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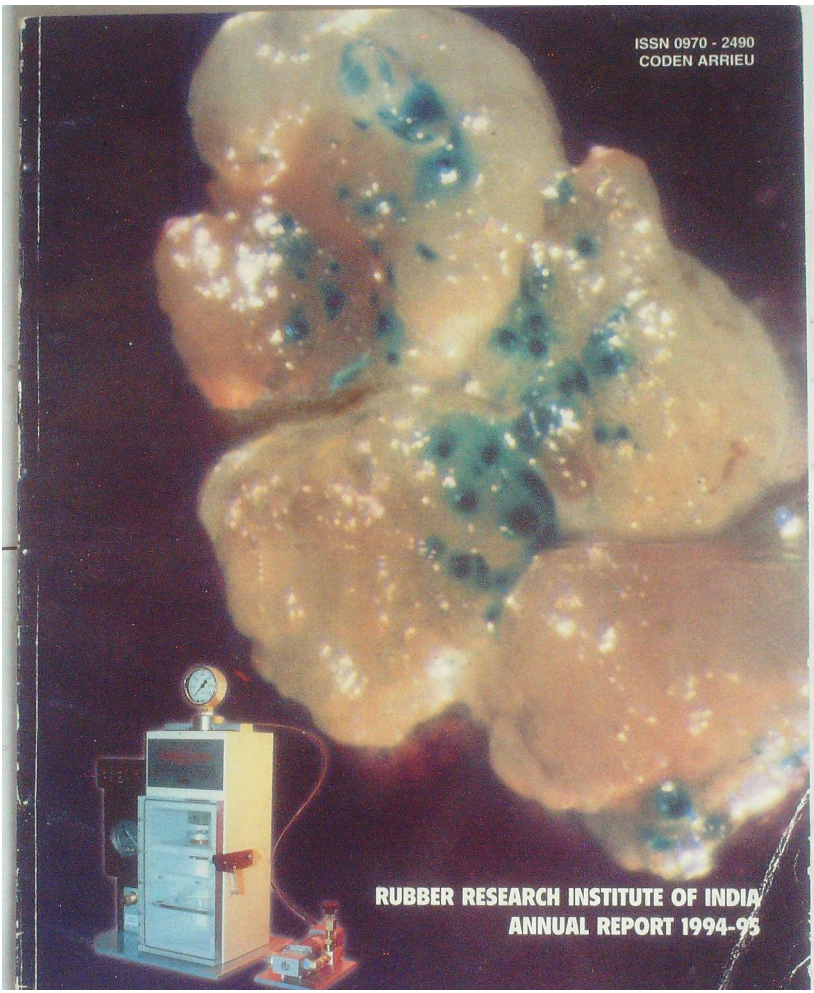

RUBBER RESEARCH INSTITUTE OF INDIA
ANNUAL REPORT 1994-95

Rubber Research Institute of India

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Transformed callus of *H. brasiliensis* with marker gene and Biolistic Particle Delivery System (Gene gun) used for genetic transformation.

Photograph

Mr. K. P. Sreerenganathan

December 1996

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

Functions

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

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.

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ANNUAL REPORT
1994-95

RUBBER RESEARCH INSTITUTE OF INDIA
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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DIRECTOR'S REVIEW

At times success causes concern. The outstanding clone, RRII 105, evolved by the Rubber Research Institute of India (RRII) is such an example. This clone under the traditional rubber growing tracts in India has a productivity potential of 300-500 kg/ha/annum, over and above the other existing high yielding clones. The planters therefore prefer to plant RRII 105 only and this has resulted in a situation that there are more than 2,50000 ha under RRII 105 in the state of Kerala alone. Such monoclonal planting is causing concern. Though the Institute has recommended blending of clones, farmers did not follow that recommendation mainly because there are very few alternative clones which can match the yield potential of RRII 105. The RRII has therefore, given top priority in evolving and releasing high yielding clones with equivalent or higher yield potential. About 12 such hybrid clones have been selected and in order to shorten the lag period for commercialisation the Institute has taken the initiative to introduce these experimental clones (described as RRII-EX clones) for large scale on-farm trials. Stress tolerance is going to be one of the most important attributes for the success of future plantations as the new areas for extension of cultivation lie in the non-traditional regions of India. Naturally, breeding and selection for stress tolerance have been given due priorities in our strategies. The 1981 IRRDB collection of wild germplasm is being screened for desirable traits such as disease tolerance and stress tolerance. A genome analysis laboratory is being set up so that identification of genotypes for different desirable characteristics can be confirmed at molecular level. The same technique is being utilised for measuring genetic distance between parent clones and to detect genes linked to disease resistance and to help plan hybridisation programmes. Another interesting development is perfection of a protocol for generation of plants from protoplast. This has been achieved in collaboration with the University of

Nottingham, UK. The Institute has also made a beginning in the standardisation of techniques for production of transgenic rubber plants with desirable genes.

RRII is coordinating an international programme on Tapping Panel Dryness. It is becoming increasingly evident that the TPD syndrome is the cumulative effect of different kinds of biological stress including the stress induced by exploitation. Attempts are being made to compute ratios between stress-driven free radicals generated and levels of scavenging enzyme systems. It is also becoming evident that one of the early biochemical casualties in the development of this syndrome is cellular energy metabolism.

Attempts have also been made to develop crop weather models with an objective of using it as a predictive model for areas with varying degrees of stress. The Institute has developed certain models in collaboration with the Wageningen Agricultural University, The Netherlands.

Through prioritisation of programmes in recycling of used products and in technological improvement to enhance the service life of rubber products, attempts are being made to narrow down the gap between production and consumption of natural rubber. Although recycling has been practised in the rubber industry in India on a fairly large scale, there is enough scope for improvement in the quality of recycled rubber products. The Institute, therefore, is now giving greater emphasis on these aspects.

The Institute's priorities are thus oriented to address the emerging challenges the Indian rubber industry now encounters under the new liberalised market economy.

AGRONOMY AND SOILS DIVISION

The Agronomy and Soils Division is engaged in investigations on the nutritional requirements of high yielding clones of rubber at various stages of growth in the different agroclimatic regions in South India. Other thrust areas of investigation include irrigation and water requirement, soil and water conservation, density of planting, intercropping and weed management of rubber at various stages of growth in different agroclimatic situations. Research work on forms and methods of fertilizer application, physicochemical properties of rubber growing soils and standardization of analytical methods were in progress. Work on Diagnosis and Recommendation Integrated System (DRIS) was in progress with a view to use it as a tool to help in discriminatory fertilizer recommendations. The service of discriminatory fertilizer recommendation was continued for large estates and small holdings for which the facilities available at the central laboratory at RRII were also utilized apart from the eight regional/satellite laboratories and four mobile soil testing laboratories.

1. Nutritional studies (immature phase)

The experiment to assess the fertilizer requirement of clone RRII 105 at Kodumon Estate was in progress. Treatments were imposed and growth observations recorded. No significant difference among the different fertilizer treatments was noticed for girth of the trees during the period. The same trial on clone RRII 105 at TR & T Estate, Mundakayam was discontinued due to heavy incidence of pink disease.

The two experiments at RRII Farm and Koney Estate are being continued. Treatments were imposed and growth observations recorded. The data on girth (1995) and girth increment (1991-95) for the experiment at RRII Farm (Table - Ag.1) show significant clonal differences. Clone RRII 118 recorded maximum girth which was significantly higher than clones RRII 5 and PB 217, but was on par with clone PB 260. Clone PB 260 was also superior to PB 217. But neither the main effect of fertilizer nor the interaction effect was significant for

Table - Ag. 1. **Clonal difference in girth (1995) and girth increment (1991-95)**

Clone	Girth (cm)	Girth increment (cm)
RRII 5	45.76	34.68
RRII 118	49.01	36.33
PB 217	43.50	31.81
PB 260	46.83	35.10
SE	0.72	0.89
CD	2.50	2.90

girth. In the case of girth increment the clones RRII 118, PB 260 and RRII 5 were found to be on par and statistically superior to the clone PB 217.

In the case of the experiment at Koney Estate, fertilizer treatments were imposed and growth observations recorded. The data on girth (1995) are presented in Table - Ag.2.

Table - Ag. 2. **Clonal differences in girth (February 1995)**

Clone	Girth(cm)
RRII 5	48.08
RRII 105	48.16
RRII 203	55.62
RRII 208	47.33
RRII 300	44.45
RRII 308	43.69
PCK 1	41.78
PCK 2	46.32
PB 311	48.89
RRIC 100	57.39
SE	1.15
CD	3.68

Significant clonal differences were noticed for girth. Clones RRIC 100 and RRII 203 are more vigorous in growth than all other clones. However, clonal difference in the manurial requirement was not indicated.

2. Nutritional studies (mature phase)

2.1 Clonal/Regional requirement

The experiment with clone RRII 105, located at Vaniampara Estate is being continued. Monthly yield recording and annual growth recording were undertaken. The data on mean yield and girth, recorded during 1994 , presented in Table - Ag. 3. The effect of N alone was significant.

Table - Ag.3. **Effect of nitrogen on mean girth and yield (1994)**

N (kg/ha)	Girth (cm)	Yield (g/tree/tap)
0	63.48	49.09
20	66.63	60.30
40	65.98	55.71
SE	0.87	2.23
CD	2.54	6.55

Application of N at 20 kg level was found to be beneficial for increasing girth. In the case of yield, there was response to N application and 20 kg level was found to be sufficient.

2.2 Micronutrient experiments

A field experiment was laid out at Cheruvally Estate (Erumely), on clone RRIM 600 to find out the effect of Boracol BSF-A, a micronutrient mixture containing Fe, Zn, Cu, Mo and B on the yield of rubber. Graded doses of Boracol at 50, 100, 150 and 200 g/tree were compared with no Boracol as control. The data on yield indicated that the effect of Boracol was not significant.

3. Density of planting, growth and yield

The experiment at Shaliacary Estate, Punalur, was discontinued due to heavy wind damage in the area. A new experiment on density of planting was started at CES, Chethackal with the treatments, as given in

Table - Ag. 4. **Density of planting at CES, Chethackal, (1995, RRII 105)**

	Density (trees/ha)	Spacing (m)
Main plots		
S1	420	4.9 x 4.9
S2	479	4.6 x 4.6
S3	549	4.3 x 4.3
S4	638	4.0 x 4.0
S5	749	3.7 x 3.7
Sub-plots		
M_1 - Manuring on per area basis at recommended dose		
M_2 - Manuring on per plant basis at recommended dose		

Table - Ag. 4. The area was planted in 1994 with clone RRII 105. The experiment is in progress

4. Irrigation and moisture management

4.1 Response to irrigation

The experiment at Manjoor Estate, in mature rubber has been discontinued because of irregular tapping in the area.

4.2 Effect of irrigation on growth

A field trial was started at Shaliacary Estate to study the effect of different levels of irrigation on the growth of rubber. Different levels of irrigation are being compared with no irrigation as control (Table - Ag. 5). The data on girth (1994) and girth increment (December '92 to March '94) were statistically analysed. The experiment indicated response to irrigation in the case of girth and girth increment but there was no significant difference between the various levels of irrgation.

4.3 Water requirement of immature rubber (lysimeter technique)

Rubber was planted in one lysimeter during July, 1991 and monitoring of water balance was continuously done. The mean evapotranspiration during December 1993 to April 1994 was found to be 5.23 mm per day.

Table - Ag. 5. **Effect of irrigation on growth**

Irrigation	Girth (cm)	Girth increment (cm)
25% of ET	26.93	20.25
50% of ET	27.40	20.81
75% of ET	27.80	21.14
100% of ET	28.50	21.48
No irrigation	24.00	17.95
SE	1.53	1.24
CD	2.35	1.91

4.4. Effect of silt pits

The field trial to study the effect of different intensities of silt pits on soil and moisture conservation was continued. The data on soil moisture at two depths during summer months are presented in Table - Ag. 6.

It is seen that silt pits with or without saw dust have significantly improved the soil moisture status at both 0-15 and 15-30 cm depths.

Table - Ag. 6. **Mean soil moisture (per cent)**

Treatments		Depth (cm)	
Pits/block	+ saw dust/pit	0-15	15-30
100	-	17.36	20.43
150	-	19.56	21.20
200	-	20.27	24.49
100	5 kg	20.34	23.44
150	5 kg	20.33	21.93
200	5 kg	21.46	24.63
No pits		12.72	14.58
SE		0.93	1.32
CD (P = 0.05)		2.93	4.17

Table - Ag. 7. **Silt deposited during one year period**

Treatments		Silt deposited	
Slit pits	+ saw dust	(kg/pit)	(tonnes/ha/year)
100	-	26.98	2.68
150	-	25.56	3.83
200	-	24.01	4.80
100	5 kg	27.53	2.75
150	5 kg	25.74	3.86
200	5 kg	24.08	4.82
SE		0.246	
CD		0.774	

The silt deposited per pit during one year period ending 1994 October was recorded (Table - Ag. 7). An average of 3.83 to 4.81 tonnes of silt per ha per year was collected in the pits.

5. Weed management

5.1 Chemical and cultural control

Pre-emergence application of Diuron at 2.5 kg a.i. per ha controlled weeds in a nursery effectively for a period of 120 days and was significantly superior to the lower doses tried. Pre-emergence application of Diuron at 2.5 kg per ha a.i. followed by a second application of the herbicide at 1.0 kg a.i. per ha after two months, controlled weeds effectively and reduced the total weeding costs per hectare of nursery area with a cost savings of 55.8 per cent over that of manual weeding (Table - Ag. 8).

6. Intercropping in rubber

6.1 Mature rubber (CES, Chethackal)

The two varities of coffee (*Coffea arabica* var. *cauveri* and *Coffea canophora* - *robusta*) planted in the interrows of rubber trees continues to give satisfactory yield. The data on yield of rubber are presented in Table - Ag. 9

Table - Ag. 9. **Effect of intercrops on yield of rubber (1994-95)**

Intercrops	Yield (g/tree/tap)
Rubber + single row *robusta* coffee	36.93
Rubber + single row *cauveri* coffee	40.68
Rubber + double row *cauveri* coffee	44.99
Rubber alone	34.53
SE	2.70

The growing of intercrops did not significantly affect yield of rubber.

7. Forms and methods of fertilizer application

7.1 Use of controlled release fertilizers

The field experiment on immature rubber at CES, Chethackal is being continued. Soil samples were drawn from 0-30 cm depth at intervals of 1, 5, 15, 30, 60 and 90 days after application of fertilizer and different fractions of N were estimated in fresh samples. The recovery of No_3 - N in ppm from different treatments is subjected to statistical analysis (Table - Ag.10). The release of NO_3 - N was comparatively faster in the

Table - Ag. 8. Cost per hectare of manual/chemical weeding in seedling nursery

Treatments	Cost (Rs/ha)			
	Manual weeding	Herbicide	Spraying	Total
Manual weeding	9960.00	-	-	9960.00
Chemical weeding*	1120.00	2805	480	4405.00

* 2.5 kg pre-emergence applications + 1.0 kg post emergence application of Diuron.

Table - Ag. 10. **Effect of controlled release N fertilizer on the release pattern of No_3-N (ppm)**

Treatment	Period after treatment imposition (days)						Mean
	1	5	15	30	60	90	
Urea(standard practice)	20.00	32.60	58.67	33.00	12.00	10.00	27.83
NPK Mg pellet, 100%	7.33	11.33	20.33	28.33	41.33	49.33	26.33
NPK Mg pellet, 75%	6.80	13.30	16.33	25.00	40.67	43.30	24.25
Nimin coated urea, 100%	11.67	27.67	44.67	51.67	8.66	9.00	25.56
Nimin coated urea, 75%	13.33	18.33	41.66	48.66	13.33	10.33	24.28
Neem cake mixed urea, 75%	9.66	29.33	56.00	40.67	10.00	14.00	26.61
Control (No manure)	6.67	7.33	7.00	7.67	8.00	9.00	7.61
Mean	10.79	20.00	34.95	33.57	19.19	20.76	

CD (P=0.05) for fertilizers3.58; for stages 3.87; Fertilizers x stages 9.48

standard practice where urea was untreated. The No_3 - N concentration increased progressively upto the 90th day in the case of nimin coated urea and neem cake mixed urea and only upto 15th day in the case of untreated urea.

The data on mean girth recorded during February, 1995(18 months after the treatment imposition) was statistically analysed (Table-Ag. 11). Though the girth recorded for NPK Mg pellet treated plots were numerically superior, it was on par with all other treatments except control.

Table - Ag. 11. **Effect of controlled release fertilizer on diameter (February 1995)**

Treatments	Mean diameter (cm)
Urea	4.54
NPK Mg pellets, 100%	4.85
NPK Mg pellets, 75%	5.00
Nimin coated urea, 100%	4.65
Nimin coated urea, 75%	4.74
Neem cake mixed urea, 75%	4.73
Control (No manure)	4.02
SE	0.14
CD (P = 0.05)	0.43

Another field experiment on controlled release of fertilizers was started during 1994 at Kuzhimattom, in a small holders' estate on immature rubber. The treatment details are given below.

T_1 - 10:10:4:1.5 NPK Mg as urea, MRP, MOP and $MgSO_4$ at the standard recommended dosage

T_2 - 75% of the recommended dosage NPK Mg pellets; single application.

T_3 - T_2 in two splits

T_4 - 50% of the recommended dosage as NPK Mg pellets; single application

T_5 - T_4 in two splits.

T_6 - 10:10:4:1.5 NPK Mg as nimin coated urea, MRP, MOP and $MgSO_4$ at the standard recommended dosage in two splits.

T_7 - 75% of T_6 with respect to nitrogen alone as nimin coated urea, and MRP, MOP and $MgSO_4$ as in T_6 in two splits.

T_8 - 10:10:4:1.5 NPK Mg as neem cake mixed urea, MRP, MOP and $MgSO_4$ at the standard recommended dosage in two splits.

T_9 - 75% of T_8 with respect to N alone as neem cake mixed urea and MRP, MOP and $MgSO_4$ as in T_8 in two splits.

T_{10} - No fertilizer control.

The treatments were imposed. Soil and leaf sample collection for analysis and girth recording are undertaken periodoically.

7.2 Effect of water soluble and water insoluble forms of phosphate fertilizers on growth

The experiment started in 1989 at Kinalur and Vaniampara Estates to evaluate the efficiency of Mussoirie Rock Phosphate, Super Phosphate and Ammophos on growth of rubber is being continued. Data on girth increment for the period 1989 to 1995 is presented in Table - Ag. 12. No significant difference was observed between water soluble and insoluble forms of P - fertilizers in both locations.

Table - Ag. 12. **Girth increment (cm)**

Treatments (Dose/ha)	Vaniampara Estate	Kinalur Estate
40 kg P_2O_5 (as RP) + 40 kg N (as AS)	35.05	40.44
40 kg P_2O_5 (as RP) + 40 kg N (as urea)	33.75	38.77
40 kg P_2O_5 + 40 kg N (as AP)	35.20	38.09
40 kg P_2O_5 (as SSP) + 40 kg N (as AS)	34.33	37.17
40 kg P_2O_5 (as SSP) + 40 kg N (as urea)	33.90	42.19
SE	1.88	3.25

AP - Ammonium phosphate (20:20), AS - Ammonium sulphate,

RP - Mussorie Rock Phosphate, SSP - Single Super Phosphate.

7.3 Comparative evaluation of rock phosphates (incubation study)

An incubation study was conducted to evaluate the effectiveness of different indigenous rock phosphates in terms of phosphorus availability. Samples were drawn at intervals of 15, 30, 45, 60, 75 and 90 days of incubation and the available P status was estimated using Bray - II reagent. Phosphorus availability from different indigenous sources at different intervals are furnished in Table - Ag. 13.

The results indicated that during 15 days of incubation, Tunisia followed by MRP registered the highest P availability while MRP had the lowest value after 75 days. The reason for low availability of P in MRP treated sample after 75 days of incubation, was attributed to the fixation of easily released P into non-available forms.

Table - Ag. 13. **Available P (mg P/100 g soil) estimated after 15 and 75 days of incubation**

Sources	Levels			
	L_1	L_2	L_3	Mean
MRP	1.07	1.53	2.1	1.57
	(0.01)	(0.17)	(1.07)	(0.41)
Rajphos	0.60	1.13	1.87	1.20
	(0.67)	(1.17)	(1.67)	(1.17)
Tunisiaphos	0.77	1.53	2.57	1.62
	(0.70)	(1.17)	(1.53)	(1.13)
Control	-	-	-	0.03 (0.03)

CD (P = 0.05) for comparison of sources = 0.11 (0.10)

CD (P = 0.05) for source levels = 0.18 (0.18)

Figures in parantheses correspond to values for 75 days

7.4 Comparative evaluation of Maton Rock Phosphate

A field experiment was initiated in collaboration with M/s Hindustan Zinc Ltd during 1994 in Malankara Estate, Thodupuzha on clone RRII 105 to find out the efficiency of Maton Rock Phosphate and partially acidulated Maton Rock Phosphate on growth of rubber. Graded doses of Maton and partially acidulated Maton Rock Phosphate are being compared with Mussorie Rock Phosphate. Treatments were imposed and girth recorded periodically.

7.5 Comparison of different sources of P

The field study to evaluate the effectiveness of bowl sludge, a waste product from latex centrifuge factory, is being continued at TR & T Estate, Mundakayam. Girth increment data for the period 1989-94 (Table - Ag. 14) indicate that bowl sludge is on par with Super Phosphate and Mussoorie Rock Phosphate in increasing girth of plants.

The P status of soil samples, collected from all the plots (Table - Ag. 15) indicates that available P is significantly higher in MRP and bowl sludge applied plots.

A block study was also started at CES, Chethackal in 1994 to compare the efficiency of bowl sludge with MRP as phosphate ferti-lizer for mature rubber. Dry rubber content and block yield were recorded periodically.

Table - Ag. 14. **Effect of different sources of P on girth increment**

Treatments	Girth increment (cm)
Super Phosphate	41.08
Mussoorie Rock Phosphate	41.95
Bowl sludge	42.34
Control	37.76
CD	3.27

Table - Ag. 15. **Available P status of soil**

Treatments	Available P (mg/100g)
Super Phosphate	0.48
Mussoorie Rock Phosphate	0.90
Bowl sludge	1.50
Control	0.21
CD (P = 0.05)	0.54

7.6 Root activity studies using P^{32} on mature rubber

A project was initiated in collaboration with Radio Tracer Laboratory, Kerala Agricultural University, Thrissur to study the root activity pattern of mature rubber trees using P^{32} as a tracer. The experiments involve trials to standardise dose of radio labelling, sampling procedures, study of active root zones and seasonal changes in root activity pattern. The preliminary experiments were completed and data interpreted.

7.7 Potassium nutrition

The field experiment on mature rubber of clone RRIM 600 with seven levels of K_2O, designed in randomised block design with 3 replications was continued for the fourth year also. Treatments were incorporated in two split doses and the measurements of volume of latex and dry rubber content were recorded at intervals. During this year, numerically high values for volume of latex and dry rubber yield were recorded for 45 kg K_2O per ha level followed by 60 kg K_2O per ha level (Table - Ag. 16).

Soil and leaf samples were collected and analysed for the nutrient status. The soil samples were analysed for the available K status with 3 extractant viz. Morgan, ammonium acetate and Mehlich - 1. The available K estimated by all the 3 methods correlated positively with the water soluble + exchangeable K fraction, leaf K concen-

Table - Ag. 16. **Influence of K on dry rubber yield**

Treatments (kg K_2O/ha)	Dry rubber yield (g/tree/tap)
0	39.52
15	43.10
30	47.40
45	54.10
60	49.60
75	47.60
90	44.40
CD (P= 0.5)	11.00

tration and levels of fertilizer K. The water soluble + exchangeable K fraction contributed less than 10 per cent of the total K and this fraction alone was influenced by fertilizer K application. Similary the fixed K status was also very low (less than 10 per cent of the total K) indicating the low K fixation in the rubber growing laterite or lateritic soils.

7.8 Effect of liming on nutrient uptake, biomass production and nodulation in *Pueraria phaseoloides*

A pot culture study in completely randomised block design with six replication was conducted to study the effect of liming and the consequent changes in soil pH, on the availability of nutrients and on the biomass production and nodulation of the cover crop *Pueraria phaseoloides* . The dry matter yield, nutrient availability and nutrient uptake were estimated (Table - Ag. 17 and 18) for treatments with five different levels of lime. Liming was found to have significant positive effect on increasing dry weight and on availability of P, K and Mg.

8. Physico-chemical properties of rubber growing soils

8.1 Effect of continuous cultivation on soil properties

The investigation was initiated to assess the change in soil properties of monocropped rubber plantation in the third cycle of planting and to have an appraisal of nutrient status of soil in each planting cycle.

The study was conducted selecting soil profiles from rubber plantation and

Table - Ag. 17. **Effect of liming on dry matter yield**

Treatments (lime requirement, %)	Dry wt (g)		
	Shoot	Root	Total
0	19.75	4.19	23.94
25	19.68	4.03	23.71
50	20.26	4.38	24.64
75	20.88	4.87	25.75
100	25.05	6.02	31.07
CD	2.96	0.97	3.39

Table - Ag. 18. **Effect of liming on soil p^H and available nutrients**

Treatments (lime requirement %)	p^H	Organic carbon(%)	Available nutrients (mg/100 gm soil)			
			P	K	Ca	Mg
0	4.61	2.58	4.42	6.66	24.54	1.61
25	5.71	2.78	5.58	6.71	86.87	1.97
50	6.01	2.72	5.83	7.21	111.08	2.10
75	6.64	2.69	5.33	7.28	155.45	2.40
100	7.05	2.53	6.33	9.37	191.37	2.56
CD(P=0.05)	0.15	NS	0.83	1.69	15.14	0.33

adjacent natural forests of Nilambur, Chemoni, Vithura and Mundakayam. Soil samples were collected horizonwise and analysed for total N. Total N content in one meter depth of rubber estates in the four locations were 19, 18, 16, 13 megagram per hectare (Mg/ha) while in forest soil nitrogen in one meter profile in the four locations were 27, 30, 19, 15 Mg per ha (Table - Ag. 19). The percentage reduction in total N content as a result of rubber cultivation were 30, 40, 12 and 14 in the four locations.

8.2 Study on the sub-soil acidity and aluminium toxicity in rubber growing soils and its amelioration using phosphogypsum

The experiment is envisaged to study the extent of aluminium toxicity in sub soil layers of the rubber growing tracts in relation to the root growth of rubber plants. Attempts were made to ameliorate the toxic levels of A in subsoil layers using surface applied amendments. An experiment conducted to study the redistribution of exchangeable A and Ca as a consequence of lime ($CaCO_3$) and phosphogypsum using soil columns in PVC pipes, revealed that the surface applied phosphogypsum significantly reduced exchangeable A concentration as compared to lime. The results indicate that phosphogypsum provide better distribution of applied Ca in the profile.

9. DRIS approach for interpretation of foliar analytical values

The data bank of leaf analytical values were expanded by collecting and including the analytical values for the period 1991-94, available in the advisory services register. For including micronutrients also in the diagnosis, some samples were also analysed for the elements Fe, Mn, Zn, and Cu.

10. Standardisation of analytical methods

10.1 Seasonal variation in leaf nutrient status

Objective of the study was to find out the seasonal variation of leaf N, P, K, Ca and Mg content of mature trees of clone RRII 105 in Kottayam region. Thirty mature trees of twelve years of age and 20 trees of 10 years of age were selected for the study. Low - shade leaf samples of each tree were collected at 30-35 days interval from April to January and analysed for N, P, K, Ca and Mg. Mean values of each nutrient for each month were found out and correlations worked out.

10.2 Development of a rapid tissue testing method

A series of experiments were started to develop a rapid tissue testing method for use in advisory services.

11. Soil survey and classification mapping of soils

A survey was initiated in collaboration with soil survey unit of Department of Agriculture, Government of Kerala, with the objectives of identification, classification and mapping of soils under *Hevea* in Kottayam district. Profiles were excavated at different sites spread over different taluks and morphology was studied in each profile. Soil samples were collected and chemical characterization is in progress.

12. Collaborative studies

The Division collaborates with other divisions in the project on TPD to identify the role of nutrition on the incidence of this disorder. Samples of soil, leaf and latex collected from normal as well as TPD affected plants were analysed. Direct relationship between TPD incidence and tree nutrition could not be established from the limited data generated.

Table - Ag. 19. **Total N content in 100 cm profile of four rubber plantations and nearby virgin forests**

Rubber				Forest			
Depth (cm)	BD (Mgm^{-3})	Total N (%)	Total N (Mg/ha)	Depth (cm)	BD (Mgm^{-3})	Total N (%)	Total N (Mg/ha)
Nilambur							
0-19	1.24	1.18	4.24	0-19	1.50	0.22	6.27
19-35	1.26	0.14	2.82	19-35	1.65	0.16	4.22
35-57	1.88	0.15	6.20	35-57	1.91	0.14	5.88
57-100	1.88	0.07	5.66	57-100	1.77	0.14	10.78
Total			18.92				27.15
Chemoni							
0-14	1.27	0.26	4.62	0-11	1.37	0.30	4.52
14-24	1.86	0.17	3.16	11-33	1.76	0.21	8.13
24-38	1.68	0.13	2.35	33-64	1.66	0.17	8.75
38-52	1.75	0.10	2.45	64-100	1.68	0.15	9.07
52-76	1.80	0.06	2.59	-	-	-	-
76-100	1.75	0.07	2.94	-	-	-	-
Total			18.11				30.47
Vithura							
0-26	1.08	0.21	5.90	0-22	1.35	0.24	7.13
26-51	1.29	0.13	4.12	22-40	1.20	0.18	3.89
51-76	1.31	0.10	3.28	40-59	1.48	0.10	2.81
76-100	1.45	0.09	3.13	59-80	1.53	0.09	2.89
80-100	-	-	-	80-100	1.50	0.07	2.10
Total			16.43				18.82
Mundakayam							
0-9	1.00	0.18	1.62	0-11	1.10	0.22	2.66
9-32	1.10	0.16	4.05	11-24	1.20	0.18	2.81
32-51	1.20	0.09	2.05	24-45	1.10	0.15	3.47
51-73	1.40	0.08	2.46	45-69	1.20	0.09	2.59
73-100	1.40	0.07	2.65	69-100	1.40	0.08	3.47
Total			12.83				15.00

13. Advisory work

Analysis of 7700 soil and 1220 leaf samples were conducted in regional laboratories for offering discriminatory fertilizer recommendation. In the Central Laboratory at RRII, 830 leaf and 1390 soil samples were analysed and fertilizer recommendation offered.

14. Sustainable agriculture

Observational trials on the effect of biofertilizers on the growth and yield of both immature and mature rubber plantations were undertaken. The growth and yield of rubber trees which were applied with biofertilizers are comparable with the standard estate practice. Population of microbes were assessed at periodical intervals and it was found that the population of bacteria and phosphate solublizers increased due to biofertilizer application, population of fungi and actiomycetus were found to be reduced compared to pre-treatment levels.

The establishment of sustainable agriculture model farm at CES, Chethackal is in progress. Intercrops such as pineapple and banana have started yielding.

15. Studies on nutrient management

15.1 Litter and floor dynamics

An experiment was started during 1994 at CES, Chethackal to study the dynamics of leaf litter and weeds in nature rubber plantations. Microplots were marked during January in a 13 year old RRII 105 area. The leaves fallen during wintering was allowed to deposit in the microplots. When wintering was over, the surface of the microplots were covered with plastic net to prevent further addition of leaves. The weight of the fresh leaf litter was assessed and the contents of N, P, K were determined every month till November 1994 from all the 15 microplots maintained. The quantity of litter disintegrated during the 10 months period (February - November) and the quantities of N, P and K released from the litters are given in Table - Ag. 20 and 21.

Table - Ag. 20. **Dry weight and nutrients released from leaf litter (kg/ha)**

	Dry weight (1994) Feb.	Nov.	Nutrient released
Leaf litter (RRII 105)	3998.40	140.00	
NPK content in leaf litter			
N (1.66%)	66.37	2.32	64.05
P (0.05%)	1.99	0.07	1.92
K (0.54%)	21.59	0.76	20.83

Quantity of leaf litter disintegrated : 3858.40 kg/ha

Percentage of disintegration : 96.50

Table - Ag. 21 **Dry weight and nutrients released from weed (kg/ha)**

	Dry weight (1994) Feb.	July	Nutrient released
Quantity of weed biomass	632.20	17.50	
NPK content of weeds			
N (2.87%)	18.14	0.50	17.64
P (0.16%)	1.01	0.03	0.98
K (2.19 %)	13.84	0.38	13.46

Quantity of weed mass disintegrated : 614.70 kg/ha

Percentage of disintegration of weeds : 97.00

BIOTECHNOLOGY DIVISION

1. Somatic embryogenesis

This process is envisaged to serve two purposes: 1) As a pathway for the development of genetic transformation experiments. 2) Possible use as an alternate pathway for larger *in vitro* plant production. Several explant sources are being tried to ascertain effectiveness and nucellar tissue proved to be the most preferable. The nucellar callus has many features. The embryo originate from single cells. The ability for embryogenesis is maintained during several subculturing; but the number of embryos per unit tissue mass diminshes over a period of time; especially after one year. Recently this embryogenesis system has been put to use for developing other systems, in particular, genetic transformation studies.

2. Shoot-tip/meristem culture

Shoot-tip cultures are initiated from explants originated from mature clonal trees. Commercial clones representing category I, II and III were tried and the *in vitro* response to shoot development as well as rhizogenesis varied drastically from clone to clone. Over four hundred plants were generated and are maintained for further growth prior to transplanting in the field. It has been observed that *in vitro* plants having three or four whorls of leaves survived better in the field with lower rates of mortality; hence holding longer under greenhouse conditions/shade house may be one of the ways to reduce mortality of *vitro* plants.

3. Genome analysis

DNA fingerprint analysis in *Hevea* germplasm

Identification of DNA markers for various traits were attempted through Random Amplified Polymorphic DNA (RAPD). The RAPD profiles generated from isolated DNA samples were evaluated. Methods were standardised for the isolation of good quality DNA and to get complete digestion with various restriction enzymes. Work is underway to prepare a partial genomic library. The final objectives are 1) identification of the entire gene and gene products of the DNA markers identified 2) development of DNA based diagnostics for various traits and 3) identification of repeated sequences and development of microsatellite based primers for DNA fingerprinting to study the genetic relatedness between cultivars and wild species.

BOTANY DIVISION

The major thrust area of the Botany Division is the genetic improvement through hybridization and ortet selection. Priority has also been given for evaluation of clones having better performance with respect to yield/secondary characters than RRII 105. Investigations on propagation, anatomy and cytogenetics are also in progress.

1. Evolving high yielding clones for traditional area

1.1 Hybridization and clonal selection

Observations on growth parameters and yield were recorded from a total of 25 small scale trials of hybrid clones in different stages of evaluation. Monthly yield recording and periodical recording of total volume, DRC and plugging index were continued in the 1985 small scale trials of hybrid clones. Eight clones, which were identified as potential high yielders in the first year of tapping, continued to show comparable or higher yield than that of RRII 105 over the first two years of tapping. Heterosis ranged from 4 to 40% (Table - Bot. 1).

Table Bot. 1 Mean yield and standard heterosis of eight clones during the first two years of tapping

Clones	Mean yield (g/tree/tap)	Standard heterosis (%)
82/2	58.81	-
82/14	84.14	40.06
82/17	63.40	5.90
82/21	58.71	-
82/22	78.69	31.50
82/29	80.20	34.40
82/30	64.19	7.30
RRII 105	59.84	-

A total of 141 hybrid clones of the 1990 small scale trials were subjected to test tapping at the age of 52 month's after assessing the girth. Data revealed highly significant clonal differences for both girth and juvenile yield. In one small scale of 11 hybrid clones of 1990 with RRII 105 as control, the latter recorded 99 g/tree/10 tappings, whereas clones 29, 118, and 480 recorded 112, 127 and 132 g respectively. Similarly in another trial of 30 hybrid clones and six parents, nine clones recorded comparatively higher yield than RRII 105 at 52 months. Among ten other hybrid clones resultant of 1988 hybridization programme (1992 small scale trial), four clones viz., 15, 22, 61 and 69 recorded high juvenile yield of 28.30, 18.78, 13.42 and 14.93 g per tree per 10 tapping at two years' growth in comparison to 9.57 g for RRII 105. A new small scale trial was laid out with 16 hybrid clones of 1989 hybridization programme along with RRII 105 employing a randomized block design with three replications. During 1993-95, a total of 11,797 hand pollinations in 22 cross combinations of 17 parent clones selected on the basis of yield and yield components were attempted and the details on pollination and fruit set during 1993 are furnished in Table - Bot. 2. During the following season of 1995, 5449 crosses involving 10 parent clones were attempted.

1.2 Ortet selection

Experiments on ortet selection were in progress. The small scale trial with 21 ortet clones at Cheruvally Estate, revealed highly significant clonal differences in girth, bark thickness, total volume, DRC and dry rubber yield at 60 months growth. Four clones

Table Bot. 2. **Pollination and fruit set (1993)**

Cross combination	Pollinations (n)	Fruit set (%)
RRII 105 x RRIC 104	403	0.5
RRII 105 x PB 235	246	1.22
RRII 105 x RRIC 52	366	7.38
RRII 105 x MT 99/9	-	-
RRIM 600 x RRII 118	453	13.25
RRIM 600 x RRII 104	496	11.09
RRIM 600 x RRIC 52	240	5.45
PB 217 x AVT 73	519	1.16
PB 217 x PB 5/51	598	-
PB 217 x PR 107	138	0.72
PB 217 x PB 260	-	-
PB 242 x AVT 73	327	1.53
PB 242 x RRII 105	294	0.68
PB 242 x PB 235	289	-
PB 252 x AVT 73	261	2.30
GT1 x PB 5/51	153	5.88
PB 5/51x RRII 105	240	10.83
Total	5278	4.13

recorded an average yield of 29.00, 87.00 29.75, 31.83 and 31.11 g/tree/10 tappings in comparison with 18 g for RRII 105.

In the small scale trials of 47 ortet clones laid out in 1991 at Koney Estate, 28 clones exhibited better growth than RRII 105 and 20 clones showed better growth than GT 1 during the 4th year after planting.

A small scale trial comprising 25 ortet clones was laid out at CES, Chethackal with suitable statistical design. Fourteen ortets collected from various small hodlings were multiplied and established in polybag nursery for laying out a trial.

From a total of 165 mother trees identified from Kaliyar Estate, 53 trees were selected for multiplication based on yield, DRC and other secondary characters.

A seedling tree near Iritty reported to be a high yielder and disease tolerant, was subjected to detailed observations.

1.3 Special techniques in breeding

Regular observations on yield and other secondary characters were continued in all the field experiments of polyploid population and the clones developed from seed irradiation. During the eighth year of tapping from the trial on irradiated materials (1977) RRII 51 recorded a mean yield of 70.06 g/tree/tap, whereas RRII 105 recorded 60.60. Annual girth recording was continued from the two trials laid out in 1985 and 1992. The selected trees from the trial on irradiated materials (1985) were subjected to yield monitoring on a monthly basis.

2. Evaluation of clones

2.1 Large scale trials

In the Sri Lankan clone trial laid out in 1976, monthly yield recording and periodical recording of secondary characters were carried out. In the mixed clone trial laid out in 1981, recording of secondary characters and fortnightly recording of yield were carried out. In the 1989 large scale trial comprising 14 experimental clones at Nettana, test tapping was carried out during 1994 at the age of 5 years. Among the 14 clones, PCK 2 and PB 255 recorded the highest yield of 12.37 and 12.36 g/tree/tap followed by RRII 300 and KRS 163 (10.85, 10.45 and 10.33 g/tree/tap respectively). SCATC 93-114 recorded the lowest yield of 2 g/tree/tap. A large scale trial comprising 11 clones was laid out at Arasu Rubber Corporation.

During the 14th year of tapping in the clone trial laid out in 1973, RRII 206 recorded

the highest yield (91.57 g/tree/tap) followed by RRII 203 (90.01 g) and RRII 208 (84.08 g). The control clone PR 107 recorded only 51.56g.

Monthly assessment of growth parameters was continued in the two multidisciplinary evaluation trials of 13 clones each in RRII. In trial 1, mean annual girth increment over a period of first three years of growth ranged from 6.94 to 10.02 cm with the highest in RRII 118, followed by RRII 5, RRII 208, RRII 300 and the lowest in SCATC 93-114 followed by PCK 1 (Table - Bot. 3). Mean summer girth increment which reflects the response of clones to drought condition over the first three years was the highest in the Chinese wind tolerant clone Haiken 1, followed by SCATC 93-114, RRII 118, RRII 300 and RRII 208 (Table - Bot. 3). Among 13 clones in trial II, clones PB 314, RRII 105, PB 280, PB 312 and PB 255 recorded comparable juvenile yield of 22.48, 22.41, 21.53, 20.89 and 20.73 g/tree/tap over two seasons in 1993 and 1994 (4th and 5th year of tapping). The data revealed highly significant clonal differences.

Table - Bot. 3 **Growth during the first three years**

Clones	Mean girth increment(cm)	
	Annual	Summer
RRII 5	8.84	2.02
RRII 105	8.20	2.01
RRII 118	10.02	2.22
RRII 208	8.66	2.14
RRII 300	8.64	2.21
RRII 308	8.42	1.94
RRIM 600	7.84	2.09
RRIM 703	8.07	2.06
PCK 1	7.79	1.96
PCK 2	8.47	1.93
SCATC 88-13	8.14	1.94
SCATC 93-114	6.94	2.24
Haiken 1	8.06	2.26
Mean	8.31	2.08
CD	0.59	0.20

Recording of yield, girth and secondary characters of nine RRII clones and GT 1 in 1978 clone trial at the CES was continued. Annual mean yield over the first three years was the highest for RRII 351 (44.32 g/tree/tap) followed by RRII 350 (38.25 g/tree/tap) whereas the yield for the control GT 1 was 29.16 g/tree/tap. Yield and secondary characters of seven popular clones in 1979 clone trial at CES were also recorded. Mean yield over the first five years showed that RRII 105 was the highest yielder (76.56 g/tree/tap).

2.2 On-farm evaluation

A block trial comprising 13 clones were raised at Arasu Rubber Coporation, Keeriparai. In almost all the block trials, RRII 105 continued to record the highest yield.

Yield data for three years from the block trial at Ceasermudy Estate, Kanjirapally, showed that RRII 105 was the highest yielder followed by RRII 5, RRII 208 and RRII 300.

RRII 105 continued to record the highest yield in the experiment laid out at Malankara Estate. Mean yield over the fifth to the tenth year revealed that RRII 105 is the highest yielder followed by GT 1 and RRIC 102. In another block trial of 12 clones at Chithelvetty Estate, RRII 1 recorded the highest mean yield (1400kg/ha/yr) followed by PB 260 and RRII 105 during the second year of tapping. In the 1983 block trial at Myladi, RRII 105 recorded the highest yield followed by PB 235 at the fourth year of tapping. Among eight clones at Manikkal Estate, RRII 105 recorded the highest yield during the second year of tapping. A block

trial of eight clones was laid out at Sasthamkotta, Kollam District.

3. Performance of clonal composites

3.1 Multiclone blends in comparison to monoclone population of RRII 105

The trials laid out at CES, Chethackal and at RES, Nagrakatta during 1992-93 were maintained properly. Field planting of an experiment on multiclone planting was carried out at Arasu Rubber Corporation, Keeripparai, Kanyakumari Dist, Tamil Nadu during 1994 season. Eight blocks, with three clone combinations in each block, in the proportion of 50, 35 and 15 per cent respectively of clones recommended in category I, II a and II b were planted. The clones selected were RRII 105, PB 235, PB 28/59, PCK 1, PCK 2, PB 311 and RRII 5.

4. Polycross progeny evaluation

Casualty enumeration and gap filling were carried out in the field trial on evaluation of progenies of prepotent clones. Plant protection measures against shoot-rot were carried out and proper maintenance was done.

5. Breeding clones for combining compact canopy and good yield

One year old seedlings having different canopy architecture, dwarf, semi-dwarf, intermediate and normal, were subjected to detailed investigations of growth parameters of root and shoot systems. Incorporating the selected plants having compact canopy and high vigour, two field experiments were laid out at CES, Chethackal. Selfing was attempted in the genetic variant. Growth parameters were recorded from the observational trial (1988) on the progenies of genetic variant. Compared to the control RRII 105 (44.72 cm), the normal types (47.53 cm) recorded more vigour in terms of girth.

6. Breeding for drought tolerance

Seedlings resultant of crosses between parent clones selected on the basis of drought tolerance attributes are being maintained in the nursery. An account of the crosses undertaken is given in Table - Bot. 4.

Table - Bot. 4. **Crosses for evolving clones with drought tolerance (1993)**

Cross combination	No. of pollinations	Final fruit set(%)
RRII 105 x PB 86	286	6.29
RRII 105 x RRIM 703	405	7.65
RRII 105 x AVT 73	470	1.70
RRII 105 x RRII 208	-	-
RRII 105 x PB 260	-	-
RRII 105 x RRIM 600	590	0.17
Ch 2 x PB 217	720	0.14
Ch 2 x PB 86	390	-
Total	2861	3.19

Periodical observations on girth and girth increment of 10 popular clones were recorded and the summer girth increment index was worked out. The clones were statistically on par with respect to that attribute. Clone PB 311 showed the highest summer girth index of 64.62 per cent.

7. Breeding for disease resistance

7.1 Screening clones for powdery mildew resistance

Casualties were supplied in the field experiment on screening clones for mildew resistance of 20 selected clones. Inoculum potential during the period under report was not sufficient for assessment of the clones for their reaction to powdery mildew under field conditions.

8. Evaluation of popular clones

8.1 Commercial evaluation of clones

Yield data collected from eight popular clones planted on commercial scale in different estates have revealed that RRII 105 was the highest yielder followed by PB 28/59, PB 260 and PB 217. There was wide variation in the performance of most of the clones from region to region.

9. Estimation of genetic parameters

9.1 Genetic studies

9.1.1 Variability, correlation and heterosis for yield and yield components

An evaluation of the performance of 23 hybrid clones, resultant of a cross of RRII 105 x RRIC 100 during the first year of tapping in the mature phase, in comparison to early performance during 54 months after field planting revealed significant clonal variation for yield and yield atributes like rate of latex flow, total volume of latex per tap, plugging index, girth at opening, number of latex vessel rows and bark thickness (Table - Bot. 5). Significant correlation observed between yield and the above traits except girth and bark thickness was also in conformity with the findings in the early phase. Highly significant early versus mature association was observed for dry rubber yield (r=0.9098), total volume of latex per tap (r= 0.7584), plugging index (r=0.7070), no. of latex vessel rows (r= 0.6886), bark thickness (r=0.6404), girth at opening (r=0.5610) and rate of latex flow (r= 0.5434). In this cross five hybrid clones which were identified as having better potential for yield in the early phase continued to exhibit the same trend in the mature phase too.

9.1.2 Genetic analysis of hybrid progenies

The trial laid out during 1993 was maintained properly and gap filling was carried out.

9.2 Estimation of combining ability for parental selection

One round of test tapping was carried out in the 1990 parent progeny trial at HBSS, Nettana at the fourth year from planting. Among the parental clones RRII 105 and GT 1 recorded the highest yield of 70 g per tree per 10 tappings, whereas IAN 45-873 recorded the lowest yield of 16 g. Among the progenies, those of GT 1 recorded the highest yield of 62 g per tree per 10 tappings

Table - Bot. 5 **Genetic parameters for yield and yield attributes of 23 hybrid clones**

	Heritability		CV		GCV		PCV	
Characters	Early	Mature	Early	Mature	Early	Mature	Early	Mature
Yield	67.69	71.84	41.54	43.85	34.56	37.50	41.92	44.24
Girth at opening	34.77	6.05	8.83	8.12	5.19	2.01	8.80	8.17
Girth increment on tapping	55.00	43.44	26.34	53.25	18.99	35.33	25.25	60.37
Total volume of latex per tap	33.00	68.09	74.79	45.47	42.71	37.36	76.63	45.28
Rate of latex flow	60.26	71.33	48.28	35.28	37.67	30.02	48.53	35.55
Number of latex vessels	37.00	51.85	27.89	29.56	17.03	21.07	29.04	29.74
Bark thickness	37.00	50.16	8.13	9.85	4.24	7.04	6.96	9.95
Plugging index	56.00	57.79	49.20	29.43	36.82	22.52	49.29	29.62

whereas progenies of Tjir 1 recorded the lowest yield of 13 g per tree.

10. Cytogenetic investigations

Detailed karyomorphological analysis of four clones of *Hevea brasiliensis* (RRII 105, PCK 1, RRIM 703 and KRS 163) were carried out.

Palynological investigations on diploid and induced tetraploid clones of RRII 116 and PR 107 have been done. Pollen grains of diploid were observed to be 3 zonocolporate. Pollen sterility and size considerably increased in the tetraploids. The tetraploid showed 3 zonocolporate and 4 zonocolporate pollen grains in addition to very small ones. Diploid PR 107 showed 4.95 per cent pollen sterility sterility in contrast to 16.06 per cent observed in the tetraploid. RRII 116 recorded a pollen sterility of 3.56 per cent whereas tetraploid recorded 26.00 per cent. There was great size difference in the pollen grains of the diploid and tetraploid clones (Table - Bot. 6).

Table - Bot. 6 **Equatorial and polar diameter of pollen-grains**

Cytotype	Equatorial diameter (µm)	Polar diameter (µm)
	Mean ± SE	Mean ± SE
RRII 116 (2x)	37.00 ± 0.28 (32.5 - 40.0)	28.69 ± 0.32 (27.5 - 37.5)
RRII 116 (4x)	46.81 ± 0.59 (37.5 - 52.9)	38.06 ± 0.39 (32.5 - 42.5)
PR 107 (2x)	39.72 ± 0.27 (37.5 - 42.5)	30.88 ± 0.31 (27.5 - 35.0)
PR 107 (4x)	45.84 ± 0.55 (37.5 - 52.5)	36.72 ± 0.38 (32.5 - 42.75)
S.E	0.51	0.35
C.D	1.58	1.09

(Values indicate the range in parenthesis)

11. Floral biology and fruit set

Two popular clones RRII 105, RRII 118 were selected and hand pollinations were attempted to elucidate the causes of low fruit set in *H. brasiliensis*.

11.2 Studies on bark renewal

To study the extent of bark regeneration, five popular clones (RRII 105, RRII 203, RRII 300, RRII 308 and GT 1) were selected and periodic increment on bark thickness were recorded up to 66 months. Statistical analysis showed that there is no significant difference between clones in the extent of bark regeneration.

12. Bark anatomical investigations

12.1 Variability, correlations and path coefficient analysis for yield in relation to anatomical characters with emphasis to TPD, diseases and drought tolerance

For the second set of TPD affected trees grafted with normal bark, cent per cent success was obtained. On tapping six months after grafting, normal latex flow was observed from the grafted bark. Compared to TPD affected bark, under rest, newly grafted bark was better for cambial activity and proportion of soft bast region. As nearly six month's tapping (alternate daily) was over, extension of TPD to the inner bark was observed. The condition of grafted region was comparatively better compared to the affected bark retained.

Bark anatomical characters of 25 popular clones (at the age of three years) have been recorded. The data are being processed.

12.3 Evaluation of clones for bark anatomical components

Bark anatomical characters of 40 clones have been recorded. The data are being summarised.

13. Wood anatomical investigations

A preliminary study was conducted to elucidate the effect of ethrel stimulation on quality of rubber wood. The stimulant was applied on selected trees of RRII 105 for $3^1/_2$ years. Anatomical studies on wood samples collected are in progress.

14. Studies on propagation

The field experiments laid out were maintained properly and growth parameters recorded. Experiment on bench grafting was also continued. A new field experiment was initiated at Central Nursery, Karikkattoor to study the effect of delayed opening and pulling out on bud take and establishment of green budded plants. Another experiment on sprouting and rooting pattern of budded stumps is in progress.

15. Genetic basis of stock-scion relationship

15.1 Performance of certain modern clones on different root systems

Recording of data on monthly yield, annual girth and secondary characters was continued. Mean yield in own versus(vs.) assorted stock-scion combination is furnished in Table - Bot. 7. The values are in general higher in own stocks in comparison to assorted stocks. However, a 't' test revealed that the difference between own and assorted stock -scion combinations is not significant.

Table - Bot. 7. Mean yield over first two years in own vs. assorted stock scion combinations

Scion	Yield (g/tree/tap)	
	Own	Assorted
RRII 105	56.71	56.02
RRII 118	29.33	29.12
RRII 203	39.31	36.55
RRII 208	43.12	40.62
GT 1	29.87	27.59
GI 1	31.57	31.89
RRIM 600	35.27	26.41
Mean	37.88	35.46
SE	3.68	3.95

16. Studies on early evaluation

16.1.1 Juvenile Vs. mature performance

Data on girth and juvenile yield by test tapping at an age of two years indicate that among each group, juvenile yield in general is related to girth (Table - Bot. 8). High yielders in general, recorded high juvenile yield.

Table Bot. 8. **Data on girth and juvenile yield at two years' growth**

Clones	Girth(cm)	Yield** (g/tree/10 tap)
RRII 105	10.09	9.57
PB 235	14.51	19.05
PB 260	14.87	12.07
RRIM 600	11.70	6.04
PB 217	13.54	9.47
GT 1	10.97	6.89
PB 5/51	12.96	1.39
RRII 38	10.11	1.38
Mean	12.13	7.91
CD	4.38	9.80

** Significant at 1% level.

GERMPLASM DIVISION

The Germplasm Division continued activites related to the introduction, collection, conservation, characterisation and evaluation of *Hevea* germplasm.

1. Introduction, collection and conservation of germplasm

1.1 Wickham materials from secondary diversity centres

The collection of older and elite cultivars of indigenous and exotic origin, being conserved in the budwood nursery at RRII, was properly maintained.

1.2 Wild germplasm

The 4709 wild accessions introduced from Brazil, were properly maintained in the source bush nurseries at CES, Chethackal.

2. Evaluation of germplasm

2.1 Conservation gardens

Recording of annual girth and monthly yield were stopped in Garden I due to the large number of vacancies as a result of wind damage over the years. The remaining trees were maintained for conservation and breeding purpose. Monthly yield and annual girth were recorded from Garden II. Data collected from 35 clones in the garden for genetic divergence studies, are being processed for statistical analysis. Monthly girth and yield are being recorded from Garden III. Flower and seed morphology studies were initiated in a few clones. Quarterly girth data were collected from the 5 IRCA clones in Garden IV.

A new garden (Garden V) comprising 20 clones of secondary diversity origin, was established in a RBD with three replications with plot size of 5 trees.

2.2 Nursery evaluation, juvenile characterisation and cataloguing

Laboratory screening for *Phytophthora* resistance was initiated in the source bush nurseries in collaboration with the Pathology Division, and the work is being continued.

From the various preliminary studies conducted so far, 100 genotypes were selected for further evaluation, based on yield, girth, bark thickness and number of latex vessels.

2.3 Field evaluation of Brazilian germplasm

After preliminary evaluation, 40 genotypes were selected from field trial 1990, based on girth and these materials were supplied for the hot spot screening under the World Bank Project.

Quarterly girth observations were recorded from the 143 wild accessions planted in 1992. Test tapping on these accessions was also carried out. Of the 50 ortets planted in five trials in 1992, one trial consisting of 10 genotypes, was dropped due to high vacancy caused by poor soil depth.

Nine ortets and control RRII 105 were planted in RBD with three replications and plot size of 9, in July 1994. Another set of 72 wild accessions were also planted during the current year in three trials, adopting a simple lattice design with 24 genotypes and one control (RRII 105) each and half yearly data on growth parameters were recorded.

MYCOLOGY AND PLANT PATHOLOGY DIVISION

The Mycology and Plant Pathology Division carried out both basic and applied research on various diseases and pests of rubber and their control measures. Studies were also undertaken to augment nutrient status of rubber growing soils by inoculation with microorganisms and on waste utilization for economic purposes and to prevent pollution. Screening of germplasm collections for abnormal leaf fall disease resistance and investigation on the effect of weather condition on powdery mildew disease are other areas of research initiated.

The scientists and staff of Mycology and Plant Pathology Division actively took part in organising the Symposium on Diseases of *Hevea* conducted by IRRDB on 21st and 22nd November 1994 at Cochin.

1. Abnormal leaf fall disease

Due to prolonged monsoon, incidence of abnormal leaf fall disease was very severe during the period. Susceptible clones like RRIM 600, PB 86 and PB 235 registered severe leaf fall in the traditional rubber growing areas. In an evaluation of the disease in clone RRII 105 at Kumarankudy Estate, Punalur, 38 per cent leaf fall was recorded.

The trials to evaluate oil based mancozeb was continued during the season. Mancozeb 70 per cent powder formulation at a dosage of 3.36 kg. a.i. per ha gave higher leaf retention when sprayed using micron sprayer in clone PB 235 and was on par with the currently recommended level of copper oxychloride (4.5 kg a.i. per ha). Combination products of Mancozeb and copper oxychloride as well as liquid formulation of Mancozeb were not as effective (Table -Path. 1)

In aerial spraying block trials using oil based Mancozeb, the leaf retention was much higher when compared to that in copper oxychloride sprayed area. While in

Table - Path. 1. **Comparison of the effect of micron spraying of Mancozeb formulations with copper oxychloride**

Treatments	Formulation	Dosage (a.i. kg/ha)	Leaf retention (%)
Mancozeb 70%	powder	2.24	36.03 (36.76)
Mancozeb 70%	powder	3.36	58.87 (50.03)
Mancozeb 50% + COC 15%	powder	2.24	44.29 (41.72)
Mancozeb 50% + COC 15%	powder	3.36	38.96 (38.56)
Mancozeb 26% + COC 10%	liquid	3.36	42.04 (40.30)
Mancozeb 26% + COC 10%	liquid	4.65	47.72 (48.66)
COC 56%	powder	2.24	38.82 (38.52)
COC 56%	powder	3.36	46.10 (42.75)
COC 56%	powder	4.50	55.59 (48.20)
Unsprayed	–	–	20.72 (26.89)
CD (P= 0.05)			7.77

the block micron spraying trial, copper oxychloride was found to be better (Table - Path. 2).

Based on this observation, a field trial was conducted at Palapilly region on clone RRIM 600 to study the effect of Bordeaux

Table-Path. 2. **Effect of Mancozeb in the control of abnormal leaf fall disease in block trials in clone RRIM 600**

Treatments	Formulation	Micron spraying		Aerial spraying	
		Dosages (kg/ha)	Leaf retention (%)	Dosages (kg/ha)	Leaf retention (%)
Mancozeb 70%	powder	5.00	45.39	5.00	92.72
Mancozeb 50% + COC 15%	powder	5.00	43.33	5.00	78.50
Mancozeb 26% + COC 10%	liquid	5.00	27.05	--	--
COC 56%	powder	8.00	62.57	5.00	19.51

Two new spray oils, one manufactured by M/s Indian Oil Corporation and the other by M/s Cochin Refineries Ltd. were field tested. Although these oils gave satisfactory performance in low rainfall areas, it was not so in high rainfall areas. The approval was therefore deferred and further testing will be taken up.

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 these clones were 55.10, 3.26, 5.55 and 17.02 per cent respectively. A new experiment to evaluate crop loss in relation to the dosage of COC used in clone RRII 105 (block trial) has been initiated. The pretreatment yield is being recorded in a 1976 replanting, planted with RRII 105 in Palappilly area of Trissur district.

2. High volume spraying

In order to improve the efficacy of Bordeaux mixture 1 per cent and 2 per cent spray oil were added to 1 per cent Bordeaux mixture in the laboratory using various emulsifiers. It was found that 1 per cent and 2 per cent oil in Bordeaux mixture did not cause any toxicity on sprayed leaves.

mixture and oil combinations to control abnormal leaf fall disease. The treatments included were 1 per cent Bordeaux mixture + 1 per cent oil, 1 per cent Bordeaux mixture + 2 per cent oil and 1 per cent Bordeaux mixture alone.

The effect of these treatments on leaf retention is presented in Table-Path. 3. Bordeaux mixture without and with 1 per cent oil showed better control than that with 2 per cent oil.

3. Evaluation of panel protectants/ wound dressing compounds

An experiment was carried out to evaluate fungicides for the control of black stripe disease in the susceptible clone RRIM 600 at Lahai Estate which is a hot spot for this disease. The results of the trial are

Table Path. 3 **Effect of Bordeaux mixture and spray oil on abnormal leaf fall disease**

Treatments	Leaf retention (%)
1% Bordeaux mixture + 1% oil	58.00
1% Bordeaux mixture + 2% oil	52.00
Bordeaux mixture alone	56.00

presented in Table-Path. 4. Mancozeb (0.0375% a.i. and Phosphorous acid (0.08% a.i.) were found to be effective. These fungicides were recommended for use in rubber plantations.

Table Path. 4. **Control of black stripe disease**

Treatments	Dosage (% ai)	Disease index (%)
Mancozeb (Indofil M 45)	0.75	9.89
Mancozeb (Indofil M 45)	0.375	10.67
Phosphorous acid (Akomin 20)	0.08	14.56
Metalaxyl (Apron 35)	0.035	18.78
Phosphorous acid (Phosget 40)	0.08	13.78
Phosphorous acid (Phosjet 40)	0.16	15.89
MEMC (Emisan 6)	0.015	19.89
CD (P=0.05)		NS

Mean of three replicates each of 1 block (400 trees)

4. Pink disease

A field experiment was initiated on 3 year old RRII 105 plants at Mundakayam for pink disease control using Bordeaux paste, Bordeaux paste with 10 per cent mineral oil, Bordeaux paste with 2 per cent zinc sulphate, Validacin 2 per cent and Calixin 1 per cent. The treatments were imposed at cobweb stage of the disease and the percentage recovery of plants was recorded. The results are presented in Table - Path. 5. Bordeaux paste with 2 per cent zinc sulphate showed numerical superiority over other treatments. The systemic fungicides were inferior to Bordeaux mixture.

Table - Path. 5. **Pink disease control by Bordeaux paste and systemic fungicides**

Treatments	Recovery of plants %
Bordeaux paste	52.0
Bordeaux paste + 10% oil	52.0
Bordeaux paste + 2% zinc sulphate	56.0
Validacin 2%	44.0
Tridemorph (Calixin) 1%	44.0

Studies on various aspects of pink disease incidence in RRII 105 indicate that the incidence varies in different places. Plants showing more girth are found to be more prone to pink disease. In the case of steep terrains the plants in the lower half showed enhanced girthing and higher pink disease incidence. The number of branches and branching pattern in the case of RRII 105 favour the incidence of pink disease. Pink disease appeared in the middle of June in 3 year old plants while only by late July in 2 year old plants.

A field experiment to study the effect of prophylactic application of biofungicides from wood waste, controlled wounding and cultural operations on pink disease control revealed that prophylactic Bordeaux paste application was superior followed by lime washing with 1 per cent copper sulphate and lime washing alone. The girth of plants under controlled wounding and scrubbing was higher compared to other treatments.

5. Shoot rot disease

The experiment to control shoot rot disease using various systemic fungicides was continued at 2 locations viz. Palapilly and Mundakayam. The treatments, dosage and the mean disease index are furnished in Table-Path.6.

6. Powdery mildew disease

An experiment to evaluate new systemic and nonsytemic fungicide formulations for powdery mildew disease control in the nursery was carried out at Cheruvally Estate. The results are presented in Table-Path. 7. Among the fungicides tested, Penconazole (0.05%) Hexaconazole (0.01%) and an emulsifiable concentrate of sulphur

Table-Path. 6. **Control of shoot rot disease using systemic fungicides**

Treatments	Dosage	Mean disease index (%)	
		Mundakayam	Palapilly
Phosphorous acid (Akomin)	2ml/l	18.6	15.0
Phosphorous acid (Akomin)	4ml/l	12.7	22.0
Phosphorous acid (Akomin)	8ml/l	8.7	18.0
Phosphorous acid (Phosjet)	1 ml/l	16.0	19.0
Phosphorous acid (Phosjet)	2ml/l	18.6	12.0
Phosphorous acid (Phosjet)	4ml/l	12.7	17.0
Fosetyl-Al (Aliette)	2g/l	19.3	20.0
Metalaxyl MZ (Ridomil Mz)	3g/l	10.3	20.0
Bordeaux mixture	1%	8.7	15.0
SE		2.79	
CD(P = 0.05)		5.90	NS

Table - Path. 7. **Control of powdery mildew disease**

Treatments	Dosage (% a.i.)	Disease index (%)
Hexaconazole (Contaf 5 EC)	0.02	36.50 ab
Hexaconazole (Contaf 5 EC)	0.01	36.90 ab
Penconazole (Topas 10 EC)	0.05	33.90 a
Carbendazim (Jeyvistin 50 WP)	0.05	40.50 bc
Carbendazim (Jeyvistin 50 WP) + Sulphur (Sulfex 80 WP)	0.025 + 0.10	45.30 cd
Sulphur (Sulfex 80 WP)	0.20	46.10 d
Sulphur (Microsul 52 EC)	0.20	36.10 ab
Control (water sprayed)	--	54.90 e

Mean of four replicates. Values followed by same alphabet are not significantly different (P=0.05) according to DNMRT.

(0.20%) were found to be effective in reducing disease intensity.

7. Minor leaf spot disease

Five fungicides were tested in the field for their efficacy in controlling *Gloeosporium* leaf spot disease, with weekly and fortnightly applications. Statistical analysis of the disease index showed that Indofil M 45 (0.2%) Ridomil Mz (0.2%) and Bavistin (0.05%) were effective in controlling the disease and were on par with 1 per cent Bordeaux mixture when applied at weekly intervals. Weekly application of these fungicides was found to be significantly superior to fortnightly application as seen in Table-Path. 8.

8. Biological control

In vitro antagonism of *Trichoderma* spp. was observed for *Phytophthora meadii* causing abnormal leaf fall. Attempts were made to test the capability of the antagonists to cause lysis of oospores of the pathogen. A higher percentage of lysis of the oospores were observed when burried in sterile soil pre-inoculated with the antagonist (Table-Path.9). Penetration of oospores by hyphae of the antagonist was also evident.

Trichoderma spp. inhibited the growth of two pathogens *Pythium seleroteichum* and *Botryodiplodia theobromae* which caused collar and root diseases in nursery seedlings when tested *in vitro*. Attempts were also made to mass multiply the antagonists on rubber wood saw dust. The technique has to be further perfected.

9. High pressure injection for wood preservation

The pressure injection equipments for injecting trees before felling was remodelled and the time for injection could be reduced to 15 min. Furniture made out of copper

Table - Path. 8. **Effect of fungicides in *Gloeosporium* leaf disease control**

Treatments	Application	% Disease index
Indofil M 45 (0.2%)	Weekly	34.55 (35.90)
Bavistin (0.05%)	Weekly	43.11 (41.02)
Calixin (0.1%)	Weekly	72.22 (58.24)
Bordeaux mixture (1%)	Weekly	31.78 (24.29)
Ridomil Mz (0.2%)	Weekly	30.00 (32.87)
Indofil M 45 (0.05)	Fortnightly	56.89 (49.02)
Bavistin (0.05%)	Fortnightly	51.44 (45.83)
Calixin (0.1%)	Fortnightly	79.44 (63.06)
Bordeaux mixture (1%)	Fortnightly	43.66 (41.31)
Ridomil Mz (0.2%)	Fortnighly	60.00 (50.86)
CD (P = 0.05)		7.67

Figures in parentheses indicate are sine transformed values; CD is for transformed values

Table - Path. 9. **Effect of *Trichoderma* spp. on lysis of oospores of *Phytophthora meadii***

Treatments	No observed	No. lysed	% lysed
P. meadii + *Trichoderma* spp.	86	56	65.11
P. meadii	153	3	1.96

sulphate injected wooden planks were found to be free from insect and fungal attack even after 7.5 years. Extracts from wood waste of Rubber, Mahogony, Teak, Anjily, Jack, Rose wood and *Entrolobium* were tested against *Botryodiplodia theobromae* culture. The percentage of growth inhibition was more in rose wood extract (Table-Path.10). Thirty year old rubber trees were pressure injected each with four litres of extracts prepared from 800 g. of wood waste of Rose wood, Teak wood, Jack wood, Anjili wood, Leucenia wood and Mahogany wood. Copper sulphate solution was used for comparison. The trees were felled and planks made for further studies.

Third generation budded plants of

Table - Path. 10. **Percentage growth inhibition of *Botryodiploidia theobromae* on different growth media**

Growth media (Wood extracts from)	Mean diametrical growth (cm.)	Percentage of growth inhibition
Rubber	7.68	0.00
Mahogony	3.20	63.14
Teak	1.76	83.33
Anjily	1.05	94.35
Jackwood	1.90	81.78
Rosewood	0.60	100.00
Enterolobium	1.42	88.21
SE	0.06	
CD (P = 0.05)	0.16	

mutant plants induced by streptomycin sulphate were maintained and observation on disease incidence and growth were recorded.

10. Host parasite inter-relationship

To study the role of nitrogenous fertilizer on the incidence of *Corynespora* leaf

spot disease, a field trial was initiated at Central Nursery, Karikkattoor with different levels of Nitrogen including the recommended dose.

In vitro studies on toxin production by *Corynespora cassiicola* was attempted. The fungus was allowed to grow in potato dextrose broth, rubber leaf extract broth and Czapek's broth media. Filter sterilized culture filtrate was extracted with diethyl ether and the residue of the ether extract was assayed for its toxicity against a test bacterium, *Bacillus subtilis*. Sterilized paper discs impregnated with the extracted residue were placed in *Bacillus subtilis* seeded nutrient agar plates and the inhibition zone was observed after 24 hours. Filter sterilized culture filterate when placed on young rubber leaves under laboratory conditions caused disease symptoms on the 4th day similar to that in natural incidence.

In vitro studies on the production of hydrolytic enzymes by *Corynespora cassiicola* under the influence of different levels of nitrogen were carried out. Increased nitrogen level in the medium enhanced the production of hydrolytic enzymes especially cellulolytic enzymes.

11. Root disease

A field trial on brown root disease control was started at Manikal estate, Mundakayam. The fungicides Calixin (2 dozes) ie. 12.5 and 6.25 ml, Tilt 20 ml and Thiride 20 g, Emisan 5 g were used in 2 litres of water for each tree. Each treatment has 4 replications. The treatments are repeated once in 4 months and observations on the treated plants recorded every month. Two rounds of fungicide treatments have been done.

12. Multidisciplinary evaluation of clones

The incidence of powdery mildew in two different trials at RRII experiment station was recorded. Certain clones registered a higher incidence of *Colletotrichum* leaf spot disease.

13. Screening of germplasm material/ HP seedlings

A total of 336 genotypes were subjected to preliminary screening for resistance against *Phytophthora meadii* using artificial inoculation technique.

14. Crown budding experiment

Yield recording from the experimental area at Thodupuzha, where the clone PB 311 was crown budded with resistant clones RRII 33 and Fx 516, was carried out. The intensity of abnormal leaf fall disease and powdery mildew disease in the three crowns viz. PB 311, RRII 33 and Fx 516 was assessed. The percentage leaf retention in PB 311, RRII 33 and FX 516 was 50, 90 and 85 respectively.

15. Microbiology of leguminous cover crops

A pot culture study was conducted to find out the effect of humic acid and lignite dust on nodulation and biomass production of *Pueraria phaseoloides*. Humic acid at 1g, 1.5 g and 2 g and lignite 5 g were mixed with 500 g soil and *Bradyrhizobium* inoculated seeds were sown. After 40 days the plants were analysed for various parameters. Nodulation and biomass production were more in humic acid treated soil. Maximum beneficial effect was recorded at 2 g humic acid level. Table-Path. 11.

The field experiment on the dual inoculation of *P. phaseoloides* with *Bradyrhizobium* sp and *Beijerinckia* sp was continued. Soil samples were collected from plots under different treatments for chemical analysis.

Table - Path. 11. **Effect of lignite and humic acid on nodulation and biomass of *P. phaseoloides***

Treatments	Nodule number	Nodule weight(mg)	Biomass (g)
Lignite (5g/500 g soil)	14	118	7.1
Humic acid (1g/500 g soil)	12	119	7.3
Humic acid (1.5 g/ 500 g soil)	23	128	8.0
Humic acid (2g/500 g soil)	28	137	8.5
Control	9	86	5.9

The acid tolerant species of *Azotobacter* was inoculated in pots planted with rubber seedlings. The population of the bacteria in rhizosphere soil was estimated and is presented in Table - Path. 12.

Table - Path - 12. ***Azotobacter* sp population in soil**

Days	Soil (x 10^2 cfu/g)	Rhizosphere (x10^5 cfu/g)
15	120	32
30	140	47
45	114	50
60	117	46

16. Mushroom culture

Investigation on the possiblity of shitake mushroom cultivation on rubber wood saw dust was carried out. The fungi first produce white encrustation on the surface of mushroom beds which turns into black mass in two months. Upon watering the white growth again appeared on the surface. However, no sporocarp was produced.

17. Pollution studies

Liquid wastes of rubber processing factories containing varying quantities of biodegradable organic compounds were found to be a good source for biogas production. Effluents from ribbed smoked sheets processing, crumb processing and latex centrifuge factories were tested in combination with crumb factory solid wastes, saw dust, predigested saw dust (mushroom compost) and cowdung for biogas production. Incorporation of predigested sawdust with the effluents registered high level of biogas production, degradation of solids as well as microbial and hydrolytic enzyme activities. Among the three liquid wastes, sheet serum in combination with various solid wastes produced more biogas with more methane content. Corresponding to this, favourable changes in total solids, microbial and enzyme activities were also observed.

18. Rhizosphere studies

The effect of coinoculation of an isolate of VAM (*Glomus* sp) and the nitrogen fixing bacteria - *Azotobacter* sp *Beijerinckia* sp or phosphate solubilising bacteria on the growth of *Pueraria phaseoloides* plants was studied in pot culture. The rhizosphere population of various groups of micro-organisms and plant growth characters were recorded and given in the Table-Path. 13 and 14. The coinoculation of VAM with various groups of bacteria was found to favour plant growth in comparison to inoculation with these organisms individually.

Another experiment to study the effect of different fungicides and insecticides on VAM colonisation on root of P. phaseoloides. was initiated.

Field trial to study the effect of phosphobacterial inoculation on rubber seedlings at four different levels of rock phosphate was repeated at Central Nursery, Karikatoor. Periodic girth and height measurements show positive effect of phosphobacterial inoculation.

Table.- Path. 13. **Effect of mycorrhizal and bacterial inoculation on rhizosphere microbial population of *P. phaseoloides* (per g soil)**

Treatments	Bacteria x 10^6	Fungi x 10^5	Actino-mycete x 10^5	Azoto-bacter x 10^2	Beijerin-ckia x 10^2	Phospho-bacteria x 10^5
No bacteraia + No mycorrhizae	56	33	21	-	4	42
Mycorrhizae alone	86	52	20	-	8	53
Azotobacter sp alone	74	45	22	86	5	71
Beijerinckia sp. alone	64	41	21	--	45	54
Phosphobacteria alone	95	49	19	--	14	120
Azotobacter sp + mycorrhizae	112	68	22	108	6	82
Beijerinckia sp + mycorrhizae	95	63	23	--	71	64
Phosphobacteria + mycorrhizae	125	74	20	--	19	143
C D (P = 0.05)	6.78	6.3	5.6		4.1	4.33

Table - Path. 14 **Effect of mycorrhizae and bacterial inoculation on growth of *P. phaseoloides***

Treatments	Shoot length (cm)	Shoot weight (g)	Root length (cm)	Root weight (g)	Nodule No	Nodule weight (g)
No bacteria + No mycorrhizae	42	7.2	17	4	64	.35
Mycorrhizae alone	111	22.3	22	8.9	115	1.42
Azotobacter sp alone	80	15.3	20	7.9	126	1.62
Beijerinckia sp alone	88	18	23	9.0	134	1.73
Phosphobacteria alone	124	24.7	24	10.6	130	1.67
Azotobacter sp + mycorrhizae	118	26.1	26	12.07	150	1.84
Beijerinckia sp + mycorrhizae	133	28.2	26	11.63	158	1.8
Phosphobacteria + mycorrhizae	159	32.9	30	15.2	165	1.92
CD (P=0.05)	6.36	0.78	2.45	0.65	5.28	0.11

19. Biological control of white grubs

Comparative evaluation of biological and chemical management of white grubs infesting rubber seedlings revealed that the biological and chemical treatments proved to be effective (Table-Path. 15). Application of the entomopathogen, *Beauveria brongniartii* was the most effective treatment in reducing

Table - Path. 15. **Comparative evaluation of biological and insecticidal formulations for the management of *Holotrichia serrata*.**

Treatments	Dose* (kg/ha)	Mean percentage of plant damage per plot **	Grub population/ 30 cm^3
Beauveria brongniartii	1 x 10^6 ***	4.35 (12.01)	0.00
Landrin 15 G	25	10.95 (18.82)	0.05
Isofenphos 5 G	25	11.52 (19.15)	0.05
Phorate 10 G	25	13.66 (21.50)	0.10
Carbaryl + Lindane (Sevidol 4:4 G)	25	14.35 (22.04)	0.15
HCH 10 D	100	18.60(25.58)	0.25
Untreated check	--	62.00(52.00)	2.00
C.D. (P=0.05)		(8.07)	

* For insecticides; ** Mean for four replications at eleven months after treatment.
*** Spores/g of soil; Figures in parenthesis represent angular values.

the white grub damage followed by Landrin 15 G, Isofenphos 5 G, Phorate 10 G, Sevidol 4:4 G and HCH 10 D in descending order of merit.

20. Vertebrate and non-insect pests

Rat burrows in an area of 0.5 ha of rubber nursery were treated with bromadiolone (Roban) baits at 0.005% concentration. The control of rodent population, estimated on the basis of the number of live burrows of respective species, showed 96.47% success (Table - Path. 16).

21. Beekeeping in rubber plantations

Studies on the introduction and management of European bees, *Apis mellifera* was initiated. Five colonies of *Apis mellifera* were multiplied into ten colonies at RRII and the brood rearing is on the increase in all colonies. European honey bees were frequently attacked by wasps and birds.

22. Minor pests

Severe incidence of Mucuna leaf-eating caterpillar *Tiracola plagiata* was effectively controlled by the application of BHC 50 WP at 2 per cent concentration in

Table - Path - 16. **Efficacy of roban in controlling rat pests in nurseries**

Rodenticide	Burrow counting period	Total burrows	Rodent species		
			Bandicota bengalensis	*Bandicota indica*	*Rattus meltada*
Roban	Pre-control	85	52	21	12
	Post-control	3	1	1	1
	Control (%)	96.47	98.08	95.24	91.67

the plantations of Arasu Rubber Corporation, Kanyakumari district.

Termites are found to build earthen galleries on the trunk of trees and remove the corky layers of the trunk region. An experiment was laid out at Desamangalam Estate, Trissur district for control of termites infesting rubber trees. There were 7 treatments viz. BHC 0.2%, and 0.4%, Chlorpyriphos 0.2% and 0.4%, Fenvalerate 0.02% and 0.04% and control with three replications. The treatments were imposed by drenching the insecticidal solutions at the base of trees. The final observations are yet to be recorded.

It was observed that the habit of feeding on the tender leaves of rubber plants by slugs is on the increase. Three to four repeated applications of Bordeaux paste on the trunk of plant at an interval of 45 to 60 days deterred the slugs and snails from attacking the plants. Other host plants of slugs and snails identified in rubber growing areas are *Tectona grandis, Clerodendron, Anfractnosum, Glycosmis pentaphylla, Mangifera indica, Artocarpus integrifolia, A. hirsuta, Piper nigrum, Diascorea* sp. *Amorphophalus* sp. *Colocasia* sp. *Ailanthus* sp. *Ipomoea batata, Musa* sp. *Capsicum* sp. *Solanum melongena, Abelmoschus esculentus, Carica papaya, Pueraria phaseoloides, Tabernae montane, Melastoma* sp. and *Macaranga* sp.

The slugs and snails breed during June, July, August and September and infest rubber plants mainly from September onwards.

23. Nematodes

A field trial to find out the effect of different granular insecticides on the control of nematode infestation and its effect on the growth characteristics of rubber seedlings was conducted. The experiment was laid out in a completely randomised design with four replications. The treatment included Phorate, Carbofuran, Aldicarb and Sevidol at the rate of 6 kg per ha. The results showed that among the different granular insecticides used, Carbofuran at the rate of 6 kg per ha is effective for the control of nematode infestation in rubber seedlings.

Studies on the spatial distribution of nematodes in rubber plantation revealed that the density of both the parasitic and non-parasitic nematodes varied according to the depth of the soil and distance from the base of the plant.

24. Rubber wood preservation

Different combinations of antifungal compounds such as borax, boric acid and Sodium pentachlorophinate, Phosphamidon and Oxycarboxin, Monocrotophos and Oxycarboxin were tested for the control of sapstain fungus on rubber wood. The growth of *Fusarium* sp. *Aspergillus* sp. *Trichoderma* sp and *Penicillium* sp. was significantly less in most of the treatments. Insect borers were effectively controlled by borax + boric acid + NaPCP, Dimethoate + Oxycarboxin, Dimethoate + Tridemorph and copper sulphate + borax.

Diffusion treatment of rubber wood planks with sodium pentachlorophenate in combination with either zinc sulphate or copper sulphate was found to be very effective for the prevention of fungal and insect attack.

PLANT PHYSIOLOGY AND EXPLOITATION DIVISION

The Physiology and Exploitation Division continued research on biochemistry, crop physiology, stress physiology, water management, stock-scion interaction, exploitation, tapping panel dryness (TPD), introduction of medicinal plants for intercropping etc. in addition to the routine assignments on testing of materials, training, advisory work and other extension activities. Onfarm trials on CUT were extended to more holdings.

1. Physiological and biochemical parameters for early prediction of yield

1.1 Protein profiles of lutoid membrane and C-serum

The objective of this study was to identify key proteins in the latex and relate the same to the yield potential of a given clone. Determination of the amounts and the molecular weight of C-serum and lutoid membrane polypeptides were done in high and low yielding clones of *Hevea* using standard biochemical techniques. The clones included in this study were Ch 4, PIIB 84, Ch 29 and Tjir 1 (low yielders) and RRII 105, PB 235, PB 217 and PB 215 (high yielders). In general, the high yielders showed presence of additional polypeptides in the lutoid membrane.

2. Biochemical parameters for early evaluation of drought tolerance

2.1 Studies on heat shock proteins

The objective of this study was to examine the response of *Hevea* leaf tissue to high temperature and low tissue water potential in terms of expression of any heat shock protein (s) that can be related to the stress tolerance of a clone. Heat shock response of three clones, viz. RRII 105, GT 1 and RRIM 600 were studied at different temperatures and time intervals. Proteins were extracted from leaf discs after subjecting them to the stress conditions and polypeptide profiles were recorded. The results are inconclusive.

2.2 Studies on cell membrane stability

In continuation of the earlier experiments on cell membrane stability, a modified method was tried with the leaves collected from different clones. In one experiment, the leaf discs from clone RRII 105 preheated in a plant osmoticum-polyethylene glycol (PEG 6000) solution, were subjected to heat shock(45°C for 1 hr) before measuring the electrolyte leakage. Both the stresses were applied separately as well as together. Combined effect of the two stresses on membrane stability was much greater than the individual effect of PEG alone (Table - Phy. 1). However, heat alone caused 38.5% injury.

Table - Phy. 1. **Mean per cent injury to RRII 105 leaf discs**

PEG Treatment (%)	Per cent injury		% increase over heat
	PEG	PEG+heat	
40	2.2	40.2	4.7
50	4.3	44.8	16.7
60	14.3	54.0	40.6
70	22.6	59.8	55.7
80	33.1	59.5	54.9

In another experiment leaf discs from clones RRII 105, RRIM 600, SCATC 88/113, Haiken 1 and PB 260 were first immersed

in PEG solution, and then treated in hot water to measure the stress tolerance. Percent injury is given in Table - Phy.2.

Table - Phy. 2. **Percent injury in *Hevea* during single and multiple stress treatments**

Clone	Temp. (°C)	PEG(%)	PEG + heat
RRII 105	35.3	23.3	62.3
RRIM 600	21.5	20.8	49.6
SCATC 88/114	34.0	26.2	69.7
Haiken 1	18.6	21.9	47.2
PB 260	20.2	20.4	37.2
CD(P=0.05)	3.05	NS	4.47

Significant differences among clones indicate that SCATC 88/113 and RRII 105 are susceptible to drought and temperature stresses, whereas clones like RRIM 600, Haiken 1 and PB 260 are tolerant to drought and temperature. Further studies are required to relate membrane stability of a clone with its performance in the field under stress conditions.

3. Environmental paramters on yield and major yield components

3.1 Interaction of the environment with yield components

The yield and major yield components viz. initial flow rate (F), dry rubber content (Cr) and plugging index (P) were recorded in 12 clones at monthly intervals at Central Experiment Station, Chethackal. Highest mean annual yield was observed in clone RRII 105. The correlation and path analysis were worked out for yield and yield components wjth environmental parameters *viz.* maximum temperature (Tmax) and soil moisture content (SM). Initial flow rate showed a significant positive correlation while P showed a negative correlation with yield. Path analysis reveals that P has a direct negative effect on yield, whereas F and Cr have a direct positive effect. Soil moisture has a negative effect on P, and Tmax influences P through SM. In addition to that, Tmax has a direct effect on Cr.

3.2 Environmental impact on latex composition

Latex diagnosis parameters like P, Cr, total solids content (TSC), thiol, inorganic phosphate and sucrose were analysed in wet season (July) and dry season (February) for six clones. It is observed that Cr, TSC and thiols are higher in dry season compared to wet season. This study is being continued.

4. Physiology of rooting and stock-scion interaction

4.1 Rooting in air-layers

To study the physiology of rooting in different clones of *Hevea*, air-layering technique using sphagnum moss was standardised. The results of a perliminary study using different rooting media in three *Hevea*

Table - Phy. 3. **Effect of rooting media on rooting percent of air-layers**

Clone	Rooting (%)			
	Sphagnum moss	Soil	Coconut husk	Coconut husk+ soil
RRIM 600	86.6	0	0	6.7
RRII 105	33.3	0	0	0
GT 1	66.7	0	0	0

clones are shown in Table - Phy. 3. This technique is being carried out in different clones with and without root promoting hormones to assess the rooting ability of the clones. Preliminary studies on biochemical characteristics of rooting in hard to root and easy to root cultivars were also carried out. Air-layering was done in one, two and three year old plants of different clones to study the effect of age on rooting.

4.2 Root stock-scion interaction

4.2.1. Studies on photosynthetic variability in polyclonal seedlings

Eighteen month old polyclonal seedlings of *Hevea* were used for study of carbon dioxide exchange rate (CER) per unit leaf area, growth and leaf traits such as length, breadth and number per plant. The mean and range of the above parameters are presented in Table - Phy. 4.

Table - Phy. 4. Mean, range and covariance in CER and leaf traits and seedling girth in polyclonal seedlings

Variables	Mean	SE	CV(%)	Range
CER (μ mol $m^{-2}s^{-1}$)	8.8	0.26	25	4.1-14.3
Leaf area (cm^2)	111.2	4.33	33	53-252
Leaf length (cm)	22.3	0.44	17	16-38
Leaf width (cm)	7.6	0.16	17	4.9-12.3
SLW (mg cm^{-2})	6.2	0.08	11	4.3-8.5
No. of leaves	43.0	2.08	41	15-99
Total leaf area per plant (dm^2)	135.7	6.82	38	51-299
Girth (cm)	3.75	0.08	18	2.2-4.7

Carbon dioxide exchange rate ranged from 4 to 14 μmol m^{-2} s^{-1}. Similarly all the other parameters studied showed considerable variation between the seedlings. Existence of such huge variability offers the potential for genetic exploitation of desirable traits. The frequency distribution of the population for CER showed that majority of the seedlings had a CER close to the mean CER of the population with only a few individuals having CER values in the extreme ranges.

The correlation among the above mentioned parameters are worked out (Table - Phy. 5). Carbon dioxide exchange rate showed a negative correlation with single leaf area, leaf breadth and length. Leaf number per plant exhibited negative correlation with leaf size. Specific leaf weight is positively correlated with CER. Total leaf area per plant showed a significant positive correlation with girth of plants. Total carbon dioxide fixed by the plants (calculated from CER per unit leaf area and the total leaf area per plant) also showed positive association with girth of the plants.

Table - Phy. 5. **Correlation coefficient of CER with leaf traits and girth.**

	Leaf area	Leaf length	Leaf width	SLW	No. of leaves	Total leaf area	Girth
CER	-0.43 **	-0.35 **	-0.48 **	0.25 **	0.18 *	-0.20	-0.22
Leaf area		0.88 **	0.88 **	0.1 **	-0.38 **	0.33 *	0.37 **
Leaf length			0.72 **	-0.08	-0.38 **	0.25 *	0.22
Leaf width				0.06	0.28 *	-0-38 **	0.41 **
SLW					-0.09	-0.12	-0.04
No. of leaves						0.71 **	0.22
Total leaf area							0.51 **

4.2.2. Budgrafting of modern clones on genetically indentical root stocks produced by air–layering

Rooted air-layers of different clones have been planted in polybags for further studies on root stock-scion interactions. Genetic homogenity is guaranteed in air layers and therefore variability in the root stock material is removed. On these genetically identical air-layers, a few modern clones will be budgrafted for future studies on root stock-scion interations.

5. Multidisciplinary studies on tapping panel dryness (TPD) syndrome

5.1 Lipid composition of latex in reltion to TPD

Latex samples were collected from normal and partially dry trees and different lipids in the bottom fraction and rubber cream were estimated. Preliminary analysis of the data show that the content of total lipids, phospholipids and sterols in the bottom fraction are low in the partially dry trees compared with the normal trees whereas the content of triglycerides shows an opposite trend. The above parameters in the rubber cream are low in the partially dry trees compared with the normal trees.

5.2 Latex physiology and biochemistry

As part of the IRRDB programme on TPD, a case study for monitoring changes in physiological and biochemical parameters associated with incidence of TPD was initiated in a new location.

To monitor changes in physiological and biochemical parameters in individual trees in a monoclonal population at periodic intervals and to relate such changes with the onset of TPD syndrome, this study was started in October 1994. Fifty trees of RRII 105 have been monitored for five months. Thiols, sucrose and inorganic phosphorus were determined in the latex at fortnightly intervals. Superoxide dismutase assay was done in latex of sixteen trees at an interval of 30 days. This study is being continued.

6. Medicinal plants in mature rubber plantations

6.1 Biomass yield of medicinal plants

The field experiment laid out during June 1992 with three species of medicinal plants viz. *Strobilanthes haenianus*, *Adhatoda vasica* and *Plumbago rosea* was continued. Economic yields of these species recorded at 24 and 30 months after planting are presented in Table - Phy. 6.

Table - Phy. 6. Yield of medicinal plants grown in mature rubber plantation.

Species	Spacing cm x cm	Yield (kg/ha) at 24 months	Yield (kg/ha) at 30 months
Strobilanthes haenianus			
F1	45 x 45	5.21	9.5
F2	45 x 45	4.1	8.3
Adhatoda vasica			
F1	37.5 x 30	1.9	2.9
F2	37.5 x 30	2.3	3.3
Plumbago rosea			
F1	37.5 x 30	1.5	1.5
F2	37.5 x 30	1.4	1.4

F1 = 30 kg N/ha F2 = 60 kg N/ha

7. Exploitation system and yield

In the large scale trial on the clone RRII 105, the 1/3S cut continues to give higher yield with alternate day's tapping. In general 1/3S is giving encouraging result. Weekly tapping with 5% ET also gives good yield, with less labour engagement.

The trial started in 1985 in clone RRII 105 at CES was continued. The yield from the double cut system ($2x^1/_4$ S↓↑ d/2 6d/7 (t,t) was higher than that in other systems

during the year 1994-95. Two of the trees under daily tapping continue to give good yield and have no TPD even in the fifth year of tapping.

Studies on the effect of different exploitation systems on yield and growth in the clone RRII 118 were continued.

The trial on the effect of different rest period on yield and TPD was continued. Rest seems to be beneficial in giving more yield when compared to continuously tapped trees. Girthing was also better in the trees given tapping rest for one, two or three months.

In the yield cum exploitation trial at Karnataka, girth data was processed and accordingly opening of the trees was postponed.

7. Tapping system for small growers

Inspite of the adverse effects of daily tapping, over 40 per cent of small growers in India follow daily tapping due to socio-economic reasons. The study for identifying tapping system for such growers was continued. Girth increment was the highest under 1/3S d/1 6d/7 in the trial on the clone RRII 203. The dry rubber content of latex from these trees were comparable to $^1/_2$ S d/2 6d/7 trees inspite of daily tapping. It is proposed to extend the study on this tapping system to clone RRII 105.

8. Controlled upward Tapping (CUT)

The large scale trial was continued. Trees tapped on 1/3S ↑ $^1/_2$ S d/2 6d/7 continued to give better yield. On-farm trials on CUT were further extended to more holdings. $^1/_4$ S ↑, 1/2S d/2 6d/7 (change over system) during non-rainy and rainy seasons, respectively is ideal for small and medium growers.

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

For solar assisted drying of sheet rubber, a solar heat collector of 4m^2 area was fabricated and attached to the smoke drier having a capacity of 96 sheets. Evaluation of the performance of the drier under different climatic conditions and loadings, is in progress.

2. Sun drying of sheet rubber

Due to non-availability of smoke houses, sheet rubber prepared by many of the small rubber growers is dried in open sun. Sun drying is not hazardous when the moisture content in the sheet rubber is high. But as the drying proceeds, the UV rays in sun light can affect the properties of sheet rubber adversely. Hence, a systematic study has been taken up, to evaluate the effect of sun drying on quality and properties of sheet rubber. Sheets were prepared and dried under sun using trolleys. It was noted that 7-8 days are required for complete drying of sheet when the sunshine hours were maximum, but the portion of rubber in contact with the reaper on the trolley becomes sticky.

3. Epoxidation of natural rubber

In order to improve the plasticity retention index (PRI) of epoxidised natural rubber (ENR) different combinations of antioxidants were tried. Combined use of styrenated phenol (Antioxidant SP) and mercaptobenzimidazole (Antioxidant MBI) in the range 0.1 to 0.25 phr gave high PRI values (85 to 98). However, combined use of 2, 2, 4- trimethyl 1,2 - dihydroquinoline (Antioxidant HS) and MBI in the range 0.05 to 0.25 phr each, gave PRI values greater than 100 in all cases.

4. Studies on prevulcanization of latex

Sulphur prevulcanization of NR latex was conducted at 60, 70, 80 and 90°C for different periods. The extent of crosslinking, tensile properties, water absorption, and stress relaxation characteristics of the films were determined. The volume fraction of rubber (Vr), which is a measure of crosslink density of the films, showed maximum value when prevulcanization was conducted at 80°C for 2h or 90°C for 1h. At each temperature tensile strength and elongation at break decreased as the heating period increased, whereas modulus increased till maximum corsslinking was obtained, thereafter a decrease was observed. Water absorption was rapid and the rate of stress relaxation slightly increased when the extent of prevulcanization increased.

5. Comparative evaluation of different forms of NR

The work has been completed and the data analysed statistically. Sheet rubber showed comparable consistency with that of ISNR 20 in raw rubber and vulcanizate properties. The vulcanizate properties were better for sheet rubber except heat build-up characteristics. Sheet rubber showed superiority over ISNR 20 and crepe rubber, in raw rubber properties except volatile matter. Significant differences were not observed among ISNR 20, processed in the estate sector and non-estate sector.

6. Short sisal fibre-natural rubber composites

Modification of the mould for preparing a timer belt was completed. Using this mould belts were fabricated from short sisal fibre - natural rubber composite. The performance of these belts in actual use is being evaluated.

7. Rubber modified slow release fertilizers

Conditions for preparing rubber modified urea using different forms of natural rubber were standardised. Evaluation of nitrogen release characteristics of the sample in soil is in progress.

8. Rubber blends

In order to assess the feasibility of ENR 50 as a substitute for natural and nitrile rubber in rice dehusking rolls, silica filled vulcanizates of NR, ENR 50 and NBR were compared for physical properties, ageing and rice bran oil resistance. NBR showed a slight superiority over NR and ENR 50 in most of the properties studied.

9. Blends of different forms of NR

Different forms of NR such as skim, superior processing and epoxidised rubber are used in rubber products with specific objectives. Often, these are used in blends with other forms of rubber to overcome processing or technological constraints. A study has been initiated to find out the effect of blending of these rubbers with suitable conventional grades of natural rubber. Blends of skim rubber and ISNR 20 at different proportions were prepared. The raw rubber

properties, cure and scorch characteristics of ACS-1 compounds and vulcanizate properties of black filled (HAF) mixes were studied. The water absorption and damping characteristics were also evaluated. The blends were found to have high hardness and stiffness.

10. Molecular breakdown of different forms of NR

Elastomers undergo molecular chain scission during mastication and this behaviour varies with different rubbers. The optimum energy for mastication and mixing is an important parameter, as far as processability is concerned. Hence, a study has been initiated to develop an index for breakdown behaviour for different forms of natural rubber. Different forms of natural rubber such as sheet, crepe, ISNR, ENR and superior processing rubber were used for evaluating the breakdown index.

11. Production and application of rubberised bitumen

For the preparation of rubberised bitumen a definite proportion of micro crumb (obtained from waste vulcanized rubber) was directly added to bitumen at 160°C and kept at this temperature for different periods. The properties of rubberised bitumen thus obtained are being analysed for different parameters.

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. Studies on different aspects of ancillary sources of income and by-products are other important areas of research. Inter-divisional collaborative projects are also undertaken.

1. Commercial evaluation of planting materials

This is a continuous study undertaken by the division since 1974 to generate information on the commercial yield of prominent planting materials. The third report of the study was published in 1990 and the fourth is under preparation. A database is being constructed covering details on tapping system, density of planting, clonal, regional and seasonal differences in yield in terms of latex and field coagulum. The database includes field level information of 45 large estates for a period of 27 years (1966-1994).

2. Evaluation of the insurance scheme for rubber plantations in the context of natural damage

The scheme during its first five year period of operation was evaluated on the basis of the estimated natural damage, loss/solvency ratios and cost-benefit analysis. The extent of natural damage was estimated on the basis of a field survey confined to the estate sector covering 47 units. The average extent of natural damage reported was 0.96 per cent out of which 66 per cent was accounted for by wind and 24 per cent by fire. The study identified the inherent rigidities of the scheme from the point of view of the growers. The major drawbacks of the scheme were provisions relating to

the non-indemnifiable limits for the immature and mature phases as well as the system of event based payment of compensation. Based on the findings, suitable modifications in the provisions of the scheme were also suggested.

3. Time-series analysis of foreign trade in rubber products

The study covering the period from 1971-72 to 1992-93 showed that the present pattern of the exports is virtually an extension of the existing industrial structure. The structure of Indian rubber goods manufacturing sector is dominated by dry rubber products which accounts for around 85 per cent of the gross rubber consumption. The balance of trade had been favourable throughout the period and amounted to Rs. 495.48 crores during the terminal year, 1992-93. In the post GATT scenario, the analysis indicated the necessity to reorient the export policy with due emphasis on latex based products to cater to both domestic and export markets.

4. Market survey on medicinal plants

A trial undertaken by the Plant Physiology Division of RRII in 1987 indicated the technical feasibility of growing six medicinal plants as intercrops in mature rubber plantations. A follow-up study was conducted by the Division to assess the market potential of these plants, on the basis of a field survey covering 75 randomly selected ayurvedic drug manufacturing units and leading dealers. The area required to meet the present demand is only 518 ha of rubber plantations and a major part of demand of certain species is met from natural sources. Recognising the narrowness of the market, the study suggested buy-back agreements between growers and consumers before recommending intercropping on a commercial basis.

5. Ancillary products

The availability of rubber wood during 1994-95 was estimated to be 1376 thousand m^3 of which 826 thousand m^3 was stem wood and sawn timber suitable for treatment amounted to 288 thousand m^3. The branch wood was entirely used by the households and small scale factories as firewood. The pattern of industrial use of stem wood is given in Table - Age. 1. The share of rubber wood consumed by plywood and treatment

Table - Age. 1. **Pattern of rubber wood consumption**

End uses	Consumption ('000 m^3)	Relative share (%)
Packing case	447	54.1
Safety match	78	9.4
Plywood	198	24.0
Treated wood	87	10.5
Others	16	2.0
Total	826	100.00

units showed significant increase at the expense of safety matches and packing case sector. A study conducted by the Division on the role of rubber wood sector in India in the conservation of environment estimated that full utilisation of the economically available rubber wood can conserve 19000 ha of natural rain forests on an annual basis. The rapid rise in the price of natural rubber during the later months of 1994-95 affected the replanting schedules of growers and reduced the market availability of rubber wood. The net result was a significant increase in the price of rubber wood to the extent of more than 35 per cent.

The estimated production of rubber seed oil and cake during 1994-95 was 3800 MT and 7050 MT respectively. The inferior quality soap manufacturing units were the main consumers of rubber seed oil. The estimated production of rubber honey during

1994-95 was 900 MT. The share of rubber honey from colonies of newly introduced *Apis mellifera* popularly known as European bees increased significantly.

6. Other studies

A collaborative project with the RCPT Division to study the comparative performance of different forms of NR also has been completed. Other research projects include studies on the operational efficiency of rubber plantations, input subsidy and adoption of modern technology for primary rubber wood processing industries.

CENTRAL EXPERIMENT STATION, CHETHACKAL, KERALA

The Central Experiment Station of the Rubber Reserach Institute of India at Chethackal, Ranni in Pathanamthitta District has an area of 254.80 ha. Long-term field experiments dealing with clone evaluation, exploitation studies, screening of Brazilian germplasm, pests and diseases, intercropping of medicinal and other cash crops have been laid out in this station by the Botany, Germplasm, Physiology, Pathology and Agronomy Divisions. Over 4000 genotypes of wild Brazilian germplasm and 122 clones of Wickham materials have been established and maintained in the station for evaluation.

Table - Ces. 1. **Rainfall**

Month	Rainfall (mm)
1994	
April	194.0
May	167.5
June	497.5
July	640.0
August	464.7
September	198.6
October	649.7
November	221.6
December	26.3
1995	
January	62.4
February	69.6
March	53.7
Total	3245.6

During 1994-95, an area of about 15 ha was planted for different experimental purposes. The total crop production during the period was 151.85 t. The total rainfall during the period under report was 3245.6 mm (Table - Ces. 1).

There were 213 permanent workers and 204 casual workers on rolls, during the priod. The total mandays engaged for different operations in the station during 1994-95 were 71697.

The dispensary functioning in the station provided medical services for 11481 cases.

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the non-indemnifiable limits for the immature and mature phases as well as the system of event based payment of compensation. Based on the findings, suitable modifications in the provisions of the scheme were also suggested.

3. Time-series analysis of foreign trade in rubber products

The study covering the period from 1971-72 to 1992-93 showed that the present pattern of the exports is virtually an extension of the existing industrial structure. The structure of Indian rubber goods manufacturing sector is dominated by dry rubber products which accounts for around 85 per cent of the gross rubber consumption. The balance of trade had been favourable throughout the period and amounted to Rs. 495.48 crores during the terminal year, 1992-93. In the post GATT scenario, the analysis indicated the necessity to reorient the export policy with due emphasis on latex based products to cater to both domestic and export markets.

4. Market survey on medicinal plants

A trial undertaken by the Plant Physiology Division of RRII in 1987 indicated the technical feasibility of growing six medicinal plants as intercrops in mature rubber plantations. A follow-up study was conducted by the Division to assess the market potential of these plants, on the basis of a field survey covering 75 randomly selected ayurvedic drug manufacturing units and leading dealers. The area required to meet the present demand is only 518 ha of rubber plantations and a major part of demand of certain species is met from natural sources. Recognising the narrowness of the market, the study suggested buy-back agreements between growers and consumers before recommending intercropping on a commercial basis.

5. Ancillary products

The availability of rubber wood during 1994-95 was estimated to be 1376 thousand m^3 of which 826 thousand m^3 was stem wood and sawn timber suitable for treatment amounted to 288 thousand m^3. The branch wood was entirely used by the households and small scale factories as firewood. The pattern of industrial use of stem wood is given in Table - Age. 1. The share of rubber wood consumed by plywood and treatment

Table - Age. 1. **Pattern of rubber wood consumption**

End uses	Consumption ('000 m^3)	Relative share (%)
Packing case	447	54.1
Safety match	78	9.4
Plywood	198	24.0
Treated wood	87	10.5
Others	16	2.0
Total	826	100.00

units showed significant increase at the expense of safety matches and packing case sector. A study conducted by the Division on the role of rubber wood sector in India in the conservation of environment estimated that full utilisation of the economically available rubber wood can conserve 19000 ha of natural rain forests on an annual basis. The rapid rise in the price of natural rubber during the later months of 1994-95 affected the replanting schedules of growers and reduced the market availability of rubber wood. The net result was a significant increase in the price of rubber wood to the extent of more than 35 per cent.

The estimated production of rubber seed oil and cake during 1994-95 was 3800 MT and 7050 MT respectively. The inferior quality soap manufacturing units were the main consumers of rubber seed oil. The estimated production of rubber honey during

1994-95 was 900 MT. The share of rubber honey from colonies of newly introduced *Apis mellifera* popularly known as European bees increased significantly.

6. Other studies

A collaborative project with the RCPT Division to study the comparative performance of different forms of NR also has been completed. Other research projects include studies on the operational efficiency of rubber plantations, input subsidy and adoption of modern technology for primary rubber wood processing industries.

CENTRAL EXPERIMENT STATION, CHETHACKAL, KERALA

The Central Experiment Station of the Rubber Reserach Institute of India at Chethackal, Ranni in Pathanamthitta District has an area of 254.80 ha. Long-term field experiments dealing with clone evaluation, exploitation studies, screening of Brazilian germplasm, pests and diseases, intercropping of medicinal and other cash crops have been laid out in this station by the Botany, Germplasm, Physiology, Pathology and Agronomy Divisions. Over 4000 genotypes of wild Brazilian germplasm and 122 clones of Wickham materials have been established and maintained in the station for evaluation.

Table - Ces. 1. **Rainfall**

Month	Rainfall (mm)
1994	
April	194.0
May	167.5
June	497.5
July	640.0
August	464.7
September	198.6
October	649.7
November	221.6
December	26.3
1995	
January	62.4
February	69.6
March	53.7
Total	3245.6

During 1994-95, an area of about 15 ha was planted for different experimental purposes. The total crop production during the period was 151.85 t. The total rainfall during the period under report was 3245.6 mm (Table - Ces. 1).

There were 213 permanent workers and 204 casual workers on rolls, during the priod. The total mandays engaged for different operations in the station during 1994-95 were 71697.

The dispensary functioning in the station provided medical services for 11481 cases.

REGIONAL RESEARCH STATION, GUWAHATI, ASSAM

The thrust areas of research at the Regional Research Station, Assam were multidisciplinary evaluation of clones, assessment of nutritional requirements under different fertility status of soil, diseases and pest management.

1. Multidisciplinary evaluation of clones

The girth of the trees recorded in this trial indicated maximum growth for RRIM 600 (56.68 cm) followed by RRII 118 (56.04 cm). The mean yield recorded from this trial which was opened for tapping in 1993 is given below. While RRIM 600 recorded the highest yield, the DRC was higher in GT 1.

In the 1986 trial, girth was maximum for clone RRIC 102 (57.07 cm) followed by RRII 118 (56.56 cm). In this trial, four clones have been opened for tapping and the remaining are scheduled for opening during next year.

Table - Nea 1. **Yield performance of different clones**

Clone	Yield (g/tree/tap)	DRC
RRII 105	24.58	26.22
RRII 118	24.37	26.14
RRII 203	19.22	24.00
RRIM 600	29.70	26.32
RRIM 605	19.69	22.29
PB 86	22.05	23.06
PB 235	25.45	24.96
PB 5/51	26.73	26.17
GL 1	21.93	23.21
GT 1	24.83	26.62

2. Nutritional studies (immature phase)

The cumulative girth data generated from the trials laid out at Mendipather in 1987 and at Nayekgaon in 1986 indicate a positive response for the highest doses of nitrogen (60 kg/ha).

3. Interaction between K and Mg

Girth data obtained from the experiment laid out in Sorutari Research Farm indicated that the combination of the highest dose of magnesium (15 kg/ha) with no potassium and the highest dose of potassium (40 kg./ha) with no magnesium gave higher girth increment. Similar observations were recorded from the trial at Nayekgaon.

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

The cumulative data on girth obtained from the trials at Sorutari Research Farm and at Nayekgaon Rubber Estate showed higher girth increment in the case of young rubber plants which received rock phosphate.

5. Survey of diseases and pests

Pests and diseases survey was carried out in 47 locations in Assam, Meghalaya and Tripura and the damages caused by them were assessed by visual scoring.

Powdery mildew disease caused by *Oidium heveae* was the predominant disease

noticed on tender leaves in all stages of growth of rubber plants in all the locations surveyed. High disease intensity was noticed at Chandrapur, Panbari, Topatoli, Ouguri, Taranagar and Madhuban Rubber estates causing repeated massive premature defoliation and die-back of twigs and branches. Flowers were also infected.

Colletotrichum gloesosporiodes was noticed on tender leaves during June to September in all the plantations surveyed. High intensity of this disease was noticed widely in nursery plants and in young plantations. Pod rot caused by *C. gloeosporioides* was also noticed in some plantations of Assam, Meghalaya and Tripura. Leaf blight caused by *Periconia hevеae* was noticed in nurseries and young plantations.

Incidence of brown root rot disease caused by *Phellinus noxius* was found in some plantations at Topatoli, Panbari, Chandrapur and Ouguri in Assam and Byrnihat in Meghalaya.

Mild infestation of termites, slugs and snails were also observed in some plantations of Assam and Meghalaya. Scale insect *Saissetia nigra* infestation was noticed in nursery plants by the end of April to August. Subsequently entomogenous fungus *Hypocrelia reineckiana* controlled the insect population naturally.

6. Isolation, identification and maintenance of pathogens

Routine isolation of fungal pathogens was made from various diseased samples of *Hevea* plants collected from different locations and identified locally. Thirty five fungal isolates associated with various diseases were maintained as stock cultures for further studies.

7. Control of powdery mildew

In the trial on economic feasibility of sulphur dusting initiated at Sorutari Research Farm, the requirement of sulphur powder per hectare per round was comparatively higher than that in the traditional areas. The incidence of *Oidium* leaf disease was below 10% when assessed after five rounds of dusting.

8. Control of *Oidium* leaf disease using zinc

A trial for control of *Oidium* leaf disease using zinc was initiated in seedling nursery at Sorutari Research Farm. Among the treatments three monthly spraying of Chelazin liquid and sulphur dust controlled *Oidium* more effectively when compared to Bavistin wettable sulphur and chelazin powder.

9. Performance of polyclonal materials.

More than fifty polyclonal seedlings have been opened for tapping. The yield recorded indicate that some of the polyclonal seedlings perform better than the budded plants of similar age belonging to different clones.

10. Introduction and evaluation of germplasm

The Brasilian germplasm materials were maintained properly in the germplasm nurseries at the experiment farm at Sorutari. Amost all of the 650 Brasilian germplasm materials were test tapped at 35 cm height during July to August, 1994. Visual scoring has been done and best performing germplasms were identified.

11. Influence of stocks on scion performance

Seedlings were classified, uniformly budded with the clone RRIM 600 and trans-

planted to field. The height, no. of whorls, no. of leaves and total leaf area of the transplanted plants were recorded periodically.

Another set of one and two year old seedlings (40 nos each) were budded and kept ready for transplanting to repeat the experiment.

REGIONAL RESEARCH STATION, AGARTALA, TRIPURA

The Regional Research Station, Tripura, situated at the Rubber Board Complex at Bhalukia Tilla, Agartala has been equipped to undertake research work in the disciplines of Agronomy/Soils, Plant Physiology and Plant Breeding. The station has a small library, a mobile tissue testing laboratory and a well equipped meterorological oservatory. The research farm at Mohanpur has an area of 84.83 ha with 29 tapping blocks and a nursery.

1. Nutritional studies

1.1 Mature phase

This fertilizer trial is laid out with clone RRIM 600 in a 3 factorial design. The treatments consists of 3 levels of N (0, 30,60 kg/ha); P(0, 30, 60 kg/ha) and K (0,20,40 kg/ha). The mean yield recorded during the year is presented in Table - Net.1

Table- Net 1. **Average yield at different levels**

	Levels of Nutrients		
	0	1	2
Nutrients			
N	35.87	37.16	39.08
P	33.68	39.42	38.96
K	35.94	36.98	39.19

1.2 Immature phase (polybag plants)

The trial was started with a view to study the response of *Hevea* plants to higher dosages of nutrients. The mean girth and girth increment for the year '94-95 is shown in Table - Net. 2.

Table -Net. 2. **Mean grith and girth increment (1994-95)**

Treatments	Mean girth (cm)		Girth increment (cm)
	Aug. '94	Feb. '95	(% increase)
T_1 30:30:30	48.60	50.00	1.40
T_2 30:30 (15) : 30	49.18	50.44	1.26
T_3 60:60:60	51.34	52.74	1.42
T_4 60:60 (30) : 60	51.18	52.46	1.28
T_5 90:90:90	48.80	50.94	2.14
T_6 90:90 (45) : 90	50.61	51.96	1.35

Water soluble form of phosphorus in parentheses

2. Density-cum -nutritional trial

This trial comprises two clones (RRII 105 and RRII 118) laid out in three densities (D_1:420, D_2:606 and D_3 :824 points/ha) and three levels of NPK (M_1:40:40:20, M_2: 60:60:30 and M_3:80:80:40). The girth data recorded revealed that plants under the lowest density attained the highest absolute girth. However, the plants under the lowest density experienced more wind damage. The dosage 60N : 60P :30K was optimum for the attainment of maximum girth under the lowest density. A devastating storm affected the trial in April, 1994 and almost 30 per cent plants were destroyed.

3. Forms and placement fertilizers

3.1 Phosphatic fertilizers (immature phase)

This trial is being conducted to compare the efficiency of different sources of phospatic fertilizers in rubber. The clone used is RRIM 600. The trial was opened for tapping in 1994 but since excessive late dripping was noticed tapping had to be abruptly stopped during winter.

3.2 Mode of fertilizer application (N and P)

It was observed that a combination of ammonium sulphate and single super Phosphate applied as band continued to give the highest girth 35.04 cm. However, a combination of ammonium sulphate and rock phosphate applied as band was found to provide maximum girth increment (13.98 cm) during the year. Among all the placement treatments the band application was found to favour girth increment the most.

4. Agro-ecological and socio-economic impacts

4.1 Litter fall, accumulation and decomposition

This trial commenced during February 1993 with the objectives (a) quantification of total litter fall in the mature phase (b) to study the rate of decomposition of the litter (c) to analyse the nutrient content of the litter and (d) to assess the total litter. From the data collected during the period under report, the inferences drawn are pesented in Table Net. 3.

Table- Net. 3. **Litter fall**

	Total litter fall (ha/year)	Mean litter standing crop (kg/ha)	Annual decay constant
Leaves	4966.0	170.30	2.92
Twigs	1917.8	47.18	4.06
Petioles	960.6	30.02	3.20
Total	7844.0	247.38	3.17

5. Clone trial

5.1 Clone trial (1979)

The yield data on BO 1 panel showed the following hierarchy in yield : PB 235, RRIM 600, RRII 105, RRIM 703 and RRII 203. Basd on an index combining yield and stability, RRIM 703 was observed to be the most stable among the clones.

5.2 & 5.3 Clone trials (1987 a and b)

These trials for evaluation of multidisciplinary aspects and stress tolerance were summarily abandoned due to extensive damages caused by high velocity winds.

6. Breeding and selection

6.1 Half-sib progeny evaluation

This trial was laid out to identify useful recombinants on open pollination and for evaluating their own progenies. Forty nine recombinants along with fifteen female parents were laid in a trial following two dimenstional lattice design. The morphological characters of the candidates were recorded.

6.2 Full-sib progeny evaluation

Twenty seven cross combinations from hand pollination programme (1991, 1992 and 1993) were multiplied for evaluation in comparison with parents. These genotypes are from crosses involving six clones viz. PB 86, SCARC 88/13, Gl 1, RRIM 600, RRII 208 and RRII 105. The comparative trial for evaluation will be laid out during 1995.

6.3 Evaluation of polyclonal seedlings

The trial was initiated during 1987. 104 seedlings, which attained tappable girth were opened and yield evaluation is being done on the basis of dry rubber from individual trees.

7. Germplasm conservation, evaluation and maintenance

As many as 366 clones from Amazonian collection (IRRDB, 1981) are being maintained. On the basis of girth data, 104 genotypes were selected for multiplication and evaluation. Of these, 81 genotypes were brought under a comparative trial for yield evalution with RRIM 600 as control.

8. Effect of low temperature on growth

Data on photosynthesis was recorded for 15 clones in immature phase during September 1994 to March 1995. A preliminary analysis showed that net photosynthesis rate has definite positive relationship with transpiration.

9. Effect of low temperature on yield

Ten clones were selected for intensive studies on the effect of low temperature on yield and yield components. Data on plugging index, total volume of latex, dry rubber content, sucrose and inorganic phosphorus were recorded every week. Data are being analyzed.

REGIONAL RESEARCH STATION, TURA, MEGHALAYA

The Regional Research Station, Tura, concentrated on various projects in relation to evaluation of high yielding and disease resistant clones which will be suitable for Garo Hills conditions.

1. Field experiments at Ganolgre

1.1 Multidisciplinary evaluation of clones

On the basis of girth recorded in ten clones from 1985 trial, RRII 203 (54.77 cm), PB 235 (54.45cm), RRIM 600 (54.06 cm) and RRII 118 (53.86 cm)' have attained maximum girth while Gl 1 (45.67 cm) and PB 5/51 (43.58 cm) showed minimum growth. On the other hand, in the 1986 clone trial, RRIC 105 (54.68 cm), PB 311 (49.02 cm) and RRII 208 (48.81 cm) showed maximum girth and the minimum girth was recorded in clones RRII 5 (40.22 cm) and PCK 1 (37.85 cm).

1.2 Performance of polyclonal seedlings

The polyclonal seedlings were planted during 1990 to evaluate their performance in comparison to other high yielding clones. It has been observed that these seedlings have attained an average girth of 12.58 cm. Generally, growth of these seedlings are satisfactory.

1.3 Rubber based cropping system

The growth performance of rubber (RRIM 600) and tea were better than orange under this trial. The yield of green tea leaves was encouraging and during the year 509 kg of green tea leaves were harvested.

1.4 Block plantation

RRIM 600 has been planted in two different hillocks as a block plantation. These plants have attained an averge girth of 40.85 cm.

2. Field experiments at Darechkgre

2.1 Multidisciplinary evaluation of clones

Due to high elevation, all clones pla-nted in this trial were adversely affected and only 45 plants are suriving. These plants show retarded growth.

2.2 Intercropping with perennial crops

Under this trial only tea and orange are surviving. During the year orange plants were damaged by elephants while the growth of tea is good. Rubber did not grow at this elevation (1100 MSL).

3. Experiments in plant pathology

3.1 Plant diseases

No serious outbreak of any rubber disease was recorded during the period, except incidence of *Oidium heveae* during 1994. The disease was controlled to a considerable extent by dusting sulphur in time.

3.2 Mushroom culture

Pure culture of mushroom of the species *Pleurotus flabellatus, P. sajor caju* and *P. ostreatus* were maintained. The spawn of edible mushrooms were prepared and distributed.

3.3 Microbiological studies

The fungi isolated from forest soils included *Pencillium* spp., *Cephalosporium coremioides, Cladosporium harbarum, Aspergillus* spp. and yeasts. There was quantitative variation in the strate between the soils from different forests.

3.4 Litter decomposition

This study showed that under natural conditions the rubber leaf litter decomposes quite readily and the plant remains after 7 months was found to be only 20.3 per cent. The soil microflora, which accelerates decomposition, were isolated.

4. Research programmes in plant physiology

4.1 Effect of wintering

The minimum temperature during the winter period was 4.5°C. All the clones included in the trial showed negligible girth increment during winter due to adverse effect of low temperature. All the clones defoliated in January/February and refoliated in March.

4.2 Effect of different aspects of slope

The plants (RRIM 600) growing on lower side of West - South West aspect of slope has attained 44.61 cm girth while on North East aspect it was only 40.76 cm. Plants grown on the upper side of slope showed 39.39 cm and 38.66 cm girth respectively. Soil moisture content was also higher in SSW slope than in the latter.

4.3 Bud sprouting in polyhouse

To find out the sprouting percentage of budded stumps in polybags inside and outside the polyhouse during winter season at 600 m elevation, an experiment has been laid out and 100 nos of budded stumps of RRIM 600 has been planted in each month during Nov., Dec., Jan and Feb. months in and outside the polyhouse. Plants kept inside the polyhouse always showed more than 50 per cent sprouting while those outside showed less than 15 per cent sprouting during winter period. The growth of plants were also better inside the polyhouse.

4.4 Physiological evaluation of clones

Clonal variation in girth increment during different seasons among the ten clones of *Hevea* has been observed. All the clones showed higher girth increment during rainy season than during dry and winter season. PB 235 showed higher girthing during all seasons followed by RRIM 600 and RRII 203. Girthing was less in PB 5/51, Gl 1 and GT 1 in all the seasons. A negative correlation was observed between girth and stomatal conductance and also between girth and transpiration rate in 10 clones of *Hevea* while a positive correlation

existed between girth and leaf temperature of these clones.

4.5 Evaluation of yield

The study was started in November 1994 using the trees in the 1985 clone trial to find out the yield variation among the clones under high elevation condition in West Garo Hills of Meghalaya. Only three clones (RRIM 600, PB 235 and RRII 203) have attained tappable girth. Tapping was started on 1/2s d/2 system. Higher DRC and plugging index were observed in the clone PB 235.

5. Experiments in agronomy

5.1 Intercropping

The average girth of the clone RRII105, intercropped with cover crops, banana and pineapple, has attained 35.6 cm 30.6 cm and 28.9 cm respectively. During the year, a total of 2589 nos. of pineapple fruits and 124 bunches of banana were harvested. Although, cyclones affected bananas the rubber trees were not damaged in intercropped area. Rabbit rearing as an alternate source of income during the immature phase of rubber by feeding them with only Pueraia cover crop was not quite successful.

5.2 Weed control

To control the noxious weed, *Imperata cylindrica* in the rubber plantations, chemical weedicides glyphosate and paraquet (Gramaxone) were tried at different concentrations. The preliminary results indicated that use of glyphosate was more effective as comapred to paraquet.

REGIONAL RESEARCH STATION, KOLASIB, MIZORAM

This trial was started in the year 1985 with 10 clones. The average girth of the different clones are presented in Table - Nez.1

Table-Nez. 1. **Growth of different clones**

Clones	Mean girth (cm)
RRII 105	53.30
RRII 118	62.33
RRII 203	58.84
RRIM 600	61.86
RRIM 605	59.20
PB 86	48.00
PB 235	63.53
PB 5/51	54.40
Gl 1	52.25
GT 1	54.98

The clones PB 235, RRII 118 and RRIM 600 recorded higher girth. The trees will be opened for tapping during next year.

2. Polyclonal seed garden

A polyclonal seed garden was established in 1988-89 with seven different clones namely RRII 105, RRII 118,SCATC 93-114, RRIM 600, RRII 300, GT 1 and PB 235. The clone SCATC 93-114 recorded the highest girth of (45.72, 44.63 and 44.88 cm) at the foot hill, Mid hill and Hill top respectively.

3. Influence of physiographic features on growth

The trial was started in1987 to study the influence of physiographic features on growth of *Hevea* with RRII 105. It has been observed that the rubber plants in the eastern slopes have the highest absolute girth (Table -Nez.2).

Table-Nez.2 **Effect of aspect of slope on girth**

Aspect	Girth (cm)
North	25.80
South	28.91
East	31.04
West	30.04

4. Weed management

It was observed that glyphosate (5 l/ha) followed by Gramaxone (4.5 1/ha) at 50 per cent weed regeneration as blanket/spot application was the most economic schedule and was superior to manual weed control.

5. Nutritional trial

This trial was started in 1992 in RBD design with six treatments and four replications using clone. It was observed that treatment with NPK in two splits gave the highest absolute girth, plant height and branching height followed by the treatment 50:50:25 in two splits.

6. Establishment of cover crop

It has been observed in this trial that treatment with sowing cover crop in patches showed the highest number of nodules per plant and covered maximum area. However, the highest girth and plant height for rubber was noticed in treatment where cover crop was sown in single strip.

7. Studies on low input agrotechnology

Of the three on – farm trials initiated during 1994 two were abandoned due to non-cooperation of farmers. In the third trial, a total 943 polyclonal stumps were planted of which 694 plants survived. The effect of time of planting and size of polybags and planting pits will be evaluated in this trial.

REGIONAL RESEARCH STATION, NAGRAKATTA, WEST BENGAL

At Regional Research Station Nagrakatta, West Bengal, different trials are in progress to study the nutritional requirement of *Hevea* and identify the best fertilizer application schedule, evaluation of clones, performance of different clone blends and exploitation systems. The station has a small area under nursery.

1. Nutritional studies

In the trial initiated in 1989 among different levels of nitrogen, significantly higher girth (41.1 cm) was recorded at 60 kg N per ha which is on par with 40 and 20 kg. N per ha (Table-Neb. 1). Similarly application of 40 kg K_2O per ha recorded signficantly higher girth. Phosphorus application did not significantly favour girth increment. Nutrient interaction effect was found to be non-significant. Average annual girth increment (Dec. '93 to Dec. '94) due to fertilizer application ranges between 7.6 cm to 8.3 cm.

To study the nutrient use efficiency of rubber in Dooars, an experiment was laid out in RBD with 4 replications in 1993 with five different schedules of fertilizer application to identify the fertilizer application schedule for maximum nutrient use efficiency and growth. The annual increment in girth was higher in three split applications

Table-Neb. 1. **Effect of different levels of N,P,K. on girth**

Treatment	Girth (cm)	Girth increment (cm)
No	38.8	8.2
N20	40.2	8.0
N40	40.5	7.6
N60	41.1	7.9
SEM +	0.67	
CD (P = 0.05)	1.31	
PO	39.9	7.8
P20	40.1	7.9
P40	40.4	8.0
SEM +	0.58	
CD (P = 0.05)	NS	
K0	39.4	7.7
K20	40.2	7.8
K40	40.9	8.3
SEM +	0.58	
CD (P = 0.05)	1.13	Interaction : NS

(33.3% each) of fertilizer whereas increment in height was more in two split applications (50% each).

2. Multidisciplinary evaluation of clones

2.1 Clone trial (1990)

In one trial significantly higher girth was recorded for clone RRII 118 (37.0 cm) which was on par with clones RRII 203, RRII 300 and PB 311. In the other clone trial no significant difference in girth was observed among different clones.

2.2 Clone trial (1991)

Maximum girth was recorded in RRIC 102 (20.9 cm) PB 310 (20.8 cm) and RRIM 600 (20.8 cm). Girth increment per year was 6.0 to 8.7 cm in the different clones in this trial.

2.3 Clone trial (1993)

In the experiment laid out at Dooars during 1993 maximum girth was recorded in RRIM 600 (9.4 cm) followed by RRII 105 (8.8 cm). In the case of height, maximum was recorded in RRIM 600 (321.1 cm) followed by RRII 105 (281.5 cm).

3. Exploitation system

The trial with clone RRIM 600, laid out in the year 1991 aims at identification of the best system of exploitation under local condtions. The plants are maintained well in the trial.

4. Clone blend

This trial was laid out in 1992-93 to study the performance of different clone blends in comparison to monoclonal population of RRII 105. Planting in the trial has been completed.

5. Block planting

The three clones viz. RRII 105, RRIM 600 and RRII 300 planted as block planting in the year 1993 to study their performance in West Bengal are being maintained.

REGIONAL RESEARCH STATION, DAPCHARI, MAHARASHTRA

The Regional Research Station, Dapchari, Maharashtra, concentrated research activities on irrigation, plant physiology, clone evaluation and related fields.

1. Irrigation systems

Irrigation experiment in clone RRII 105 was continued. Plants with basin irrigation treatment recorded compartively higher girth than plants with drip irrigation (Table - Dap.1). The control plants showed

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

Treatments	Mean grith (cm)	Girth increment (cm)
	March 1995	April 94 - Mar. 95
T1 control (No irrigation)	39.15	3.49
T2 1.00 ETc, Basin	52.55	3.00
T3 0.75 ETc, Basin	52.34	2.61
T4 0.50 ETc, Basin	50.15	3.46
T5 0.75 ETc, Drip	49.34	3.41
T6 0.50 ETc, Drip	49.78	4.77
T7 0.25 ETc, Drip	46.50	3.96
SE +	1.57	0.53
CD (P=0.05)	2.42	1.15

significantly less growth compared to that of all irrigation treatments. Plants under 1.00, 0.75 and 0.5 ETc levels of irrigation treatments were opened for tapping May 1994 whereas those under 0.25 ETc and control plots have not attained tappable girth. This revealed that irrigation reduced the immaturity period. The mean annual girth increment was found to be lower in tappable plants of irrigation treatment than the control (unirrigated and immature) which indicated that exploiation had profound impact on growth of plants.

2. Effect of irrigation on yield and yield components

Hose irrigation treatment was continued in which both RRII 105 and RRII 118 clones were treated with three levels viz., 1.00, 0.75 and 0.50 ETc. Among the two clones, RRII 118 was found to be vigorous and its growth response to irrigation was also better than RRII 105 (Table-Dap.2). However, when the yield potential was compared, RRII 105 recorded high performance in all irrigation tretatments.

Table - Dap.2 **Effect of irrigation on growth and yield**

Treatments	Mean girth (cm)		Mean dry rubber yield (g/tree/tap)	
	March 1995			
	RRII 105	RRII 118	RRII 105	RRII 118
T0 Control	46.03	49.70	29.00	23.15
T1 (1.00 ETc)	55.08	61.81	42.67	30.30
T2 (0.75 ETc)	53.66	64.12	37.15	32.08
T3 (0.50 ETc)	52.87	54.82	39.50	24.04
SE±	4.13	4.13	SE±	3.97
CD (P=0.05)	10.11CD (P=0.05)		9.71	
SE±	*	1.27	SE±	1.20
CD (P=0.05)**	2.93CD (P=0.05)		2.77	

*for irrigation treatment ** for clones

REGIONAL RESEARCH STATION, DHENKANAL, ORISSA

The Regional Research Station at Dhenkanal, Orissa continued investigations on agromanagement techniques and clone evaluation for the drought prone areas in Central Orissa.

1. Experimental planting

In this clone trial planted in 1987 maximum girth was recorded in clone RRIM 600. Clone RRII 105 showed the lowest girth among the three clones (Table Ori. 1).

Table - Ori. 1. **Mean girth of three clones**

Clone	Girth (cm)
RRII 105	32.1
RRIM 600	35.9
GT 1	34.4

2. Polyclonal seedlings

Monitoring of growth was continued in polyclonal plants. The growth of polyclonal plants were satisfactory.

3. Clone evaluation (1990)

Observations on growth were recorded in 10 clones. Clone RRIM 600 and SCATC 93/114 continued to record higher girth (Table - Ori. 2)

Table-Ori. 2. **Growth of 10 clones**

Clone	Girth (cm)
RRIM 600	23.9
RRIM 701	20.1
RRII 300	20.3
RRII 208	22.0
RRII 5	21.6
PB 310	22.5
SCATC 88/113	20.1
SCATC 93/114	23.7
Haiken 1	21.3
PCK 1	19.6

4. Clone evaluation (1991)

Growth measurements of 9 clones and polyclonal plants were recorded. Higher girth was recorded in clone GT 1 (17.1 cm) and RRIM 600 (16.5 cm) and the lowest PCK 2 (12.8 cm).

REGIONAL RSEARCH STATION, SUKMA, MADHYA PRADESH

The Regional Research Station established at Sukma, Bastar Dist., Madhya Pradesh continued its research activities. The station has a small area under seedling, budwood and polybag nursery.

Field experiments were laid out in 1993-94. Although casualties had occurred in the initial stages the vacancies were filled.

1. Nutritional trial

This trial was laid out in RBD with 4 doses of nitrogen and 5 replications. The clone used was RRII 105. This experiment aims at finding out the optimum dose of 'N' requirement for rubber in Bastar region.

2. Influence of cultural operations and soil properties on growth

The trial was started in 1993 to study the influence of different cultural operations. The addition of farmyard manure, biofertilizer and interculturing had given uniform plant growth with no casualty in the initial stages.

REGIONAL RESEARCH STATION, PADIYOOR, KERALA

The Regional Research Station, Padiyoor was started during the year. An area of 40 ha was procured for establishing the station. A seedling nursery was set up. Location specific field trials are being programmed.

HEVEA BREEDING SUB-STATION, NETTANA, KARNATAKA

The following field trials were in progress at the Hevea Breeding Sub-station located at Nettana, D. K. district of Karnataka State.

1. Trial on growth, yield and exploitation systems

The two field trials with five clones each, established during 1987 and another in 1988, were maintained. In the 1987 trial mean girth varied from 49.45 cm (PB 235) to 40.61 cm (RRII 300) with a general mean of 45.00 cm. In the 1988 trial, mean girth varied from 41.23 cm (RRII 118) to 32.59 cm (RRIC 36) and the general mean was 35.71 cm.

2. Evaluation of ortet clones

Quarterly girth measurements were taken from the trial. Two rounds of yield recordings were carried out and data on yield components were taken.

Table-Kar. 1. **Variation in girth of ortet clones**

Trial I		Trial II		Trial III	
Clone	Girth (cm)	Clone	Girth (cm)	Clone	Girth (cm)
034	29.81			039A	28.51
050	23.10	C 3/10	16.85	C152	21.92
047	26.53	014	22.66	055	28.54
015	23.71	016	23.48	C140	29.80
T2	26.71	038	24.66	026	24.55
043	22.60	040	25.67	056	25.28
C1/2	27.57	C151	26.51	064	24.50
041	28.91	C9	17.16	011	22.58
017	30.03	054	27.20	C32	23.67
019	18.06	037	23.83	049	23.82
045	25.88	053	23.69	030	25.39
C 7/2	23.52	T1	29.14	C6	21.37
C 42	31.23	023	23.58	C 10/9	23.90
044	24.55	022	21.22	051	24.43
046	24.44	C 150	27.03	GT 1	26.30
012	20.70	PO	26.05	RRIM 6000	22.19
C 70	24.63	057	20.10	RRII 105	25.34
GT 1	27.00	GT 1	26.07		
RRIM 600	21.77	RRIM 600	22.28		
RRII 105	25.29	RRII 105	24.06		
General mean	25.30		23.84		24.83
Variance ratio	4.56*		4.54*		1.79*

*Significant at P = 0.05

Data on girth and plant height of 48 ortet clones planted in three trials in randomised block design with 3 replications and clones RRII 105, RRIM 600 and GT 1, as controls, were statistically analysed. The height of the 5 year old plants did not show significant variation, but clonal variation was evident for girth (Table - Kar 1). Seventeen clones showed greater girth than the vigorous control GT 1.

3. Clone trials

Three clone trials were maintained with excellent establishment of cover crops (*Pueraria* and *Mucuna*). In the 1989 mixed clone trial, quarterly girth measurements were recorded. Of the 14 clones in the trial, RRII 203 recorded the highest girth (38.93 cm) while Haiken I recorded the lowest girth (25.19 cm). One round of test tap yield was collected.

In the 1990 trial quarterly girth measurements were recorded. The 1991 clonal trial was also maintained properly with minimum casualties. Quarterly recording of girth was made in this trial also.

4. Estimation of genetic parameters

The trial was properly maintained. Three rounds of girth recording and one round of test tap yield were recorded from this trial.

5. Polyclonal garden

For establishing a polyclonal garden using 9 component clones, 4750 budgrafted plants were raised in polybags and maintained. Planting materials for a block trial was also raised.

6. On-farm trials

One trial established in a private holding with 6 clones were maintained. Annual girth recording was done.

For laying out a collaborative block trial at the Sullia Rubber Division of the Karnataka Forest Development Corporation., ten modern clones were raised in polybags and maintained at the planting site.

7. General

During 1994, the station received a total rainfall of 5484.1 mm with the highest rainfall during the month of July (1799.5 mm) and August (1190.6 mm). The maximum temperature recorded was 40°C in March and minimum during January with 8.8°C.

HEVEA BREEDING SUB-STATION, PARALIAR, TAMILNADU

Hevea Breeding Sub-Station, Kanyakumari concentrated on hybridisation work.

1. Breeding orchards

The breeding orchards established in 1987 and 1988 were maintained well. Wintering pattern and floral biology of all the clones of Breeding Orchard I (26 clones) were studied and characterisation of floral biology of clones of Breeding Orchard II (25 clones) is in progress.

2. Hand pollination

A total of 6906 hand pollinations were attempted. The parents used included Tjir 1, PB 260, RRIM 703, RRIM 701, RRII 5, PB 260, PB 311, GI 1 and PCK 1.

3. Stability analysis of clones

The trial was maintained well and observations were recorded on growth parameters such as girth, height, no of whorls

of leaves, canopy height and breadth and angle of branching.

4. Evaluation of root stocks for tolerance to stress

A nursery was raised with seeds collected from polyclonal seed gardens, ordinary out-crossed seedling trees and monoclonal seeds of different clones for evaluation under artificially created soil moisture stress and high water table.

5. Ortet selection

Potential mother trees have been selected from rubber holdings with polyclonal seedling population and are under conservation. A nursery was raised with polyclonal seeds and the seedlings are being evaluated.

6. On-farm trials

Three on-farm trials were initiated at Keeriparai Division of Arasu Rubber Corporation. Eighteen modern clones are being evaluated under the agro-climatic conditions of Kanyakumari region.

7. General

A field laboratory has been established adjacent to the office at Thadikarankonam for conducting studies on floral biology and Cytogenetics of *Hevea* clones. Agro-meteorological observatory was maintained and observations were recorded. The station receives a total rainfall of 2407 mm. The lowest monthly mean minimum temperature of 21.57°C was recorded during the month of December, 1994 and the highest mean maximum temperature of 36.05°C was recorded during the month of March 1995.

AGROMETEOROLOGY UNIT

1. Weather at various stations

The general weather conditions during 1994 at RRII and seven of the associated observatories are summarised in Table - Agromet. 1. The highest amount of rainfall was received in Nettana (5484 mm) and the lowest at Agartala. In Dapchari, maximum rainfall was concentrated during South-West monsoon contributing 99 per cent of the annual. The highest mean maximum temperature of 37.3°C was recorded at Dapchari during the month of April. The highest mean minimum of 26.4°C was observed in April at Nettana against the lowest minimum of 10.7°C in January at Agartala.

2. Agroclimatic aspects of rubber cultivation

Two automatic weather stations were installed at RRII, one inside the immature rubber plantation and the other in the observatory. Weather parameters sampled include temperature, relative humidity, wind speed, direction, radiation, surface wetness and rainfall. Steps have been initiated to develop suitable softwares to process the data generated by the automatic weather station.

On preliminary analysis, it was observed that there exists a temperature difference of 0.1°C - 0.5°C between the canopy and that of the observatory. As expected,

Table - Agromet 1. **Weather at research stations in traditional and non-traditional areas (1994)**

Station	January	February	March	April	May	June	July	August	September	October	November	December
Rainfall, mm												
Agartala	16.4	48.4	245.6	148.6	203.2	142.6	172.5	207.0	127.5	101.2	27.2	*
Dapchari	11.0	0.0	0.0	0.0	0.0	1263.6	1214.1	950.7	291.9	7.6	18.8	0.0
Kottayam	35.6	97.2	60.1	262.0	252.3	622.8	646.9	564.2	203.7	477.9	116.0	1.6
Nettana	46.6	0.0	9.4	251.4	95.5	1171.8	1819.5	1190.9	358.4	524.3	16.3	0.0
Maximum temperature, °C												
Agartala	26.4	26.1	33.5	32.9	34.8	32.2	32.3	32.9	32.8	32.2	29.7	*
Dapchari	30.7	31.1	37.1	37.3	36.7	30.7	28.2	27.2	28.9	33.7	32.8	31.2
Kottayam	32.9	32.8	33.0	32.7	32.1	29.2	28.3	29.2	30.5	30.0	30.9	32.8
Nettana	32.8	32.4	35.8	34.3	33.6	25.6	24.2	27.0	28.8	30.8	31.9	32.7
Minimum temperature, °C												
Agartala	10.7	12.6	20.6	22.4	24.4	25.8	25.5	25.2	24.9	22.0	17.7	*
Dapchari	15.6	14.7	18.8	22.8	25.7	25.4	24.7	24.5	22.8	21.3	18.5	13.9
Kottayam	21.6	23.6	23.5	23.8	24.6	23.2	22.6	22.7	23.2	22.4	22.8	21.7
Nettana	16.4	17.0	19.5	26.4	22.9	21.5	20.8	20.9	21.4	21.3	19.8	14.7
Relative humidity, %												
Agartala	73	73	74	71	75	82	79	81	81	78	74	*
Dapchari	59	55	48	55	60	78	87	86	79	70	61	56
Kottayam	71	75	73	79	80	90	90	87	82	86	78	67
Nettana	74	76	67	76	74	88	93	89	83	85	70	67

* Data not available

temperature always remained low inside the canopy but the difference was only marginal. Relative humidity was found more (1-4%) inside the canopy at all hours of the day except from 11.00 to 18.00 hours. This is probably because of the small scale advection from the irrigated areas surrounding the observatory.

3. Crop weather relations

A field trial was conducted at CES, Chethackal to study the influence of weather components which favour the incidence and spread of powdery mildew disease of rubber.

A preliminary study was conducted to observe the influence of weather on the soil moisture status and its influence on summer defoliation of *Hevea*.

LIBRARY AND DOCUMENTATION CENTRE

The documentation centre continued its important role of communication and disseminating information on natural rubber through its library, information services and publications.

During the year 1994-'95, 173 books were added to the library making the total collection 20838. Three hundred books were donated by Mrs. K G Unnithan in memory of her husband, late Mr. K.G. Unnithan, General Manager and Technologist, Trivandrum Rubber Works. The library subscribed to 155 journals and 8 dailies. Ninety eight journals were received either as gift or exchange.

The library provided documentation service to the scientists and other research workers. Three issues of *Documentation List*, 5 numbers of *Rubber Alert*, 135 issues of *SDI bulletin* and 2 issues of *List of New Additions* were compiled and distributed. As part of information dissemination, 95 scientific articles were sent to different institutions / scientists. Around 1.5 lakh photocopies of information materials were made by the reprographic section. During the current year, 11,600 documents were indexed.

A bibliography listing 546 selected scientific and technical contributions from Rubber Research Institute of India and the Rubber Board was published under the title *"Natural Rubber - Bibliography* (Volume 2). The list of holdings of 437 scientific serials were updated for incorporation in the revised edition of *National Union Catalogue of Scientific serials in India Rewan to be published by* Indian National Scientific Documentation Centre, New Delhi.

The library actively participated in the sales promotion of *Indian Journal of Natural Rubber Research* and the books *Rubber Wood* and *Plant and soil Analysis*. The library also distributed the *Annual Report of RRII*.

The library facilities were also extended to planters, manufacturers and others connected with natural rubber industry. Research scholars and students from universities and colleges also utilised these services.

ANNUAL EXPENDITURE

Expenditure at a glance (Rs. in lakhs) 1994-'95

Head of Account	Expenditure
Non Plan	
General charges	214.05
Schemes	10.82
Projects-CES	72.97
Department of Training	3.50
Total Non Plan	**301.34**
Plan	
General charges	41.00
Schemes	115.16
NERDS Research Component	62.18
Total Plan	**218.34**
World Bank Project	
Schemes	45.68
GRAND TOTAL	**565.36**

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SCIENTIFIC AND SENIOR SUPPORTING PERSONNEL

Director of Research

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

Joint Director (Research)

K. Jayarathnam M.Sc(Ag.) Ph.D

Agronomy and Soils Division

M Mathew, M.Sc. (Ag.) (retired on 31-1-95)	Deputy Director
K I Punnoose, M.Sc. (Ag.), Ph.D. (from 17.3.95)	Deputy Director
M Karthikakutty Amma M.Sc. (Ag.)(from 17-3-95)	Senior Scientist (AC)
A N Sasidharan Nair, M.Sc.	Soil Chemist
Elsie S George, M.Sc.	Soil Chemist
Mercykutty Joseph, M.Sc. (Ag.), Ph.D	Assistant Soil Chemist
Varghese Philip M.Sc. (Ag.) (from 4-4-95)	Scientist S2
P R Suresh, M.Sc. (Ag.), Ph.D.	Scientist S2
V K Syamala, M.Sc.	Junior Scientist
Joshua Abraham, M.Sc.	Junior Scientist
Annie Philip, M.Sc.	Junior Scientist
DVK Nageswara Rao, M.Sc. (Ag.)	Junior Scientist
K. Pratapan, M.Sc (Ag.)	Junior Scientist
Sherin George, M.Sc. (Ag.)	Junior Scientist
Sarah Jacob, M.Sc. (Ag.) (on leave)	Junior Scientist
M D Jessy, M.Sc. (Ag.)	Junior Scientist
P. Prasannakumari M.Sc. Ph.D.	Junior Scientist
Aleyamma Augusthy, B.Sc., Dip. N.R.P.	Assitant Technical Officer
C K Chacko, B.Sc	Senior Scientific Assistant
M J Thomas, B.Sc.	Senior Scientific Assistant

Molly Pothen, B.Sc.	Senior Scientific Assistant
K S Krishnakumari, B.Sc.	Senior Scientific Assistant
P S Kuttappan	Assistant Farm Superintendent

Biotechnology Division

M P Asokan, M.Sc., Ph.D.	Deputy Director
S Sushamakumari, M.Sc., Ph.D.	Scientist
P Kumari Jayasree, M.Sc.	Research Associate (DBT)
R Krishnakumar, M.Sc., Ph.D.	Assistant Biochemist
R G Kala, M.Sc.	Junior Scientist
V Kala, M.Sc.	Junior Scientist
R Jayasree, M.Sc.	Junior Scientist
E G Baburaj, M.Sc., L.L.B	Junior Research Fellow (DBT)

Botany Division

C K Saraswathyamma, M.Sc., Ph.D.	Deputy Director
D Premakumari, M.Sc. Ph.D. (from 17-3-95)	Senior Scientist (CE)
Joseph G Marattukalam, M.Sc.	Botanist
Y Annamma Varghese, M.Sc., Dr. Sc. (Ag.)	Botanist
J Licy, M.Sc.	Plant Breeder
Kavitha K Mydin, M.Sc. (Ag.), Ph.D.	Scientist S2
Rajeswari Meenatoor, M.Sc. (Ag.)	Scientist S2
V C Mercykutty, M.Sc., Ph.D.	Scientist S2
L Sankarimmal, M.Sc., Ph.D.	Assistant Cytogeneticist
Alice John, M.Sc. (Ag.)	Junior Scientist
Vinoth Thomas, M.Sc., Ph.D.	Junior Scientist
M D Isaac	Assistant Farm Superintendent
V. Vijayan (From 30-1-94)	Assistant Farm Superintendent

Germplasm Division

P J George, M.Sc., Ph.D.	Deputy Director
C P Reghu, M.Sc., Ph.D.	Botanist
G Prabhakara Rao, M.Sc. (Ag.)	Botanist

Jayasree Madhavan, M.Sc. (Ag.)	Junior Scientist
Saji T Abraham, M.Sc. (Ag.)	Junior Scientist
M A Mercy, M.Sc. (Ag.)	Junior Scientist
K P Leelamma, B.Sc., Dip. N.R.P.	Assistant Technical Officer

Mycology and Plant Pathology Division

R Kothandaraman, M.Sc. (Ag.), Ph.D	Deputy Director
V K Rajalakshmi, M.Sc.	Mycologist
Thomson T Edathil, M.Sc.	Plant Pathologist
C R Nehru, M.Sc., Ph.D.	Entomologist
L Thankamma, M.Sc.	Mycologist
S Thankamony, M.Sc.	Entomologist
C Kuruvilla Jacob, M.Sc.(Ag.), Ph.D.	Plant Pathologist
Sabu P Idicula, M.Sc. (Ag.)	Scientist S3
Jacob Mathew, M.Sc. Ph.D.	Scientist S3
Annakutty Joseph, M.Sc.	Scientist S3
Kochuthresiamma Joseph, M.Sc.	Scientist S3
V T Jose, M.Sc. (Ag.), Ph.D.	Assistant Entomologist
T Sailaja Devi, M.Sc.	Assistant Agromete orologist
S Vanitha, M.Sc. (Ag.) (Resigned on 3-2-95)	Junior Scientist
M Jayadevi, B.Sc., Dip.N.R.P.	Assistant Technical Officer
P M Levi Joseph, B.Sc., Dip.N.R.P.	Assistant Technical Officer
T V Kurian	Assistant Farm Superintendent

Plant Physiology and Exploitation Division

K R Vijayakumar, M.Sc. (Ag.), Ph.D.	Deputy Director
S Sulochanamma, M.Sc. (upto 16-3-95)	Plant Physiologist
N Usha Nair, M.Sc. (Ag.), Ph.D. (from 17-3-95)	Senior Scientist (BC)
P Sobhana, M.Sc.	Plant Physiologist
Sushilkumar Dey, M.Sc., Ph.D.	Environmental Physiologist
Molly Thomas, M.Sc., Ph.D.	Scientist S3
K U Thomas, M.Sc., Ph.D.	Assistant Plant Physiologist

R Rajagopal, M.Sc.,M.Phil., Ph.D., Dip. Stats.	Scientist S2
D Bhuvanendran Nair, M.Sc., Ph.D.	Scientist S2
S Sreelatha, M.Sc.	Scientist S2
A S Devakumar, M.Sc. (Ag.)	Scientist S2
M B Mohammed Sathik, M.Sc., M. Phil.	Junior Scientist
S Visalakshy Ammal, B.Sc.	Senior Scientific Assistant
K Soman	Assistant Farm Superintendent
S Geroge	Assistant Farm Superintendent

Rubber Chemistry, Physics and Technology Division

N M Mathew, M.Sc. L.P.R.I., Ph.D.	Deputy Director
Baby Kuriakose, M.Sc., L.P.R.I., Ph.D. PGDPM	.Deputy Director
N M Claramma, M.Sc.	Rubber Chemist
K T Thomas, M.Sc., L.P.R.I., M. Tech.	Rubber Technologist
N Radhakrishnan Nair, M.Sc., M. Tech.	Scientist S3
Jacob K Varkey, M.Sc., M. Tech	Scientist S2
Benny George, M.Sc.	Scientist S2
Leelamma Varghese, M.Sc.	Scientist S2
Siby Varghese, M.Sc, Ph.D.	Junior Scientist
K N Madhusoodanan, M.Sc.	Junior Scientist
C K Premalatha, B.Sc., L. P. R. I., Dip. N.R. P.	Assistant Technical Officer

Agricultural Economics Division

K Tharian George, M.A., Ph.D.	Deputy Director
P Rajasekharan, M.Sc. (Ag.) (On study leave)	Economist
Toms Joseph, M.A.	Economist
Binny Chandy, M.A.	Junior Scientist
S Mohankumar, M.A., M. Phil.	Junior Scientist
S Lakshmi, M Sc (Ag.)	Junior Scientist
P K Viswanathan, M A	Junior Scientist

Central Experimental Station, Chethackal, Kerala

M J George, M.Sc.	Deputy Director
Jacob Abraham, B.Sc., M.B.B.S.	Medical Officer

T R Chandresekhar, M.Sc., M. Tech.	Botanist
Zacharia Kurian, M.Com., A.C.A.	Assistant Accounts Officer
D Rajasekharan	Section Officer
P J Samuel B.A. (till 29-4-94)	Assistant Section Officer
P J Joseph	Assistant Estate Superintendent
R Raveendran	Assistant Estate Superintendent
N Bhargavan	Assistant Farm Superintendent
Annamma Andrews	Nurse (Higher Grade)

Experiment Station at RRII

N Reghunathan Nair, B.Sc. (Ag.)	Senior Superintendent
K I Thomas (from 7-9-95)	Assistant Farm Superintendent

Regional Research Station, Padiyoor, Kerala

Radha Lakshmanan MSc.(Ag.), Ph.D	Agronomist
Mathew Joseph	Junior Scientist

Regional Research Station, Guwahati, Assam

Radha Raman Sinha, M.Sc. (Ag.), Ph.D. (upto 16-8-94)	Deputy Director
Dhurjeti Chaudhuri, MSc. (Ag.)	Deputy Director
Gopal Chandra Mondal, M.Sc., Ph.D.	Plant Pathologist
Krishna Das, M.Sc., Ph.D.	Scientist S2
A.K. Hazarika	Assistant Accounts Officer
K.T. Joseph	Assistant Section Officer

Regional Research Station, Agartala, Tripura

Jacob Pothen, M.Sc. (Ag.)	Depu ty Director
P Mallinath Priyadarshan, M.Sc., Ph.D.	Plant Breeder
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Thomas Eappen M.Sc.	Assistant Agrometeorlogist
Mary Varghese, M.Sc. (Ag.)	Junior Scientist
K K Vinod, M.Sc. (Ag.)	Junior Scientist
Debasis Mandal	Junior Scientist
Gitali Das M.Sc. Ph.D.	Junior Scientist
Dilipkumar Daimari, M. Com.	Accounts Officer

V S Govindhankutty	Assistant Farm Superientendent
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A P Thapliyal, M.Sc., Ph.D	Plant Physiologist
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Ram Phool Singh, M.Sc. (Ag.), Ph.D.	Scientist S2
Regional Research Station, Nagrakatta, West Bengal	
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T T Varghese	Assistant Farm Superintendent
Anil P	Junior Engineer
Regional Research Station, Dapchari, Maharashtra	
K. Annamalai Nathan M.Sc., M.Phil. Ph.D.	Plant physiologist
Guwai Prakash Pandharinath MSc. (Agl)	Junior Scientist
T M George	Assistant Section Officer
M D Chacko	Assistant Farm Superintendent
Regional Research Station, Dhenkanal, Orissa	
Arun K Nair, M.Sc. (Ag.), Ph.D.	Agronomist
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C P Mary, B.Sc.	Senior Scientific Assistant

Regional Soil Testing Laboratory, Calicut, Kerala

Joyce Cyriac, M.Sc.	Junior Scientist

Statistics Section

G Subbarayalu, M.Sc.	Statistician
M J Lizy MSc. (Ag.) (upto 29-3-95)	Statistical Inspector
Ramesh B. Nair, M. Sc. (from 27-3-95)	Assistant statistician

Library and Documentation Centre

Mercy Jose, B.Sc. M.L.I.Sc.	Documentation
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

T K Somanantha Pillai	Assistant Estate Officer
K T Davis	Engineering Supervisor

Administration Section

R Soman, M. A. (from 11-1-95)	Deputy Secretary
P C Joseph (from 1-2-95)	Assistant Secretary
V C Achuthan	Administrative Officer
E K Thankamma (upto 10-5-94)	Section Officer
V Mary Philipose, B.Sc.	Assistant Section Officer
S. Thulasibaiamma (upto 2-5-95)	Assistant Section Officer

Accounts Section

V Alexander John, M.Com., M.A., L.L.B.	Deputy Director (Finance)
K C Thomas (from 16-1-95)	Assistant Director (Finance)
R Harikrishnan, B.Sc., A.C.A. (upto 30-1-95)	Assistant Accounts Officer
T Thanka (upto 11-5-94)	Administrative Officer
Annamma Kurian	Assistant Section Officer

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Karnataka

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Research divisions and functions

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 characteristics related to yield, physiology of latex flow and yield stimulation. The Rubber Chemistry, Physics and Technology Division concentrates on improvement in primary processing of rubber, its chemical modification, rubber product manufacture and quality control of processed rubber. The Agricultural Economics Division undertakes studies on economic aspects related to rubber plantations.

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

Central Experiment Station

The 225 ha Central Experiment Station at chethackal (Ranni), 50 km away from Kottayam, was started in 1966. Field trials laid out by the research divisions cover almost the entire area.

Regional Research Stations

The RRII has established a Regional Research Complex for North East India with headquarters at Guwahati, having regional research stations at Agartala in 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) , Nettana (Karnataka) and Padiyoor (Kerala).

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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