature rubber plants was controlled by the application of Fenval 0.4 per cent dust at 7 kg/ha and carbaryl 5 per cent dust at 10 kg/ha.

21. Nematodes

The effect of root knot nematode *Meloidogyne incognita* on the growth of *Pueraria phaseoloides* was studied under artificial infestation. The nematode inoculated plant exhibited normal growth for a period of five months. The nematode population as well as species were found to vary in different depths of soil.

22. Rubber wood preservation

The results of various trials with preservatives, singly and in combination by diffusion treatment and subsequent air seasoning showed that (1) copper sulphate and sodium penta chlorophenate and (2) zinc sulphate and sodium penta chlorophenate are effective.

PLANT PHYSIOLOGY AND EXPLOITATION DIVISION

The Plant Physiology and Exploitation Division undertakes research on biochemistry, crop physiology, stress physiology, water management, exploitation, tapping panel dryness (TPD), introduction of medicinal plants for intercropping etc. Considerable effort was put in for popularising controlled upward tapping (CUT). Certain biochemical studies were suspended on account of high priority given for TPD research.

1. Early prediction of yield and stress tolerance

In connection with studies on tolerance to drought and heat, 21 clones were screened for membrane thermostability and leaf epicuticular wax. Significant variation was observed among the clones. Clones RRIM 703, PB 260 and PB 255 showed less injury whereas PCK 1, PCK 2 and SCATC 88/113 showed comparatively higher injury. Haiken 1, SCATC 93/114 and RRIM 600 have higher epicuticular wax content on leaf surface.

2. Changes in latex diagnosis parameters in relation to tapping intensity

The results of the study revealed that after six months of imposing treatments clones GT 1 and RRII 203 gave a better response to 1/2S d/1 6d/7 system of tapping and higher thiol levels in the latices when compared to 1/2S d/2 6d/7 and 1/2S d/3 6d/7 systems of tapping. In clones RRII 105 and RRII 118 there was no difference in the level of thiols between d/1, d/2 and d/3 tapping frequencies.

3. Yield constraint analysis

Seasonal changes in latex diagnosis parameters viz., thiols, sugars and inorganic phosphates in clones GT 1, RRII 105 and RRIM 600 at Kinalur and New Ambadi estates were assessed. In general, a higher value of the parameters were noticed at Kulasekharam.

4. Photosynthesis and partitioning of assimilates

Eleven month old plants of two clones viz. RRII 105 and RRIM 600 raised in polythene bags were transferred to different intensities of light under the polythene net (open, 70 per cent and 30 per cent light). Rate of photosynthesis was measured one month after the transfer (November 1992) three times a day. Chlorophyll content was also measured. Significant variation was observed in photosynthetic rate and chlorophyll content (Table-Phy. 1). Under low light, higher photosynthetic rate was observed in clone RRII 105 when compared to clone RRIM 600. This might be an adaptation to the cloudy monsoon conditions in clone RRII 105.

5. Physiological evaluation of clones

Annual girth of different clones at Chethackal, Dapchari and Mudigere showed the same trend as in previous years. Seasonal variation (September and March) in yield is presented in Table-Phy. 2. Highest mean annual yield was observed in the clone RRII 105 at Chethackal whereas clone RRIM 600 gave the highest yield at Dapchari. Clones at Mudigere (high elevation) did not attain tappable girth.

Table-Phy. 1. **Rate of photosynthesis and chlorophyll content in young *Hevea* plants grown under different light regimes**

Clone	Light (%)	Photosynthetic rate (μ mole m^{-2} sec^{-1}) Time of day			Total chlorophyll (mg dm^{-2})
		8-9 AM	10-11AM	12-1PM	
RRIM 600	100 (open)	13.0	11.5	10.0	4.9
	70	11.8	12.4	11.4	5.1
	30	6.3	9.0	7.3	5.3
RRII 105	100 (open)	12.2	10.5	7.7	5.5
	70	12.3	11.9	11.2	7.2
	30	8.5	11.0	9.6	8.2
Mean		10.7	11.0	9.5	6.0
CD at (P=0.05)		1.4	1.82	2.2	0.5

Table-Phy. 2. **Dry rubber yield (g tree $^{-1}$ tap $^{-1}$) of clones at two locations**

Clone	September		March		Annual mean	
	Chethackal	Dapchari	Chethackal	Dapchari	Chethackal	Dapchari
RRII 300	42.9	28.4	28.1	14.0	35.7	20.3
PB 235	54.8	24.1	26.0	12.0	44.3	19.9
RRII 105	59.7	-	54.7	-	56.5	-
RRII 600	48.8	36.0	30.3	24.0	39.5	31.7
GT 1	35.3	13.6	25.6	13.3	32.5	17.5
PR 107	21.4	22.0	15.1	13.7	22.6	17.7
GI 1	28.4	25.7	21.1	18.8	25.5	23.4
RRIM 501	39.7	35.4	23.5	16.6	29.1	25.3
RRII 118	31.4	-	24.2	-	29.7	-
RRIM 703	57.4	-	36.5	-	49.0	-
Tjir 1	36.1	16.5	23.0	4.6	32.1	14.5
RRIM 612	26.0	15.2	11.8	6.6	19.7	13.6

6. Performance of clones at high evlevation

Monitoring of growth was continued at Mullenkolly (Wynad). Clones RRII 118 and RRIM 612 continued to record higher girth.

7. Soil moisture stress, growth and yield

In a pot culture experiment, six months old plants of 12 clones were subjected to extreme water stress by withholding watering till soil moisture reached 12 per cent. The casualty was scored six days after rewatering. It was observed that the clone GT 1, RRIM 600, PB 260 and PB 280 showed lowest causalty indicating drought tolerance (Table-Phy. 3).

8. Exploitation systems and yield

The trial started in 1985 in clone RRII 105 at Chethackal was continued. Yield and

Table-Phy. 3. **Mortality in young plants of different clones subjected to severe soil moisture stress**

Clone	Mortality (%)
RRII 105	40
RRIM 600	20
GT 1	10
PB 28/59	20
PB 217	40
PB 235	30
RRII 5	30
PCK 1	25
PCK 2	40
PB 260	20
PB 280	20
PB 311	30

incidence of TPD recorded during the period is presented in Table-Phy. 4.

Table-Phy. 4. **Yield and incidence of TPD under different systems of tapping in RRII 105 on small scale trial (1991-92)**

Treatments	Yield ($kg\ tree^{-1}\ year^{-1}$)*	Block yield ($kg\ tree^{-1}\times ha^{-1}$)	TPD (%)
1/2S d/2 6d/7	6.56	1968	26.7
1/2S d/3 6d/7	6.96	2088	17.5
2x1/4S1 l d/2 6d/7	7.95	2385	13.3

*Mean value includes TPD trees

Among thirty trees which were subjected to 1/2S d/1 6d/7 tapping, all trees except two were affected by TPD in four years.

The block level experiment comprising five tapping systems viz. 1/2S d/2 6d/7, 1/2S d/3 6d/7, 1/3S d/2 6d/7, 1/3S d/3 6d/7 + ET 1.25 per cent and 1/2S d/7 ET 2.5 per cent to 5 per cent is also in progress. The 1/2S d/3 6d/7 and 1/3S d/2 6d/7 systems continued to be comparable with 1/2S d/2 6d/7 with respect to yield and showed less incidence of TPD. (Table -Phy. 5). After increasing the ethephon concentration to 5 per cent the yield performance in weekly tapping was very good.

Studies on the effect of different exploitation systems on yield and growth in RRII 118 were continued and the data were summarised (Table-Phy. 6). Yield obtained from 1/2S d/3 6d/7 and 1/4S d/3 6d/7 + ET 5 per cent are comparable to 1/2S d/2 6d/7 during this period. Girth increment during 1986-93 was also comparable.

The trial to evaluate the effect of different rest periods on yield and incidence of TPD in RRII 105 is in progress. The trend in yield shows that the rest period is beneficial. The data are presented in Table-Phy. 7.

The experiment to study the effect of depth of tapping on yield and incidence of TPD was continued. The depth of tapping

Table-Phy. 5. **Dry rubber yield and incidence of TPD under various tapping systems in RRII 105 - Block trial**

Treatments	Yield (kg/block)				TPD (%)		
	1989	1990	1991	1992	1990	1991	1992
1/2S/ d/2 6d/7	741.23	1495.72	1931.66	2151.2	8.33	13.67	15.72
1/2S d/3 6d/7	756.97	999.97	1500.49	2074.3	4.78	7.60	8.78
1/3S d/2 6d/7	536.64	1178.51	1730.58	1917.7	4.61	7.94	8.72
1/3S d/3 6d/7 ET 1.25%	377.76	861.96	1082.13	1692.6	2.22	6.17	6.67
1/2S d/7 + ET 2.5%	253.73	420.73	665.89	1338.6	2.17	2.94	3.61
CD(P=0.05)	-	-	-	405.4	-	-	-

Table-Phy. 6. **Yield, girth increment and PI under various exploitation systems in RRII 118 during the sixth year of tapping (1992-'93)**

Treatments	Yield (kg block^{-1})	Girth increment 1986-93	Plugging index
Control (Untapped)	—	52.0	—
1/2S d/2 6d/7	2544.9	49.42	3.8
1/2S d/3 6d/7	2329.8	55.08	3.94
1/4S d/2 6d/7	1671.5	45.82	4.22
1/4S d/3 6d/7	1002.2	50.62	4.89
1/4S d/3 6d/7+ET 5%	2342.6	51.42	3.22
CD(P=0.05)	597	N.S	N.S

and yield are presented in Table-Phy. 8. In the yield cum exploitation trial at Karnataka, girth recording was done.

Table-Phy.7. **Effect of periodic tapping rest on yield**

Treatments	Yield* (kg/block)
Continuous tapping with rainguard	2587.2
One month rest in summer with rainguard	2546.3
Two month rest in summer with rainguard	2210.8
Two month rest in monsoon without rainguard	2419.0
Two month rest in monsoon and one month rest in summer without rainguard	2362.1
Two month rest in monsoon, one month rest in summer without rainguard and additional one tapping per week during peak period of yield	2422.2

* cup lump weights

Two month's yield for all the treatments could not be collected due to strike.

9. Tapping system for small growers

The trial is being continued. Dry rubber yield, growth, bark conusmption and tapping panel dryness showed the same trend as in the previous year.

10. Controlled upward tapping (CUT)

The large scale trial on CUT in clone RRIM 600 was continued during 1992-93. The cumulative yield from November 1990 to March 1993 under various systems of tapping are presented in Table-Phy. 9. Trees tapped under 1/3S↑ + 1/2S d/2 6d/7 system recorded highest yield compared to other systems. Tapping was discontinued from 16th October '92 to December '92 due to labour strike.

A new trial on CUT was taken up during this period in clone RRII 105 (1976 planting) where high incidence of TPD (50%) was observed in the virgin bark. Total number of trees in the area is 468. Out of these, 207 trees were subjected to CUT with 1/3S↑ panel. Remaining 261 trees were put under 1/4S↑ panel. Very high yield could be achieved in the high panel. The per cent increase was 329 for 1/3S panel and 187 for 1/4S panel from July'92 to March '93. As the yield was very high, trees were not subjected to stimulation.

11. Medicinal plants in mature stands

A field experiment was laid out to evaluate the impact of inter-cropping of medicinal plants on latex yield. Three species, *Strobilanthus haenianus*, *Adathoda vasica* and *Plumbago rosea* were planted in June '92.

Manuring was as per package of practices recommendations except for N for which two levels were maintained (30 and 60 kg/ha respectively). Yield data for the first six months showed no adverse effect of intercropping (Table-Phy. 10).

12. Multidisciplinary studies on TPD

Trees from a monoclonal population

Table-Phy. 8. **Effect of depth of tapping on yield and girth increment in clone RRII 105 (Panel BO.1)**

Treatment	Bark untapped	Yield (g/t/t)	Girth increment (1992-93)
Tapping depth leaving 0.5 mm bark near cambium	0.7	66.43	6.2
Tapping depth leaving 1 mm bark near cambium	1.1	59.13	7.0
Tapping depth leaving 1.5 mm bark near cambium	1.3	53.47	5.5
Tapping depth leaving 2 mm bark near cambium	1.7	45.58	5.5

Table-Phy. 9. **Cumulative dry rubber yield (kg tree^{-100}) under CUT**

Tapping systems	Yield (kg trees^{-100})
1/2S d/2 6d/7	5135 (100)
1/3S↑ 1/2S d/2 6d/7 (9 m, 2 m)	6428 (125)
2 x 1/2S↑↑ d/2 6d/7	9370 (182)
1/4S↑ + 1/2S d/2 6d/7	8229 (160)
1/3S↑ + 1/2S d/2 6d/7	9430 (184)
2 x 1/2S↑↑ d/3 6d/7	7346 (143)
1/3S x 1/2S d/3 6d/7	6831 (133)

Figures in parenthesis indicate percentage

of RRII 105 were categorised into 3 groups viz. normal, partially dry and completely dry. Trees from each group were selected for analysis of latex and bark samples. The parameters estimated were acid phosphatase activity, total lipids and composition of lipids in latex and bottom fraction, free aminoacids, sucrose, thiols, inorganic phosphorus and magnesium. In bark, estimations on the extent of lipid peroxidation, proline content, different lipids, sugars and soluble proteins were made. Latices from normal trees gave higher values for total phosphatase activity, free amino acids, total lipids, triglycerides and phospholipids when compared to partially dry trees. Similarly the soluble protein content in bark was low

Table-Phy. 10. **Yield of medicinal plants, dry rubber yield and incidence of TPD**

Name of the species	Spacing	Yield of medicinal plants		Yield of ruber (g tree^{-1} tap^{-1})		TPD incidence in rubber trees	
		(g plant^{-1})	(kg ha^{-1})	Before inter cropping	After inter cropping	Before inter cropping	After inter cropping
Control (*Hevea brasiliensis*)				45.8	63.5	14.7	20.5
Strobilanthus raenianus	F1 45 x 45	10.2	224	60.9	72.4	14.2	18.1
	F2	7.1	156	58.1	74.5	13.5	12.9
Adathoda vasica	F1 37.5 x 30	8.4	269	45.0	72.8	21.2	13.8
	F2	8.4	269	58.7	67.4	16.2	9.6
Plumbago rosea	F1 37.5 x 30	8.8	282	52.6	62.6	20.0	19.2
	F2	11.8	378	52.0	82.9	6.6	9.5

F1 = 30 kg N ha^{-1} F2 = 60 kg N ha^{-1}

in partially dry and completely dry trees when compared to normal trees. No consistent pattern was observed for sucrose thiols, inorganic phosphorus, magnesium, sterols and triglycerides in bottom fraction and extent of lipid peroxidation in bark samples.

As a part of the international programme on tapping panel dryness another experiment was laid out on freshly opened RRII 105 trees to monitor changes in physiological and biochemical parameters. The recordings of latex flow and biochemical parameters were carried out at 15 day intervals. The trees were routinely assessed for the onset of TPD. The biochemical parameters recorded were sucrose, thiols, inorganic phosphorus, magnesium, carotenoids and bursting index. The studies revealed that the trees which became dry had high bursting index and low carotenoid contents compared to normal trees.

No consistent pattern was observed for the other parameters studied. Polypeptide profile of membrane and C serum were done using SDS PAGE in 25 trees at monthly intervals for four months.

RUBBER CHEMISTRY, PHYSICS AND TECHNOLOGY DIVISION

The Division continued to work on primary processing, chemical modification, rubber technology and product development.

1. Solar drier for sheet rubber

The 800 kg solar drier was modified further for continuous operation. An additional brick wall, separated with a stagnant air column, was provided for improving thermal insulation. A furnace was constructed for firewood back-up. A false roofing was also provided to reduce the volume of the drier and for thermal insulation. A maximum temperature of 52°C was recorded in the chamber.

The 200 kg solar drier, designed and fabricated by Agency for Non-conventional Energy and Rural Technology (ANERT) was tested in the solar heating mode during October. Although the maximum temperature of the blower outlet air was 58°C, the chamber temperature was raised only to 34°C. Further modifications are needed to improve the performance of the drier.

A small drier (30 kg) was also evaluated. It was observed that sheets could be dried in 3-4 days using this drier. Attempts have been made to fabricate a drier with a capacity of around 100 sheets.

2. Sulphuric acid as an alternative latex coagulant

Studies on the corrosion aspects when sulphuric acid is used for making sheet rubber have been continued. Effect of long term ageing on the properties of sulphuric acid coagulated sheet rubber as shown Table-Chem. 1 indicates that, if sulphuric acid is used as per conditions prescribed under foot note (2) the ageing behaviour of vulcanizates is similar to that of vulcanizates prepared from sheets coagulated with formic acid. An adhoc recommendation for using sulphuric acid as coagulant was made, in the light of the acute shortage of formic acid.

Table-Chem. 1. **Percentage retention of properties after ageing at 70°C**

Period of ageing (days)	Properties	Treatments* 1	2	3	4
7	Tensile strength	104	100	97	94
	300% modulus	131	128	132	124
	EB	86	93	85	85
15	Tensile strength	85	85	87	90
	300% modulus	139	133	138	128
	EB	78	83	83	85
22	Tensile strength	82	78	81	66
	300% modulus	143	137	144	130
	EB	68	62	62	50
29	Tensile strength	69	62	62	50
	300% modulus	135	146	145	132
	EB	66	66	64	61

*1. Fromic acid, 0.5% - 400 ml; 12.5 DRC with washing, 2. Sulphuric acid, 0.5% - 300 ml; 12.5 DRC with washing, 3. Sulphuric acid, 0.5% - 300 ml; 12.5 DRC without washing, 4. Sulphuric acid, 5% - 50 ml; 20 DRC, without washing.

Sulphuric acid, 5". - 50 **ml;**

Fromulation : Rubber - 100, Zinc oxide -5, Stearic acid -2, HAF black -40, Naphthenic oil -4, Antioxidant HS -1, CBS - 0.6, S- 2.5.

3. Epoxidation of NR

A pilot plant for the production of epoxidised natural rubber (ENR) with a batch capacity of 25 kg was commissioned. The samples of ENR produced in the pilot plant have been characterised. It was observed that by suitably controlling the reaction conditions it was possible to produce ENR 50 of consistant quality and minimum side reactions. Laboratory scale preparations were continued to optimise reagent concentration. The possibilities for scaling up the process have been explored.

4. Studies on rheological behaviour of LNR

The pseudoplastic nature of liquid natural rubber (LNR) was studied using a Rheomat. LNR prepared by depolymerisation using the combined effect of mechanical, chemical and thermal energy, was used for the experiment. The samples were having Brookfield viscosity in the range of 52,000 cps to 4,92,000 cps at 30°C. Continuous shear rheometry measurements were carried out at 1 to 30 rpm. The studies revealed that LNR of low viscosity behaved Newtonian, while the high viscosity material showed pseudoplastic behaviour.

5. Phosphorus modification of LNR

Modification of LNR with phosphorus was attempted with a view to improve its flame retardant nature. NR was depolymerised in the latex stage using the phenyl hydrazine/oxygen system, epoxidised with formic acid/hydrogen peroxide and the resultant expoxidised liquid natural rubber (ELNR) refluxed with dibutyl phosphate to effect phosphorus modification. The product was characterised and its incorporation as a flame retardant in a NR formulation gave encouraging results as shown in Table-Chem. 2. This work was done in the Universite du Mains, France under an Indo-French bilateral exchange programme.

Table-Chem. 2. **Burning time (seconds) of compounds of NR and phosphorus modified ELNR***

Oxygen (%)	NR	Phosphorus modified ELNR
21.0	80	103
19.5	102	139
19.0	123	178
18.5	164	195
18.0	180	230
17.5	217	Extinguished

* Time reqired for the flame to progress through 3 cms.

6. Effect of storage on properties of latex

Periodical testing of high ammonia and low ammonia preserved centrifuged latex, processed during different seasons, is being continued. The period of storage has been found to influence not only the latex parameters, but even the properties of vulcanized films prepared from it.

7. Comparative evaluation of different forms of NR

The popular forms of NR that find application in the tyre sector is RMA 4, RMA 5, EBC and ISNR 20. Compared with the lower grades of sheet and crepe, the cost of ISNR 20 is higher and there is difference of opinion regarding the superiority of ISNR 20 over the conventional forms. A study was hence taken up to compare the properties of ISNR 20 with those of RMA 4, RMA 5 and EBC (Table-Chem. 3). Samples were collected from different centres and further work is in progress.

Three sets of samples were collected and analysed. Initial results show that there is inconsistency in properties of sheet rubber compared to ISNR 20 but the scatter is more towards the positive side.

Table-Chem.3. **Samples collected for comparative evaluation**

Sample	Source(processed from)	No of centres
ISNR 20	Fresh scrap	4
ISNR 20	Dry scrap	4
RMA 4		4
RMA 4		4
EBC IX	Fresh scrap	4
EBC	Dry scrap	4

8. Studies on NR/HDPE blends

Preliminary studies on blending of NR and HDPE and preparation of microcellular solings showed that the degree of expansion and quality of expanded sheets depend very much upon the blend ratio and the curing system. The solings prepared from the blends showed poor flexibility.

9. Heat transfer and vulcanization of NR compounds

Heat transfer in NR compounds was found to improve with loading of HAF black, acetylene black and aluminium powder. The minimum loadings of the above fillers in NR compounds in order to get an appreciable level of increase in thermal conductivity have been identified.

10. Short sisal fibre-natural rubber composites

Equilibrium swelling studies conducted in different solvents using short sisal fibre-natural rubber composites showed much reduced rate and extent of swelling of composites which contained a bonding agent. The swelling behaviour of composites is found to be indicative of the bonding between the fibre and rubber. Ageing resistance of short sisal fibre-NR composites was found to increase with fibre loading.

11. Chemical modification of rubber seed oil

Conditions for epoxidation of rubber seed oil to known levels were standardised. Use of rubber seed oil and epoxidised rubber seed oil was found to activate the cure rate of polychloroprene rubber compounds.

12. Effect of overcure and ageing on properties of retread compound

Studies made on retread compounds based on blends of SBR/BR, NR/BR and NR alone showed that overcuring and ageing have a profound negative influence on the technological properties especially the abrasion resistance of the vulcanizates. The adverse effect of overcuring and ageing were minimum for the compounds based on blends of SBR/BR and NR/BR.

13. Development work

The following items/processes were developed as per specific requests from industry:

1. Thin microcellular sheets based on NR/EVA blends suitable for preparing school bags, folders etc.

2. Rubber seals for water pipes.

3. A process for preparing reclaimed rubber from microcrumb.

AGRICULTURAL ECONOMICS DIVISION

The Agricultural Economics Division is primarily concerned with studies relating to economic aspects of natural rubber cultivation, processing, marketing and end uses. Emphasis is also given to studies pertaining to ancillary sources of income such as intercrops during mature and immature phases and by-products in tune with the changing dimensions of the national and global scenario.

1. Commercial evaluation of planting materials

This is a continuous study undertaken by the Division since 1974 with the main objective of generating information on the commerical yield of popular planting materials. Table Age. 1. shows the average yield and degree of stability of major planting materials.

Table-Age. 1. **Relative yield (kg/ha) and stability of ten clones**

Clone	5 year mean yield	CV	10 year mean yield	CV
RRII 105	1412	20	1556	19
PB 28/59	1227	26	1452	25
PB 252	1033	26	1363	33
GT 1	1019	22	1329	29
RRIM 600	1129	24	1327	21
PB 5/51	1007	20	1314	28
PB 217	1001	20	1258	29
PB 5/139	988	34	1225	28
RRII 118	939	34	1164	31
RRIIM 605	1061	17	1146	14

2. Sample survey of rubber small holdings in Tripura

This survey covered 60 sample holdings located in the three planting districts of Tripura. The main contributing factor for the growth of small rubber holdings in the state was the introduction of New Planting Subsidy Scheme in 1979. The average size of more than 50 per cent of the sample holdings was below 2 ha and the area was under subsistence farming prior to the introduction of natural rubber cultivation. Around 60 per cent of the growers were illiterate and only 25 per cent could avail of the full instalments of the subsidy. The average resource use was Rs.25,095 per ha which was only 61 per cent of the corresponding expenditure in the traditional areas. The share of material inputs in total resource use was only 34 per cent compared to 40 per cent in traditional areas.

Method of tapping was found to be unscientific and the immigrant tappers from Kerala were paid a monthly salary ranging from Rs.1,200 to Rs.1,500. Only 40 per cent of the sample holdings had proper sheet processing facility while only 35 per cent sold the produce to the licenced dealers. Nevertheless the price realisation in the Agartala market was comparable to the prevailing prices in the terminal markets of Kerala.

3. Transportation of natural rubber

This study is an updated version of two previous surveys carried out in 1967 and 1978 respectively. The total quantity of rubber transported from Kerala to other consuming centres in 1990 was 2.4 lakhs metric tonnes. About 67 per cent of the transportation was accounted for by manufacturers, 20 per cent by dealers, 9 per cent by estates and 4 per cent by processors. Table-Age. 2 shows the trends in the relative shares of the three modes of transport during the three periods.

Table-Age. 2. **Relative shares (%) of the three modes of transport**

Period	Mode of transport		
	Ship	Rail	Road
1967	58	12	30
1978	1	20	79
1990	Nil	6	94

The main factors contributing to the dominant position of road traffic were found to be acceptance of small quantities, minimum procedural formalities and absence of transshipment costs.

4. Rubber marketing co-operative societies

The study was undertaken in 1992 covering 36 rubber marketing co-operative societies in Kerala. Among the 36 societies, 24 were engaged in activities other than rubber marketing such as distribution of planting materials, development of nurseries, rubber processing, rubber goods manufacturing and banking operations. Around 70 per cent of the societies were supplying material inputs to member growers and had own facilities for plant protection activities. The average quantity of rubber handled by a society amounted to 1302metric tonnes during 1991-92.

5. Commercial application of latex sludge

A preliminary assessment of commercial application of latex sludge was made in collaboration with the Agronomy and Soils Division. Experiments conducted by the Agronomy Division showed that dried latex sludge, a waste material from latex centrifuging industry, could be used as a phosphatic source for immature rubber

in field condtion and its performance was comparable to two other phosphatic sources assessed.

The estimate of latex sludge potential in India indicated that 400 metric tonnes of dried latex sludge could be realised at 70 per cent capacity utilisation of the centrifuged latex processing industry. The processing cost of sludge was estimated to be Rs.1450 per metric tonne.

Two sources of potential savings were identified viz., the cost of replaced fertilizer and savings on account of the new procedure adopted for the preparation of NPKMg mixture for immature rubber. The net estimated savings were Rs.5573 per metric tonne and Rs.22.30 lakhs per annum at 70 per cent capacity utilisation of the latex processing industry. The industry can also generate additional empolyment opportunities to the extent of 8800 mandays depending on the extent of commercialisation of this waste material.

6. Ancillary products

Studies on ancillary products (rubber wood, rubber seed oil and cake and rubber honey) are being undertaken with the objective of estimating annual production and consumption. During the period under review, estimated rubber wood production was 1.20 million cum and the packing case manufacturing industry was the single largest consuming sector accounting for about 62.5 per cent of the stem wood consumption. The year 1992-93 also witnessed steady increases in the prices of different forms of stem wood (Table-Age. 3). However, the growers realised only Rs.550 per million cum as the trees were sold before felling. The relative share of rubber wood consumed in the treated wood processing industry registered a substantial increase from 3.9 per cent in 1991-92 to 6.9 per cent in 1992-93. During 1992-93 there were 21 rubber wood processing units in the country.

Table-Alc 3. **Average prices of different forms of rubber wood**

Forms	Reported price range (Rs/m^3)
Logs (general)	700-880
Logs suitable for treatment	500-2100
Sawn planks	1000-1200
Treated wood	8800-10,000

Rubber seeds are processed mainly in Tamil Nadu. During 1992-93 rubber seed oil production was estimated to be 4300 metric tonnes and seed cake production 8000 metric tonnes . No wide variation was apparent for rubber honey production during 1992-93 comapred to 1991-92 based on the available information.

7. Other studies

Estimation of natural damage to rubber plantations, census of planting materials used by small rubber holdings in India during 1989, cross-sectional analysis of the centrifuged latex industry in India, time series analysis of imports and exports of rubber products from India, marketing of medicinal plants, price forecasting models for NR and economics of rubber based farming systems in Kerala were also in progress.

CENTRAL EXPERIMENT STATION

The Central Experiment Station of the Rubber Research Institute of India, established at Chethackal, Ranni in Pathanamthitta district, covers an area of 254.8 ha. Long - term field experiments on clone evaluation, exploitation, evaluation of germplasm, pests and diseases, intercropping etc have been laid out here. Over 4,000 genotypes of wild Brazilian germplasm received from the Malaysian Centre and 102 clones of Wickham origin are being maintained in the station for evaluation.

During the period 1992-93 an area of about 30 ha was brought under different field experiments. The total crop production during the period was 172164.30 kg. The station received a total rainfall of 4138 mm (Table-Ces.1) during the period under report.

There were 209 permanent workers and 202 casual workers on the rolls, during the period. The total mandays engaged for different operations in the station during 1992-93 was 63968. The medical unit attached to the station provided medical facilities in 12864 cases.

During the period under report, a team of ANRPC representatives from different countries including the Secretary General visited the station. Three newly selected Junior Field Officers, two batches of estate management trainees and the Managing Director of Andaman and Nicobar Islands Forest & Plantation Development Corporation Ltd. also visited the station.

Table-Ces. 1. **Rainfall (1992-93) distribution**

Month	Rainfall (mm)
April	189.80
May	469.10
June	711.90
July	738.00
August	411.10
September	497.60
October	640.20
November	301.60
December	8.20
January	-
February	63.50
March	107.00
Total	4138.00

REGIONAL RESEARCH STATION, ASSAM

The thrust areas of research at the Regional Research Station, Assam are multidisciplinary evaluation of clones, assessment of nutritional requirements under different fertility status of soil, diseases and pests management, agroclimatological parameters and biotechnology. Biotechno logical studies are being reorganised at Regional Research Station, Tripura on a need base.

1. Multidisciplinary evaluation of clones

The girth data recorded in the 1985 clone trial at Sarutari Farm showed that PB 235 had maximum girth (51.77 cm), followed by RRII 118 (51.76 cm). Minimum girth was observed in G1 1 (43.14 cm) followed by RRIC 105 (46.98 cm). Minimum girth obtained was 42.18 cm in RRII 105.

Oidium leaf fall disease was observed during February - March 1993 causing leaf fall and shedding of flowers.

2. Nutritional studies - immature phase

In the 1987 trial laid out at Nayekgaon with RRII 105, it was observed that application of 60 kg N ha^{-1} has effected 40 per cent increase in girth over no N treatment. Similarly, phosphorus and potassium applied at the rate of 40 kg ha^{-1} each showed 3.9 per cent and 10.1 per cent increase in girth over no phosphorus and no potassium treatments.

In the 1986 trial at Mendipallhi the cumulative girth during the period indicated positive response to high doses of NPK (ie, 60 kg N ha^{-1}, 60 kg P_2O_5 ha^{-1} and 40 kg K_2O ha^{-1}) followed by 60 kg N ha^{-1}, 30 kg P_2O_5 ha^{-1} and 20 kg K_2O ha^{-1}.

3. Interaction between potassium and magnesium

The data on cumulative girth recorded from the experiment laid out in Sarutari Farm indicate that the highest girth was obtained when potassium was applied at the rate of 20 kg K_2O ha^{-1}, with no magnesium for clone RRII 105. Increasing the dose of magnesium had negative effect on growth. Similar observations were recorded from the trial at Nayekgaon in clone RRIM 600 also. Soil and leaf samples were collected during the period for nutrient analysis.

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

The cumulative data on girth so far generated from the trial in clone RRIM 600 laid out at Sarutari farm show that the treatment combination of 50 per cent water soluble and 50 per cent water insoluble P is the best suited for immature rubber.

5. Anther culture and plantlet regeneration

Somatic embryos were obtained from anther derived calli of PB 5/51.

6. Culture of mature and immature zygotic embryos

Embryos were excised aseptically from 8-20 weeks old immature and mature seeds and tested for their regeneration ability on 11 selected media to get healthy

and normal seedlings. Amongst the immature embryos, those more than 16 weeks old regenerated better.

Full plantlets were obtained from mature embryos on all the 11 media, of which three media helped to germinate more than 72 per cent embryos to full plantlet. These plantlets were successfully transferred under laboratory condition, but did not survive.

7. Plant regeneration from tissues of cover crops

Multiple shoot regeneration was obtained from the stem derived calli of *Pueraria* and *Mucuna*. Roots were obtained by culturing these shoots on hormone free media. Complete plantlets of *Pueraria* were successfully transferred to soil under laboratory condition. Complete plantlets were also obtained from stem derived calli of *Mucuna*.

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

Strains of *A. tumefaciens* were tested for virulence by infecting the bark of germplasm trees. Degree of virulence was evaluated visually by measuring the size and number of crown galls they produce.

9. Survey of diseases and pests

Pests and disease survey was carried out in 28 locations covering 13 different rubber growing tracts in Assam, Meghalaya and West Bengal and the damages caused by them were assessed by visual scoring.

Leaf fall disease, caused by *Oidium hevea*, was noticed on tender leaves in all stages of growth of rubber plants in all the locations surveyed except in West Bengal. High intensity of *Oidium* disease was noticed at Sarutari farm, Umling, Killing and Ouguri Rubber Estate causing repeated premature, defoliation and die-back of twigs and branches except at Sarutari. Flowers were also affected.

The incidence of leaf disease caused by *Gloeosporium alborubrum* was noticed on new flushes of leaves during June to September in all the plantations surveyed. High intensity of this disease was noticed in nursery and in a few plantations of Assam and Meghalaya. Pod rot caused by *G. alboroubrum* was also noticed in some plantations of Assam and Meghalaya. Leaf blight caused by *Periconia heveae* was also noticed on tender leaves in nursery plants during November to March.

Brown root rot disease caused by *Phellinus noxius* was noticed in some plantations in Assam and Meghalaya.

Scale insect (*Saisetia nigra*) infestation in nursery plants was noticed by the end of March and it increased gradually in both nursery and plantations upto the end of August. Thereafter, it started decreasing due to the activity of an entomogenous fungus which apparently controlled scale insect population. Mild infestation of termites, slugs and snails was also observed in some plantations of Assam and Meghalaya.

10. Isolation, identification and maintenance of pathogens

Routine isolation of fungal pathogens was made from diseased samples of *Hevea* collected from different locations of North East. Thirty five fungal isolates associated with virous diseases were maintained as stock cultures.

11. Control of powdery mildew

A trial for economic evaluation of sulphur dusting was initiated at Sarutari farm in mature rubber area. The trial to

control *Oidium* in the nursery in Sarutari farm indicated superiority of wettable sulphur over alternate application of wettable sulphur and Bavistin. This needs further confirmation.

12. Nursery trials

12.1 Effect of mulch on frequency of irrigation

In the trial laid out in the seedling nursery at Sarutari farm, the results suggest that black polythene and irrigation once in five days favourably influenced the growth of seedlings.

12.2 Effect of shade and frequency of irrigation

The data collected in the experiment are being pooled for statistical analysis.

13. Multiple cropping and mixed farming

An observational trial was laid out in the year 1992 to evaluate the efficacy of intercrops like banana, pineapple, ginger and covercrop.

14. Control of lalang (*Imperata cylindrica*)

This trial was laid out in the year 1992 at Sarutari farm to evaluate paraquat and glyphosate. Periodic observtion on weed infestation and biomass were recorded. The trial is being repeated for confirmatory results.

15. Performance of polyclonal material

Polyclonal seedlings were planted in the field during 1987 and regular observations were taken. Girth of the plants varied from 18-50 cm and bark thickness from four to nine mm.

16. Introduction and evaluation of germplasm

Brazilian germplasm materials were raised in different base nurseries during 1986, 1987 and 1990. Girth of plants varied from 12.4 cm to 49 cm, 12.0 to 34.0 cm and 11.2 to 29.9 cm in 1986, 1987 and 1990 trials respectively. During the second week of January 1993, plants were opened at 35 cm height for test tapping. However, severe cold prevented the continuation of tapping.

17. Genetic variability through hybridization

During the last flowering season, incidence of *Oidium* disease caused failure of the hybridization programme. Though all efforts were made this year, *Oidium* disease could not be controlled which caused all flowers to fall and hybridization work could not be undertaken.

REGIONAL RESEARCH STATION, TRIPURA

The Regional Research Station, Tripura, concentrated on location specific research on various aspects of rubber cultivation.

1. Nutritional studies

1.1 Mature phase

It was observed that the trees responded to higher doses of nutrients in resect of yield (Table-Net. 1). The girthing also showed a similar trend.

Table-Net. 1. **Average yield (g tree^{-1} tap^{-1}) for Jan. to Dec. '92**

Levels of fertilizer Nutrients	0	1	2
N	31.25	31.89	34.73
P	30.72	32.92	34.23
K	32.85	32.46	32.57

1.2 Immature phase (polybag plants)

The trial was laid out with a view to monitor the response of *Hevea* plants to higher doses of nutrients. It was observed that the plants had the highest absolute girth in the treatment NPK 60:60:60 with the full dose of P supplied in citrate soluble form.

2. Density-cum-nutritional trial

The girth data recorded showed the highest abolute girth in the highest density. But the rate of girth increment of the lower densities indicated that competition between plants in higher density plots affected growth.

3. Multiple cropping and mixed farming

In the trial laid out in RRS farm it was observed that rubber plants intercropped with pepper performed comparatively better than those with coffee as intercrop.

4. Forms and placement of fertilizers

4.1 Phosphatic fertilizers - immature phase

No marked effect in growth due to the different sources of phosphatic fertilizers was observed in clone RRIM 600 planted in 1986 at RRS farm.

4.2 Mode of fertilizer application (Mg)

In the trial laid out at Mohanpur during 1988, it was generally observed that 30 cm deep placement application of fertilizers resulted in a comparatively higher absolute girth than palcement at 15 cm depth or band application.

4.3 Mode of fertilizer application (N and P)

In the trial laid out in a farmer's field at Tulakona in 1990, it was observed that plants attained the highest girth in plots having ammonium sulphate + single super phosphate + muriate of potash applied as band.

5. Soil test crop response studies

5.1 Standardisation of soil extractants

It has been observed that removal of Fe and Al from Bray II extract yielded several fold recovery of P.

5.2 Physicochemical and mineralogical characteristics of soils

Using a cadastral map of 1:5000 scale, six profiles were excavated. The morphological properties were recorded and are being tested for physicochemical and elemental properties.

6. Evaluation of planting materials

6.1 Clone trial (1979)

Based on stability analysis of the data on wintering of 15 clones from 1987 to 1989, four common clusters - RRIM 600 and PB 86, PB 5/51 and RRII 203, RRII 5 and RRIC 52 and Gl 1 and Harbel 1 could be identified. Clones RRIM 605, GT 1 and RRII 118 were found intermediate to the above clusters, while clones RRII 105, RRIM 703, PB 235 and RRIC 105 showed independent wintering pattern. It was generally observed that clones RRIC 52, RRIM 703 and PB 235 had simultaneous shedding and reflushing of leaves while clones RRII 105 and RRIC 105 exhibited distinct leaf less gap before reflushing.

6.2 Clone trial (1987a and 1987b)

Girth at 150 cm height and girth increment are being monitored at quarterly intervals. Physiological parameters like transpiration rate, stomatal conductance as well as total chlorophyll content were also recorded. In clone trial 1987a the highest chlorophyll content was recorded in GL 1 (4.02 mg g^{-1} fw) and lowest in RRII 118 (2.67 mg g^{-1} fw). Stomatal conductance (159 m mol m^{-2} sec^{-1}) and transpiration rate (2.3 m mol m^{-2} sec^{-1}) was found to be the highest in SCATC 93-114.

In clone trial 1987b, the highest chlorophyll content (4.54 mg g^{-1} fw) was recorded in RRII 105 and lowest in GT1 (2.39 mg g^{-1} fw). Rate of transpiration was highest in RRIM 600 (2.7m mol m^{-2} sec^{-1}) and least transpiration (0.9 m mol m^{-2} sec^{-1}) was observed in PB 86, PB 235 and RRIM 605.

7. Breeding and selection

7.1 Half-sib progeny evaluation

Randomly selected progenies of five clones are being multiplied for a field evaluation along with their female parents to identify useful genetic variants.

7.2 Full-sib progeny evaluation

A total of 16 cross combinations (including reciprocals) involving RRII 208, PB 86, RRII 105, Gl 1, Haiken 1, SCATC 88/13 were undertaken. In all only 352 hand pollinations were possible mainly due to untimely rain and *Oidium* attack.

7.3 Evaluation of polyclonal seedlings

Morphological parameters were recorded periodically with a view to identify promising genotypes from among the seedlings.

8. Germplasm conservation, evaluation and maintenance

The germplasm collection maintained in this station consists of oriental clones (30), and clones from IRRDB 1981 collection belonging to the provenances of Acre (107), Matto Grosso (126), Rondonia (133) and mixed seedlings (3). Morphological data as well as wintering pattern were recorded periodically.

9. Environmental and physiological parameters and growth

The girth, chlorophyll content, spe-

Table-Net. 2. **Chlorophyll content, specific leaf weight and relative water content during March '93**

Clone	Total chlorophyll (mg g^{-1} fw)	Relative water content (%)	Specific leaf weight (mg cm^{-2})
RRII 105	3.91	85.70	8.42
RRII 118	3.52	85.80	8.05
RRIM 600	3.37	83.00	7.46
GT 1	3.74	80.40	8.99
PB 235	3.14	81.60	6.85
SE ±	0.14	1.08	2.24

Table-Net. 3. **Yield under different exploitation systems**

Treatments	Mean yield 1992-93 (g tree^{-1} tap^{-1})	
	RRIM 600	RRII 105
$^1/_2$Sd/2 continuous	25.00	23.17
$^1/_2$Sd/2 rest in Dec.	23.00	20.03
$^1/_2$Sd/2 rest in Dec/Jan.	20.72	18.39
$^1/_2$Sd/2 rest in Dec/Jan/Feb.	19.25	16.90
$^1/_2$Sd/3 continuous	20.81	18.01
$^1/_2$Sd/3 rest in Dec.	19.60	17.65
$^1/_2$Sd/3 rest in Dec/Jan.	18.26	16.27
$^1/_2$Sd/3 rest in Dec/Jan/Feb.	17.57	15.09
SE±	0.87	0.88

cific leaf weight and relative water contents were recorded periodically. The data are presented in Table-Net. 2. Other phy siological parameters like transpiration, stomatal conductance, relative humidity, leaf temperature and photosynthetically active radiation were also monitored.

10. Exploitation systems

Mean Data on yield presented in Table-Net. 3 showed that continuous 1/2s d/2 system was superior.

REGIONAL RESEARCH STATION, MEGHALAYA

The Regional Reserach Station, Meghalaya, concentrated on field experiments in Ganolgre farm and at Darechikgre and at Jenggitchakge.

1. Field experiments at Ganolgre farm

1.1 Multidisciplinary evaluation of clones

Girth data of the 1985 trial with ten clones recorded during the year showed that RRII 118 (45.63 cm), RRII 203 (45.32 cm) and PB 235 (45.02 cm) attained the maximum girth while PB 5/51 (37.04 cm) attained the minimum girth. In the 1986 clone trial, RRIC 105 (41.06 cm) and RRII 208 (39.5 cm) showed maximum girth and PCK 1 (28.91 cm) the minimum.

1.2 Performance of polyclonal seedlings

In order to study the performance and suitability of polyclonal seedlings in the West Garo Hills of Meghalaya, polyclonal seedlings were planted in 1990. The seedlings have attained an average height of 159.43 cm and girth of 6.39 cm. During winter period die-back symptoms were noticed in some of the seedlings and growth of these plants were adversely affected by low temperature.

1.3 Rubber based cropping system

The growth of tea, orange and rubber (RRIM 600) continued to be satisfactory. Adverse effect of low temperature was noticed in rubber and orange while tea plants were not much affected. During the year 222 kg green tea leaves were harvested.

1.4 Weedicide trial

With a view to controlling the noxious weed *Imperata cylindrica*, a field trial on the application of weedicides namely glyphosate and paraquat was initiated.

2. Field experiments at Darechikgre farm

2.1 Multidisciplinary evaluation of clones

All the ten clones included in this

trial were adversely affected by low temperature as well as high elevation. Only a total of 48 plants are surviving, that too with retarded growth.

2.2 Intercropping with perennial corps

As in the previous years tea and orange are growing well at 1100 m elevation while all polyclonal stumps have dried up. It shows that low temperature and high elevation are not suitable for rubber cultivation in Garo Hills of Meghalaya.

2.3 Intercropping trial, Jenggitchakgre

The intercrop trial initiated during 1990 is being continued. Growth of rubber was found to be satisfactory with both the intercrops, pineapple and banana.

3. Research programmes in plant breeding

3.1 Hybridization

With a view to evolve clones suitable to this area, hybridization programme was initiated in 1992.

3.2 Evaluation of seedlings

A total of 391 seedlings raised from open pollinated seeds of seven clones in the 1985 clone trial are under observation.

3.3 Ortet selection

Mother trees were identified in three rubber estates, namely Baghmara (32 trees), Wagaesi (27 trees) and Kharkutta (10 trees) in Meghalaya. Observations on latex yield, plugging index, rate of flow, DRC, bark thickness, panel length etc. are being recorded.

4. Research programmes in plant pathology

4.1 Mushroom culture

Cultivation of mushroom is being carried out using different plant materials as substrate. Two species of oyster mushroom viz. *Pleurotus flabellatus* and *P. sajor-caju* can be grown successfully under the conditon in the West Garo Hills of Meghalaya during major part of the year except from November to February when the temperature drops considerably. On the other hand, *P. ostreatus* can be cultivated during this period which requires a fairly low temperature as compared to other two species. Attempts are also being made for the production of spawn.

4.2 Plant diseases

A survey of rubber diseases indicated that powdery mildew and leaf-spot diseases are of quite common occurrence in rubber plantations of Garo Hills.

4.3 Soil microflora

Soil microflora showed a decreasing trend with increase in soil depth. The endophyte spore population was found to be maximum in the surface layer and decreased with depth. The VAM infection was maximum nearer to the base of the plant ie., 30 cm away and with increasing horizontal distance the level of infection dropped. Similarly the data on vertical distribution also suggested a decreasing trend with depth.

5. Reserach programmes in plant physiology

5.1 Flowering and fruiting

Percentage of trees flowered, fruited and number of pods per tree were recorded in ten clones during the year 1992. It has been observed that percentage of trees flowered was maximum in RRII 203, RRII 105 and Gl 1 and minimum in RRIM 600. Maximum pod per tree was recorded in PB 86 and Gl 1 and least in RRII 118. It was observed that with

increasing age of the tree, pod number per tree also increased. However, flowering and fruiting were adversely affected by local factors such as early rain and high wind velocity at the time of onset of flowering and fruiting.

5.2 Effect of winter

It was noticed that during the year minimum air temperature of 2.8°C upto 3 hr was recorded during the winter. The low temperature adversely affected the growth of all the clones. It was noticed that 25 to 35 days were required for refoliation after defoliation and it varies from clone to clone. Average temperature was always less than 15°C from November to February.

5.3 Effect of different aspects of slope

The average girth of RRIM 600 clone in west s outh-west and north north-east were recorded and it was 26.18 cm and 25.35 cm respectively. There was not much variation in the girth of plants growing in west south-west slope and north north-east slopes.

REGIONAL RESEARCH STATION, MIZORAM

Ongoing research programmes of the Regional Research Station, Mizoram were continued. Observations on growth of rubber, weed managment etc., were in progress.

1. Multidisciplinary evaluation of clones

The trial started in the year 1985 was contiued. The observations on girth show that RRII 118 continued to record highest girth (49.43 cm) followed by PB 235 (48.13 cm) and RRIM 600 (47.93 cm).

2. Polyclonal seed garden

The polyclonal seed garden established in 1988-89 was maintained well. The growth of the clone SCATC 93-144 continued to be good in all the positions (top, middle and foot) of the hill followed by that of RRII 118.

3. Influence of physiographic features on growth

The trial started in 1987 to study the influence of physiographic features on growth was continued. The average girth of rubber plants in four aspects as in January 1993 is given in Table-Nez. 1. Vigorous growth of rubber plants was observed in eastern slopes.

Table-Nez. 1. Effect of apects on growth of rubber

Aspect	Girth (cm) at 150 cm height
North	15.89
South	17.56
East	18.93
West	17.43

4. Weed management

The experiment laid out in 1990 was continued and observations were recorded.

5. Nutritional trial

This trial was laid out in a RBD with 6 treatments and 4 replications. The clone used is RRII 105. A trial to evaluate the effect of split application of fertilizers on growth of young rubber plants was initiated and observations were recorded.

6. Establishment of cover crop

An experiment to identify the most suitable planting technique for early establishment of cover crop in Mizoram was laid out incorporating five treatments in an area where the clone RRII 600 was planted.

REGIONAL RESEARCH STATION, WEST BENGAL

The Regional Research Station at Nagrakata, West Bengal concentrated on nutritional studies, evaluation of clones, performance of different clone blends and on exploitation systems. The station has a small area under seedling, budwood and polybag nurseries. Meteorological data are also being recorded.

1. Nutritional studies

In the 1989 trial, significant response was noticed after three years and six months planting in case of girth and girth increment by increasing the doses of nitrogen. Maximum girth (22.90 cm) was recorded at 60 kg N ha^{-1}. Response to phosphorus and potassium was not significant though the maximum (22.11 cm and 22.26 cm respectively) were recorded at 40 kg ha^{-1} level for both. The interaction of fertilizers was not significant. Post treatment soil and leaf smaples were collected plotwise and are being analysed for assessing the nutritional status.

2. Multidisciplinary evaluation of clones

2.1 Clone trial 1990

The performance of different clones in the two trials laid out in 1990, was not very significantly different in respect of girth. In the clone trial with eleven clones, maximum girth was recorded by clone RRII 118 (16.4 cm) and in the second trial which is having seven clones, PB 86 and RRIM 605 recorded maximum girth (16.2 cm).

2.2 Clone trial 1991

There was no significant variation among the eleven clones with respect to morphological characters. However, maximum girth (6.6 cm) and maximum height (314.3 cm) was recorded in clone PB 310.

3. Expoitation systems

The trial was laid out in 1991 and is being properly maintained. Observations during the immature phase are in progress.

4. Clone blends

A part of the trial to study the performance of different clone blends in comparison to monoclonal population of RRII 105, has been laid out the year 1992. Planting materials have been raised to plant the remaining part of the trial during 1993.

REGIONAL RESEARCH STATION, MAHARASHTRA

The Regional Research Station at Dapchari, Maharashtra continued research activities on physiological aspects, irrigation, clone evaluation and related fields.

1. Irrigation systems

Girth data recorded during March 1993 showed that tree growth was directly proportional to the increasing level of treatments from 0.25 ETc to 1.00 ETc. The control plants showed significantly less growth compared to that of all other irrigations treatments (Table-Dap. 1). Irrigation treatments showed more growth in RRII 105 and RRII 118. Data on trees that attained tappable girth under different irrigation treatments revealed that irrigation reduced the immaturity period.

Table-Dap. 1. **Effect of irrigation on growth**

Treatments	Girth increment (cm) from April 1992 to Feb. 1993
T_1 No irrigation	4.75
T_2 1.00 ETc, basin	8.26
T_3 0.75 ETc, basin	8.34
T_4 0.50 ETc, basin	7.33
T_5 0.75 ETc drip	7.82
T_6 0.50 ETc, drip	7.29
T_7 0.25 ETc, drip	5.94
CD	0.57

2. Physiological evaluation trial

Physiological parameters such as turgor potential and plugging index and yield parameters like latex yield, cuplump weight and DRC were recorded at monthly intervals.

Among the clones, RRIM 600 recorded the maximum yield (1485 kg ha $^{-1}$) and the performance of this clone during the drought period was also good. The clone RRIM 612 showed the lowest yield of 638 kg ha $^{-1}$. Generally, all clones showed a delcining yield trend after January. Therefore, tapping rest was given from the first week of April 1993.

3. Soil moisture stress, growth and physiological parameters

The experiment with clone RRII 105 was continued. Growth achieved, leaf area index and chlorophyll content under different soil moisture regimes as in 1993 summer is given in Table-Dap. 2. The results on growth are confirmatory to the earlier reports. Drastic reduction in leaf area index and chlorophyll content was seen during summer in the control plants. In the control plants leaf margin drying was up to 34 per cent whereas no such drying was observed in plants which received adequate soil moisture. Data on bark moisture status, photosynthesis etc. were also collected.

4. Mulching

Irrigation was given at the rate of 422.5 l tree $^{-1}$ irrigation $^{-1}$ (0.5 ETc). The treatment mulch at the rate of 4t ha $^{-1}$ with irrigation showed better growth, less weed growth, higher organic carbon content and better soil moisture regime. Soil temperature in this treatment was maintained at 20 to 26°C thoughout the year. The unmulched plants showed less girth and girth increment, more weed growth and wide fluctua-

Table-Dap. 2. **Girth (cm) leaf area index (LAI) and chlorophyll content of *Hevea* under different quantities of irrigation**

Treatments	Girth March '93	LAI	Chlorophyll (mg dm^{-2})
Unirrigated	29.2	0.69	1.10
0.50 ETc, basin	40.4	2.78	4.18
0.75 ETc, basin	42.5	3.23	4.10
1.00 ETc, basin	42.2	3.26	4.89
0.25 ETc, drip	38.2	2.24	3.81
0.50 ETc, drip	38.3	2.61	3.97
0.75 ETc, drip	39.9	3.22	4.19
CD (P = .05)	4.2	0.42	0.97

tion in soil temperature (from 20 to 46°C).

5. Clone trial

Regular observations on growth and other secondary attributes, were taken from the ongoing clone trial. The girth data recorded during March 1993 showed that clones RRII 208, RRII 6, RRIC 100, RRIC 52 and RRII 105 are the most vigorous, with mean girths of 44.36 cm, 40.60 cm, 39.94 cm, 39.50 cm and 39.11 cm respectively. PCK 2 recorded the minimum girth (33.78 cm).

6. Polyclonal trees for selection

A total of 140 plants were also opened for tapping during 1992. Polyclonal seedlings continued to record very good yield throughout the year including the drought season. The selected seedlings are being multipled for further evaluation.

7. Cost evaluation

The trial laid out in 1987 to estimate the cost of cultivation of was continued. Expenses incurred towards various inputs, cultural practices and irrigation are being monitored.

REGIONAL RESEARCH STATION, ORISSA

The Regional Research Station at Dhenkanal, Orissa continued investigations on agromanagement techniques and clone evaluation for specific drought prone areas in central Orissa. Growth and development of plants at the experimental farm of the station was satisfactory.

1. Experimental planting

In the clone trial planted in 1987, maximum girth was recorded in RRIM 600 which was significantly higher than that of RRII 105 (Table-Ori. 1), while no significant difference was observed in the girth increment (January to December 1992).

Table-Ori. 1. **Mean girth and girth increment**

Clone	Girth (cm)	Girth increment (cm)
RRII 105	20.20	6.50
RRIM 600	23.71	7.25
GT 1	22.65	6.30
S E	1.64	0.79
C D (at p.05)	2.89	N.S.

2. Polyclonal seedlings

In the polyclonal seedling area the trees had attained an average girth of 27.8 cm by September 1992 which reveals that polyclonal seedlings are quite adaptive to stress conditions.

3. Clone evaluation (1990)

Significant differences were noticed in the mean girth (Table-Ori. 2), with Haiken 1 and RRIM 600 being the best and PCK 1, the poorest.

Table-Ori. 2. **Annual girth of clones**

Clone	Mean girth (cm)
RRIM 600	12.76
RRIM 701	10.15
RRII 300	11.41
RRII 208	11.51
RRII 5	11.46
PB 310	12.56
SCATC 88/113	10.53
SCATC 93/114	12.50
Haiken 1	12.83
PCK 1	10.25
S E	0.82
C D (P = 0.05)	1.42

4. Clone evaluation (1991)

In field the trial planted in 1991, ten clones and polyclonal seedlings are being tested. RRII 5 had attained the maximum girth (8.1 cm) closely followed by RRIC 102 (7.8 cm). In this trial also PCK 1 was the poorest (4.8 cm).

5. Organic manures

In a trial laid out in 1991, on comparison of different types of organic manures, it was found that response of plants to the combination of farm yard manure (6.25 kg/pit) and cake-o-meal (0.75 kg/pit) and organic matter supplement was superior to other treatments. Further evaluation of organic manures as an initial fertilizer source has been planned for the 1993-94 season.

REGIONAL RESEARCH STATION, MADHYA PRADESH

The Regional Research Station established at Sukma, Bastar Dist., Madhya Pradesh continued its research activities. Stock seedlings and budwood nurseries were established in 1992. The field experiments laid out in 1991-92 were maintained well. Steps are under way to take up more field experiments and to study location specific problems and to evolve suitable package of agromanagement practices for this region.

HEVEA BREEDING SUBSTATION, KARNATAKA

The Hevea Breeding Substation located at Nettana, Karnataka concentrated on location specific testing of clones evolved though ortet selection and hybridization.

1. Trial on growth, yield and exploitation systems

The two trials with five clones each, one laid out in 1987 and the other in 1988, were maintained. Girth recording was done at quarterly intervals. In the 1987 trial mean girth varied from 24.61 cm (RRII 300) to 29.75 cm (PB 260). High incidence of wind damage was noted for two clones RRII 300 and RRII 105 (22%). Incidence of pink disease ranged from 3 per cent (PB 235 and PB 260) to 9 per cent (RRII 105). in the 1988 trial mean girth varied from 13.59 cm (RRIC 36) to 19.11 cm (RRII 118). Wind damage ranged from 6.25 per cent to 10.9 per cent. Incidence of pink disease was low ranging from 1 per cent (PCK 2) to 4 per cent (RRII 118).

2. Trial of ortet clones

Girth recording was carried out at

quarterly intervals. Detailed observations on growth attributes were also recorded. For early selection of promising high yielders, test tapping was initiated. Wind damage recorded from the trial was 9.19 per cent and pink disease 11 per cent.

3. Clone trials

Two rounds of girth recording were done in the 1989 trial. Brown root disease was spotted in the area and 4 trees were severly affected. Wind damage recorded for this trial was 6.1 per cent.

Two rounds of girth recording were carried out in the trial on second selections from the 1954 hand pollination programme and popular clones. No serious damage due to diseases, wind and drought was noted.

The trial on evaluation of indigenous and exoitic clones raised in an area of 2.5 ha during 1991 was maintained properly. Gaps were filled and life saving irrigation and proper protection were given during summer months.

4. Estimation of genetic parameters

The trial was properly maintained. Selective irrigation was given wherever necessary and girth recording was carried out.

5. General

The station recorded a total rainfall of 4753.80 mm during 1992 with the highest rainfall of 1205.40 mm during the month of July, followed by 1013.80 mm in August. The maximum temperature recorded was 38.5°C in the month of March and the minimum 10°C in January 1993.

HEVEA BREEDING SUBSTATION, TAMIL NADU

The station is located at Paraliar, about 40 km away from Nagercoil. In the two breeding orchards established in 1987 and 1988, branches were induced at lower levels. An attempt was made to assess the response of various clones to branch induction, for which various vegetative characters were recorded after successful induction of branches.

In the large scale trial raised in 1991 using 15 clones, plants surviving after heavy casualty during the initial stage, were maintained. Attempts were made to replace the casualties. Since cover crop establishment was poor in this area, polybagged plants of *Pueraria* and *Mucuna* were established. Life saving irrigation was given wherever necessary. One round of girth recording was also done.

High yielding seedlings in the nursery, after test tapping were pollarded for cloning. A small nursery trial using polyclonal seedlings and assorted seedlings was established to study the growth vigour of polyclonal seedlings and to assess their superiority as root stock. A source bush nursery was also maintained.

HIGH ALTITUDE RESEARCH STATION

Efforts to locate a suitable site for the establishment of a High Altitude Research Station were continued in 1993 also. Two more locations have been inspected by the expert committee and the reports were submitted. The on-farm trials initiated by the Plant Physiology and Expoitation Division in 1981 at Mullenkolli and fertilizer and intercropping trial initiated by the Agronomy and Soils Division in 1991 at Mananthavadi, are under progress.

During the year 1993, the Mycology and Plant Pathology Division has initiated a trial on powdery mildew disease control using systemic fungicide dust on clone RRII 105 at Mangalam Carp estate (Chulliyode, Sultan Battery). In the same estate a clone trial comprising of RRII 105, RRII 203, RRIM 600, RRIC 100 and PCK 2 was laid out by the Botany Division during the year under report.

AGROMETEOROLOGY UNIT

Weather at various stations

The weather parameters observed at four locations during the year 1993 are summarized in Table-Agromet. 1. Nettana recorded the highest amount of rainfall (4753.80 mm) against Agartala (2378.60 mm). Except north-eastern regions, in all the three locations both the SW and NE monsoons were very active and well distributed. A good amount of summer showers were also recorded at all the four experiment stations. Analysis of the rainfall pattern showed that at Chethackal, distribution was more even compared to that in the other locations. On the whole, rainfall received was quite good at all the four locations during the last year.

Regarding thermal conditions, maximum range of temperature (highest maximum to lowest minimum) was observed at Agartala (23.6°C) followed by Nettana (21.8°C) and minimum at Kottayam (14.7°C). The lowest minimum of 10°C was observed in January at Agartala and the highest maximum of 35.3°C was observed in March at Nettana.

The duration of sunshine hours was maximum at Kottayam in almost all the months except winter against Agartala, where the observed sunshine hours were slightly higher in winter compared to the other locations.

Table - Agromet 1. Weather at various stations (1993)

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Rainfall Total (mm)
Rainfall (mm)													
Agartala	0.0	153.4	48.6	115.2	723.4	523.4	196.2	196.2	235.8	104.4	82.0	0.0	2378.6
Nettana	0.0	—	5.3	155.7	265.5	635.4	1293.9	1109.9	383.4	699.0	43.3	162.4	4753.8
Kottayam	0.0	27.0	12.3	159.6	266.4	1034.7	996.0	217.1	95.1	432.7	258.8	77.2	3576.9
Chethackal	0.0	63.5	106.0	182.7	223.3	689.1	906.1	259.3	187.6	519.5	239.5	40.2	3416.8
Maximum Temp. (°C)													
Agartala	24.7	28.5	28.6	32.8	30.7	31.7	31.4	33.6	31.5	32.0	29.0	27.5	
Nettana	33.6	34.4	35.3	34.9	33.8	30.1	27.2	27.6	29.0	30.5	32.2	31.9	
Kottayam	32.7	33.5	34.9	34.6	33.2	30.0	28.8	30.0	30.7	30.4	30.0	31.8	
Chethackal	34.3	34.0	34.3	35.2	33.6	30.7	28.5	30.1	31.2	31.4	31.5	32.6	
Minimum Temp. (°C)													
Agartala	10.0	—	—	19.7	20.6	23.2	28.7	25.0	24.4	22.9	16.9	11.8	
Nettana	13.5	13.6	18.4	19.5	20.7	20.5	20.7	21.2	21.3	21.2	20.6	17.2	
Kottayam	20.2	21.9	24.1	24.4	24.3	23.4	22.7	23.4	23.0	23.0	20.8	22.8	
Chethackal	18.0	20.1	22.2	23.6	22.9	22.6	19.8	22.0	23.2	24.0	24.6	24.1	
Sunshine (h)													
Agartala	6.6	7.7	7.7	7.7	4.7	4.8	4.0	3.2	4.5	5.9	8.1	8.3	
Nettana	9.5	9.6	8.2	8.5	7.2	3.3	1.1	1.8	4.6	—	6.5	7.8	
Kottayam	8.5	9.9	9.3	9.4	7.4	4.9	3.2	5.3	6.3	4.3	4.7	6.3	
Chethackal	7.3	8.9	8.1	8.4	6.9	4.2	2.5	4.9	6.0	3.9	4.5	5.4	

LIBRARY AND DOCUMENTATION CENTRE

During the year 1992-93, 125 new books and 133 bound volumes were added to the library, making the total collection 20714 and 17156 respectively. The library subscribed to 175 journals and 9 dailies. About 150 other periodicals were received either as exchange for our publications or as gift.

Three issues of Documentation List, three issues of Rubber Alert, 150 issues of SDI Bulletin, a List of New Additions and a Current List of Periodicals for 1992 were compiled and distributed. Photocopies of 23 scientific articles were procured from other institutions. As part of information dissemination, 24 scientific articles were sent to different institutions/scientists. Around 1.25 lakh photocopies of information materials were made by the reprographic section. The database development of the library was also in progress. During the current year, 5220 documents were indexed.

The library is actively participting in the sales promotion of Indian Journal of Natural Rubber Research and the books Rubber Wood : production and Utilization and Plant and Soil Analysis published by the RRII. The library is also distributing the Annual Report of the RRII.

The facilities and services of the library were also extended to planters, manufacturers and others connected with NR industry through its external membership. Scientists from other research institutions, research scholars and students from universities also utilised these services.

BUDGET

Expenditure at a glance (Rs. in lakshs) 1992-93

Sl. No.	Head of Account	Approved budget	Actual expenditure
Non Plan			
1.	General charges	174.00	195.15
2.	Schemes	23.00	17.40
3.	Projects —CES	50.00	51.13
4.	Department of Training	5.55	6.73
	Total Non Plan	252.55	270.41
Plan			
5.	General charges	20.00	38.37
6.	Schemes	225.00	120.74
7.	NERDS Research Component	100.00	98.23
	Total Plan	345.00	257.34
	Grand total	597.55	527.75

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Debasis Mandal, M.Sc.	Junior Scientist
Chandra Gupta, M.Sc. (Ag.)	Junior Scientist
Dilip Kumar Daimari, M.Com. (upto 7.8.92)	Assistant Accounts Officer
P Eswari Amma	Assistant Section Officer
Regional Research Station, Tripura	
Jacob Pothen, M.Sc. (Ag.)	Deputy Director
N Durjathi Chaudhuri, M.Sc. (Ag)	Plant Physiologist
P Mallinath Priyadarshan, M.Sc., Ph.D.	Plant Breeder
Varghese Philip, M. Sc. (Ag)	Junior Scientist
Rajeswari Meenattoor, M.Sc. (Ag.)	Junior Scientist
D V K Nageswara Rao, M.Sc. (Ag.)	Junior Scientist
Y A Nanja Reddy, M.Sc. (Ag.) (Resigned on 23.3.93)	Junior Scientist
Mary Varghese, M.Sc. (Ag.)	Junior Scientist
K K Vinod, M.Sc. (Ag.)	Junior Scientist
Jibben Chakraborty, B.Com.	Assistant Accounts Officer
Regional Research Station, Meghalaya	
A P Thapliyal, M.Sc., Ph.D.	Plant Physiologist
H K Dekha, M.Sc., Ph.D.	Junior Scientist
G Pushparajan, M.Sc., Ph.D.	Junior Scientist
Jayasree Gopalakrishnan, M.Sc., M.Phil	Junior Scientist
Regional Research Station, Mizoram	
Ram Phool Singh, M.Sc. (Ag.)	Junior Scientist
Regional Research Station, West Bengal	
Supriyo Ghatak, M.Sc. (From 2-5-91)	Junior Scientist

Regional Research Station, Maharashtra	
T Mohankrishna Tadikonda, M.Sc., Ph.D.	Plant Physiologist
K Pratapan, M.Sc. (Ag.) (On study leave)	Junior Scientist
P Subramanian, M.Sc.	Junior Scientist
Lalitha Mohan Nath	Assistant Section Officer
T V Kurian	Assistant Farm Superintendent
Regional Research Station, Orissa	
Arun K Nair, M.Sc. (Ag.), Ph.D.	Agronomist
M J Augustine	Assistant Farm Superintendent
Regional Research Station, Madhya Pradesh	
Katuri Nageswara Rao M.Sc. (Ag.)	Junior Scientist
Hevea Breeding Sub-station, Karnataka	
M A Nazeer, M.Sc., Ph.D.	Senior Plant Breeder
N Bhargavan	Assistant Farm Superintendent
Hevea Breeding Sub-station, Tamil Nadu	
T A Soman, M.Sc., M. Phil.	Junior Scientist
S Suma, M.Sc.	Junior Scientist
V Vijayan	Assistant Farm Superintendent
Regional Laboratory, Nagercoil	
A Ulaganathan, M.Sc.	Junior Scientist
Regional Laboratory, Muvattupuzha	
Siby Varghese, M.Sc.	Junior Scientist
Regional Laboratory, Calicut	
Joyce Cyriac, M.Sc.	Junior Scientist
Mathew Joseph	Junior Scientist
P K Madhusudhanan, B.Sc.	Senior Scientific Assistant
Statistics Section	
G Subharayalu, M.Sc.	Statistician
A Malathy, M.Sc.	Assistant Statistician
Library and Documentation Centre	
Mercy Jose, B.Sc., M. L. I. Sc.	Documentation Officer

Accamma C Korah, B.Sc, M. L. I. Sc.	Senior Librarian
Kurian K Thomas, B.Sc., M. L. I. Sc.	Junior Publication Officer
Instrumentation Section	
S Najmul Hussain, M.Tech., A. M. I. E. T. E.	Instrumentation Officer
Thomas Baby, M.Sc., M. Phil., Ph.D.	Assistant Instrumentation Officer
Art/Photography Section	
K P Sreerenganathan	Senior Artist/Photographer
Maintenance Wing	
S Mohanachandran Nair, B.Sc. (Engg.)	Electrical Engineer
T K Somanatha Pillai	Assistant Estate Officer
Sheela A John, B. Tech.	Assistant Engineer (Civil)
K. T. Davis	Engineering Supervisor
Administration Section	
R Soman, B. A.	Assistant Secretary
Josy D' Cruz	Administrative Officer
E K Thankamma	Section Officer
V Mary Philipose, B. Sc.	Assistant Section Officer
R Babu (upto 20-1-93)	Assistant Section Officer
Accounts Section	
M G Gopi, M.Com.	Assistant Director (Finance)
Manu P Sam, B.Sc., A. C. A.	Assistant Accounts Officer
T Thanka	Administrative Officer
Security Wing	
A. K. Ramakrishna Pillai (upto 7.8.92)	Assistant Security Officer
C. K. Abraham, B. A., B. Ed. (From 8.8.92)	Assistant Security Officer

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Kolasib-796081
Mizoram.

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Research divisions and fucntions

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

The thrust areas of research of the Agronomy and Soils Division are investigations of the nutritional requriements of rubber, irrigation, intercropping, cover crop management, weed control and the study of the rubber growing soils. Development of tissue culture and anther culture systems for propagation and crop improvement of *Hevea* are the important areas in which the Biotechnology Division is engaged. The important fields of research of the Botany Division are breeding, evaluation and selection of new clones, propagation techniques, planting methods, anatomical studies and cytogenetic investigations. The Germplasm Division is concentrating on the introduction, conservation and evaluation of Hevea germplasm. The Mycology and Plant Pathology Division is engaged in investigations on the diseases and pests of rubber and associated cover crops and their control. The Plant Physiology and Exploitation Division conducts studies on identification of characterstics 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 225 ha Central Experiment Sttion 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 Tipura, Guwahati in Assam, Tura and Darechikgre in Meghalaya and Kolasib in Mizoram. The RRII has also set up regional research establishments at Dapchari (Maharashtra), Kamakhyanagar (Orissa) Nagrakata (West Bengal), Sukma (Madhya Pradesh), Paraliar (Tamil Nadu) and Nettana (Karnataka)

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

Staff

The staff strength of RRII has been 426 during the period under review. This inculdes 114 scientists 167 scientific and technical personnel and 145 personnel employed in administration and other nontechnical activities including unskilled staff.

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

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