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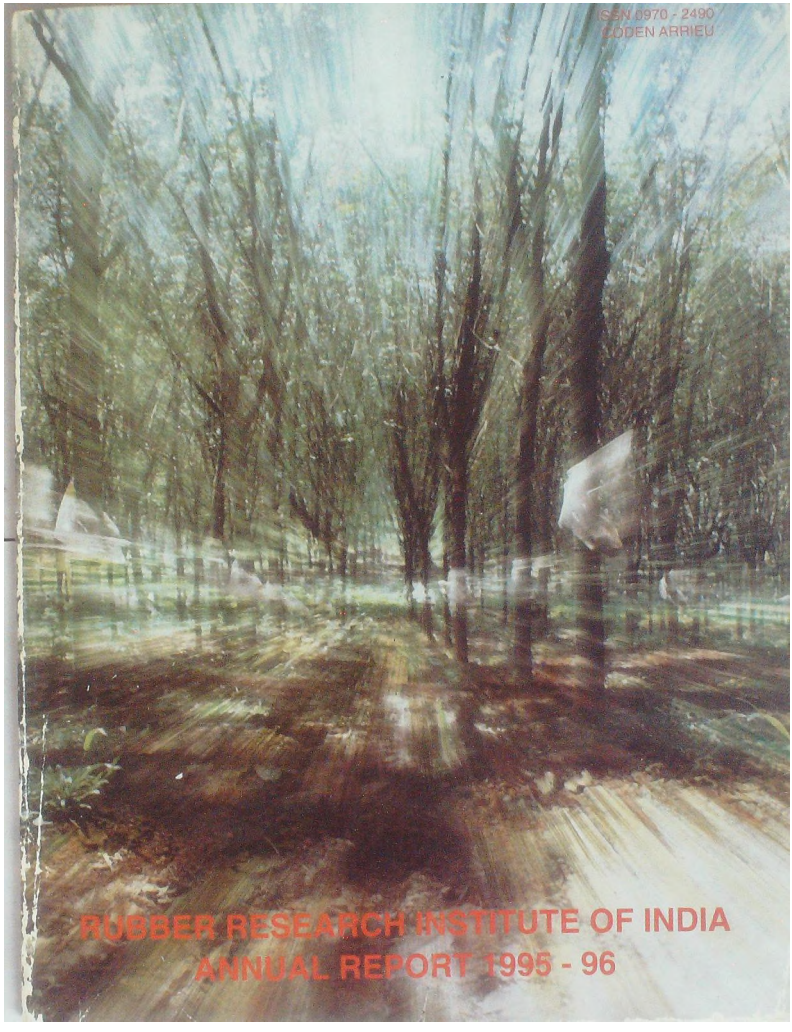

RUBBER RESEARCH INSTITUTE OF INDIA
ANNUAL REPORT 1995 - 96

Rubber Research Institute of India

Annual Report 1995-96*

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Zoomed photograph of a rubber plantation

Photograph

Mr. K. P. Sreerenganathan

December 1997

* With particulars of personnel as on 31.03.1996

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, primary processing and product development. The steady growth of the RRII in its scientific worth and research contributions has won it the recognition as an International Centre 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.

Organisation

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

Continued on inside back cover

ANNUAL REPORT
1995-96

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

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THE RUBBER BOARD

The Indian Rubber Board was constituted under the Rubber (Production and Marketing) Act, 1947 which came into force on 19th April 1947. This Act was amended first in 1954 and later in 1960. In 1982 the Act was again amended by the Rubber (Amendment) Act which is now in force.

Organisation

The Chairman is the principal executive officer and 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

Indian agriculture concentrated on increasing production and productivity in tune with the trends in global agriculture. In a period of just three decades production and productivity of agricultural and plantation crops increased considerably as a result of sustained research and extension activities. However, the deleterious aspects of modern agriculture such as excessive use of chemical fertilizers, pesticides, fungicides, weedicides, growth hormones and intensive cultivation have now been widely recognized. Production and productivity started declining after initial success. Serious problems such as salinity appeared in large areas where cultivation had to be abandoned. In other places the crops traditionally grown, could not be continued. Moreover, in the hilly tracts of India, tribal people continued their jhumming (shifting) cultivation. This did not create problems earlier as the tribal population was low. Systematic deforestation combined with increase in tribal population causes serious problems in the sustainability of forest land.

Sustainability of agriculture has recently been gaining attention of all concerned. Even though various interpretations are given to sustainable agriculture, the main concept is to maintain the productivity of land healthy for years to come. Some of the measures suggested are limiting the use of chemical fertilizers,fungicides, insecticides, pesticides and weedicides to the minimum possible extent and increased use of organic and biofertilizers, pesticides of plant origin and other similar measures.

Natural rubber is a plantation crop cultivated in large areas as a monocrop, with an economic life cycle of around 32 years. Sustainable farming should essentially be adopted in rubber plantations as well. Efforts have been under way at the Rubber Research Institute of India to formulate sustainable farming systems for rubber. Ecological sustainability of plantations as well as economic sustainability of planters, especially small holders, are given due considerations. Research projects are being reoriented towards achieving these goals.

One of the major steps towards sustainability is minimising the use of chemical fertilizers. With this aim, the Agronomy Division continued the studies on optimising fertilizer requirements for rubber in different regions. Discriminatory fertilizer recommendations were given to 12330 small holdings and 930 large holdings. Experiments have been in progress on the use of biofertilizers to replace chemical fertilizers for nitrogen and phosphorus. Intercropping of coffee with rubber did not affect the growth and yield of rubber. The cropping system model with intercrops of banana, pineapple, tuber crops, pepper, cocoa, fodder grass, cover crops with teak in the boundary, indicated that growth of rubber is not affected.

The Biotechnology Division analysed RAPD profiles of TPD tolerant and susceptible plants, derived from seed propagated trees. An extra band has been identified in the zymogram of the tolerant plants which may presumably have some influence on the TPD expression. Studies were being continued on somatic embryogenesis, shoot tip and protoplast cultures and genetic transformation.

Around 12000 hand pollinations were carried out by the Botany Division in

15 cross combinations of parents, selected based on yield components and genetic distance. A study on genetic analysis using RAPD markers was initiated. Germplasm Division continued making observations on 4539 wild genotypes for their characterisation. Based on superior performance in the initial years in preliminary evaluation trials, 81 promising genotypes were selected for large scale evaluation and trials were laid out at RRS, Padiyoor and RRS, Sukma.

Disease control studies undertaken by the Plant Pathology Division identified Trichoderma spp. to inhibit root disease pathogens. Trichoderma could be mass multiplied in rubber saw dust. The colonies of Apis cerana indica were revived after total destruction by TSBV attack. Efforts have been made to convert rubber wood saw dust into vermi compost. Deenbandhu biogas plant was found to be effective to utilize the effluent from rubber sheet processing to produce biogas. The hydrogen sulphide in the biogas could be removed successfully using calcium hydroxide pellets. Studies by the Plant Physiology Division indicated that leaf area index of rubber was 6.5 in the irrigated plots and 4.3 in rainfed plots, in a dry area of Maharashtra. The clone RRIM 600 was found to be more drought tolerant than RRII 105. Elevated CO_2 level was found to increase biomass production by 21 per cent in the nursery plants of the clone RRII 105.

The Rubber Chemistry,Physics and Technology Division evaluated the use of hydrazine hydrate and tetraethylene pentamine (TEP) for improving P_0 and PRI of rubber. Properties of blends of NR with PVC could be improved using epoxidised NR as a compatibiliser. RSS 4, ISNR 20 and EBC IX showed considerable differences in breakdown characteristics.

The Agricultural Economics Division conducted a census of planting materials used by small growers and a strong preference to RRII 105 was noticed. The annual average procurement of rubber wood by saw milling and peeling units was 2100 MT and 4260 MT respectively.

Under the World Bank Assisted Rubber Project low frequency tapping in popular clones was field tested. Under the d/4 system of tapping, RRII 105 gave an average of 1000 kg/block in 10 months. In a collaborative work with Nottingham University, UK, somatic embryos were developed using protoplast. Incorporation experiments with a reporter gene ("GUS" gene) in rubber was attempted. Evaluation of a readymade smoke house modified as solar-cum-smoke drier has shown that there is a definite reduction in firewood consumption compared to the unmodified one. Studies at RRS, Agartala indicated that yield pattern in that region for different clones decreased in the order PB 235, RRIM 600, RRII 105, RRIM 203 and RRIM 703. Various clone and fertilizer trials are being continued in the eight Regional Research Stations in the nontraditional areas. In the newly started RRS, Padiyoor, one field experiment has been laid out. At RRS, Dapchari, tapping started in the irrigated plot in the 7th year whereas in the unirrigated plot the mean girth reached was only 42 cm. The polyclonal seedling areas were also opened for tapping.

Through judicious use of ecofriendly inputs, crop improvement using both conventional and molecular tools, increasing productivity for reducing crop pressure on land and improvement in the quality of products the Institute has made a beginning towards achieving sustainability.

AGRONOMY AND SOILS DIVISION

The Agronomy and Soils Division was engaged in studies on nutritional requirements of immature and mature rubber in different agroclimatic regions of South India. The other aspects of investigation were irrigation and moisture management, soil and water conservation, intercropping and cropping systems, density of planting and weed management in rubber plantation. Investigations on forms and methods of fertilizer application were also in progress. In order to improve the interpretation of foliar analytical values, work on Diagnosis and Recommendation Integrated System (DRIS) was continued. Discriminatory fertilizer recommendations were offered to large estates.

1. Nutritional studies (immature rubber)

1.1 NPK requirement of clone RRII 105

The field experiment initiated in 1989 at Koduman Estate to assess the nutrient requirement of clone RRII 105 was continued. The treatments were combinations of nitrogen, phosphorus and potassium fertilizers. Treatments were imposed and growth measurements recorded. The data on girth (1996) and girth increment (1991-96) were statistically analysed and are presented in Table - Ag. 1.

Table - Ag. 1. **Effect of fertilizer on girth and girth increment**

Nutrients (N:P:K) (kg/ha)	Girth (cm) (1996)	Girth increment (cm) (1991-1996)
0 0 0	44.98	36.85
30 30 20	50.50	40.63
30 30 40	49.58	40.11
30 60 20	50.23	41.06
30 60 40	46.61	37.78
60 30 20	45.53	36.58
60 30 40	52.85	43.35
60 60 20	47.67	38.57
60 60 40	48.98	39.58
90 30 20	48.75	39.03
90 30 40	47.49	38.39
90 60 20	47.32	37.85
90 60 40	46.44	37.65
SE	1.12	0.98
CD	3.27	2.85

The results indicate that 30:30:20 kg N, P_2O_5 and K_2O per ha is optimum for growth.

1.2 N-biofertilizers in seedling nursery

Nursery experiment with N-biofertilizers was initiated during 1995. The treatments included three sources of Azotobacter and Azospirillum and three levels of nitrogen *viz.*, 25, 50 and 100 per cent of the recommended doses of N as urea. P and K were supplied at the recommended rates. The experiment was laid out in RBD with 14 treatments and three replications. Diameter of the seedlings was recorded monthly and soil samples were analysed for chemical properties and microbial population.

1.3 P-biofertilizers in seedling nursery

Experiment on the efficiency of P-biofertilizers on the growth of seedlings in nursery was initiated during 1995 at Central Nursery, Karikkattoor and Regional Nursery, Perumpullickal. The trial was laid out in RBD with four replications. The treatments were phosphorus solubilizers (Symbion P) alone and in combination with 25, 50, 75 and 100 per cent of the recommended P as rock phosphate. Diameter of seedling was recorded monthly and soil was analysed for chemical and microbial properties periodically.

1.4 Growth promoters in seedling nursery

In the nursery experiment initiated in 1995 to study the effect of growth promoters marketed under different commercial names *viz.*, Growbuck, Multiplex, Perfectose etc. were compared with the recommended level of NPKMg fertilizer. Diameter of seedlings were recorded monthly.

1.5 Modelling Mg uptake in young rubber

In the glass house study initiated in 1995 to study Mg uptake pattern in different clones of young rubber, the treatments were incorporated periodically.

2. Nutritional studies (mature rubber)

2.1 NPK fertilizer trial

The experiment on RRII 105, laid out at Vaniampara Estate is being continued. Observations on monthly yield and annual girth were recorded.

Table - Ag. 2. : **Effect of phosphorus on mean yield (1995)**

Levels of P (kg/ha)	Mean yield (g/tree/tap)
0	50.24
20	45.41
40	60.31
SEm	3.39
CD	9.93

There was positive response to P application at the highest level with respect to yield (Table -Ag. 2). The effect of fertilizers on girth of trees was not significant.

2.2 Clone cum fertilizer experiment

The experiment to study the clonal differences in nutrient requirement was continued to the mature phase. Significant clonal difference in girth was noticed with clones RRIC 100 and RRII 203 showing higher girth (Table -Ag. 3). Clonal difference

Table - Ag. 3. **Clonal difference in girth**

Clone	Girth (cm)
RRII 5	53.25
RRII 105	51.54
RRII 203	58.92
RRII 208	49.86
RRII 300	47.86
RRII 308	47.78
PCK 1	46.70
PCK 2	49.44
PB 311	53.33
RRIC 100	59.95
SE	1.58
CD	4.78

in nutrient requirement for growth was not indicated.

2.3 Sequential skipping of fertilizers

Field experiment comparing continuous no manuring and periodical skipping of fertilizers for one season, one year, two year *etc.* with full dose of regular fertilizer application was initiated during 1995. The treatments will be imposed during 1996.

2.4 Potassium nutrition of mature rubber

The first phase of the experiment initiated during 1990 was completed in May 1996. The analysis of the yield data for the five years showed that there was no response in yield to application of K during the first three years. The yield response was significant during the fourth and fifth year. During the fifth year 75 kg K_2O/ha recorded the highest yield. The data are presented in Table -Ag. 4.

Table -Ag. 4. **Effect of K application on dry rubber yield, leaf K and available soil K (1995)**

Applied K (kg/ha)	Dry rubber yield (g/tree/tap)	Leaf K (%)	available Soil K (kg/ha)	
	1995		0-30 cm	30-60cm
0	33.43	1.18	46.8	26.6
15	37.61	1.37	64.2	30.0
30	41.27	1.46	116.6	59.2
45	44.82	1.54	120.0	48.0
60	43.87	1.58	179.2	91.6
75	53.19	1.64	107.4	93.2
90	39.65	1.21	138.2	85.8
CD (P=0.05)	12.5	0.22	49.7	25.0

3. Density of planting

The experiment at CES, Chethackal initiated in 1994 to study the effect of density of planting on growth of rubber and corresponding nutrient requirement is in progress. The fertilizer treatments were incorporated and growth measurements recorded.

4. Irrigation and water requirement

The field experiment on immature rubber started in 1991 at Shaliacary Estate, to study the effect of different levels of irrigation on growth of rubber is in progress. The irrigation treatments were continued and growth measurements recorded (Table-Ag. 5).

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

Irrigation	Girth (cm) (1995)	Girth increment (cm) (1992-1995)
25% of ET	37.51	30.83
50% of ET	38.13	31.65
75% of ET	38.21	32.06
100% of ET	39.53	32.48
No irrigation	35.38	29.34
SE	0.91	0.65
CD	2.79	2.01

Irrigation at 50 per cent and above of ETC enhanced the growth of rubber significantly. Irrigated plants maintained a higher leaf water content and turgor pressure during the summer season.

5. Soil and water conservation

5.1 Effect of silt pits

Field experiment laid out in mature rubber plantation is being continued. Effect of silt pit on the girth and yield was not significant.

5.2 Effect of coir pith manure in pit manuring and mulching for young rubber

The field trial started in 1994 is in progress. Soil moisture measurements during summer indicated no significant difference between treatments. Similarly girth of rubber during the first two years also did not show significant difference.

6. Weed management

6.1 Evaluation of weed control methods

This experiment was laid out in

Shaliacary Estate, during 1995 with the following treatments.

T1 - Scrapping entire platform

T2 - Slashing entire platform

T3-Spraying Gramaxone (2.25 l) + Fernoxone (1.25 kg) in entire platform

T4 - Spraying Glyphosate (2 l) in entire platform

T5 - Slashing interspaces and scrapping plant basin

T6 - Slashing interspaces and applying Gramaxone (2.25 l) + Fernoxone (1.25 kg) in plant basin

T7 - Slashing interspaces and applying Glyphosate (2 l) in plant basin

Observations on weed infestation by visual rating (%) and weed density measurements (dry weight) indicated that the best overall weed control was obtained for scrapping the entire platform. Herbicide sprays of Glyphosate in the entire planting strips also showed low weed infestation followed by Gramaxone + Fernoxone spray in plant basin and slashing the remaining area.

7. Cropping systems

7.1 Effect of intercropping coffee on mature rubber

The experiment on intercropping two varieties of coffee (*Coffea arabica* var. cauveri and *Coffea canephora* var. robusta) in mature rubber plantation is being continued. Neither the growth nor yield of rubber was affected by the intercrop.

7.2 Cropping system model

A cropping system model experiment was started in 1993 at CES, Chethackal. The system consisted of rubber planted in paired rows 5.2 m apart, with the distance between paired rows being 9.1 m and the spacing of rubber within the row, 3.4 m. The intercrop components were banana for 2 years; pineapple upto 5th year; tuber crops during the 4th and 5th year; pepper, cocoa, and cover crop in the narrow interrow, and grass and teak in the boundary. The stand per hectare of rubber is 406.

Growth of rubber, changes in soil physical and chemical properties and nutrient cycling within the system are periodically monitored. The results obtained so far showed that the growth of rubber is comparable to that of a pure crop of rubber.

8. Nutrient management

8.1 Comparison of organic and inorganic sources

The trial on immature rubber was initiated during 1994, at Shaliacary Estate. The treatments included combinations of organic manure and inorganic fertilizers combined in split plot design. The main plot treatments were organic manure and no organic manure and the sub plots had all the combinations of three levels of N and P *viz.*, 0, 25 and 50 kg/ha.

Soil samples were collected and analysed to study changes in nutrient status and physical properties. Girth recorded one year after planting did not show significant difference between treatments.

8.2 Nutrient recycling

The experiment was initiated in mature rubber during 1993. Eighteen litter traps of one m^2 area were placed in one ha of mature (12 year old) rubber. Leaf litter of rubber was allowed to fall in 14 traps and weeds from one m^2 area were cut and placed in the other four traps. Dry weight of litter and weeds and nutrient concentration of leaves were recorded monthly.

The study revealed that 97 per cent of leaf litter mass was lost within nine months while a similar loss in weed mass occurred in six months. Nitrogen addition by way of leaf litter (around 4 tonnes) was 66 kg/ha and by weeds was 11.4 kg/ha.

9. Ground cover management

9.1 *Calapagonium caeruleum* as cover crop

Calapagonium caeruleum and *Pueraria phaseoloides* were planted in 0.2 ha each in Malankara Estate, during 1995 and the growth performance was compared through biomass measurements.

10. Forms and methods of fertilizer application

10.1 Comparison of water soluble and insoluble forms of P fertilizers

The experiments started in 1989 at Vaniampara Estate and Kinalur Estate to evaluate the comparative efficiency of mussoorie rock phosphate(MRP), super phosphate and ammophos on growth of young rubber is being continued. Girth increment from 1989 to 1996 is given in Table - Ag. 6.

Table - Ag. 6 **Girth increment during 1989-96 (cm)**

Treatment	Location	
40 kg /ha each P & N as	Vaniampara	Kinalur
Rock phosphate + Ammonium sulphate	39.0	45.8
Rock phosphate + Urea	38.5	45.6
Ammonium phosphate (20:20)	39.1	45.6
Single super phosphate + Ammonium sulphate	38.8	44.9
Single super phosphate + Urea	38.1	46.5
SE	0.84	0.92
CD	NS	NS

No significant difference in girth increment was observed between trees which received the soluble and insoluble forms of P fertilizer in both the experiments. A build up of phosphorus was noticed due to P application irrespective of P sources.

10.2 Bowl sludge as a source of P

The trial started in 1988 in young rubber is being continued and the trees are now in the yielding phase. The girth increment for 1989-1995 indicated that all the sources of P were equally effective (Table -Ag. 7).

Table -Ag. 7. **Effect of different P sources on girth increment (1989-1995)**

Treatment	Girth increment (cm)
Super phosphate	44.04
MRP	44.22
Bowl sludge	45.34
Control	40.40
SE	1.05
CD	3.15

A separate block trial comparing bowl sludge and MRP initiated in 1994 is being continued. The yield in the two blocks were comparable.

10.3 Comparison of Maton and Mussoorie rock phosphates

10.3.1 Incubation experiment

An incubation experiment was conducted in the laboratory comparing three levels of Maton, partially acidulated Maton and Mussoorie rock phosphate and a no phosphorus control in a CRD with three replications for a period of 90 days. Samples were drawn at 15 days interval and analysed for available P and pH. The results revealed that for all the sources and levels the availability of P increased upto 45th day (Table-Ag. 8) and the release pattern indicated that Maton rock phosphate is as good as MRP as a source of P.

Table - Ag. 8. **Dissolution pattern of P (ppm)**

Source	Levels of P_2O_5 (kg/ha)	Incubation period (days)					
		15	30	45	60	75	90
Mussoorie RP	100	7.00	6.67	7.67	5.00	5.33	5.67
	200	11.33	5.33	18.33	11.00	8.00	14.33
	300	18.67	20.33	20.67	7.00	7.00	15.67
Maton RP	100	4.33	6.00	6.67	5.33	5.83	5.67
	200	7.67	6.33	18.67	10.00	7.00	12.67
	300	12.67	15.33	17.00	12.17	6.33	14.67
Partially acidulated Maton RP	100	4.33	5.83	6.67	5.83	4.17	4.00
	200	9.83	5.83	19.67	12.00	7.33	15.00
	300	10.67	12.67	15.00	9.00	7.33	14.00
No P		0.01	0.01	0.01	0.01	0.01	0.01
SE		0.64	0.72	1.31	0.28	0.56	0.68
CD		0.90	2.12	3.88	0.84	1.66	2.02

10.3.1 Effect on cover crops

Comparative efficiency of Maton and Mussoorie rock phosphate was evaluated by monitoring growth and uptake of P by two cover crops, *Pueraria phaseoloides* and *Mucuna bracteata*. The residual effect of these rock phosphates were also studied through a second crop of cover crop. The pot culture study revealed that the 45 kg P_2O_5 per ha level of partially acidulated Maton RP gave the highest dry matter production (Table -Ag. 9). Among the different sources of rock phosphates partially acidulated Maton RP was found to be significantly superior in P uptake. All the treatments recorded higher P uptake compared to control (Table -Ag. 10).

10.3.2 Field experiment

One field experiment was also initiated with the same objective to compare the Maton and Mussoorie rock phosphate at Malankara Estate, Thodupuzha. The girth data revealed that neither the girth nor girth increment of plants showed significant difference among treatments.

10.4 Comparison of rock phosphate sources

Different sources of rock phosphates viz., Mussoorie RP, Gafsaphos, Maton RP, Jordan RP, Rajphos and Meghaphos were compared by conducting a seedling nursery trial at Regional Nursery, Perumpulickal. Monthly diameter recordings revealed that response to added P and all the sources of P were comparable (Table -Ag. 11).

10.5 Use of slow release fertilizer

In the two field experiments, one started during 1993 at CES Chethackal and the other at Kuzhimattom during 1994, the growth measurements and plant and soil nutrient status were recorded. The lower doses of controlled release fertilizers like NPKMg pellets and Nimin coated urea gave better growth compared to urea applied alone as nitrogen source. The possibility of reducing the dose of fertilizers using controlled release fertilizers is indicated.

Table- Ag. 9. **Dry weight of cover crops**

Treatments	Levels (kg P_2O_5/ha)	*Mucuna bracteata*			*Pueraria phaseoloides*		
		I crop	II crop	Total	I crop	II crop	Total
Maton rock phosphate	15	6.65	11.27	17.92	14.67	18.50	33.17
	30	6.27	11.18	17.45	9.90	19.11	29.01
	45	6.01	8.45	14.46	13.70	21.38	35.08
Partially acidulated Maton rock phosphate	15	17.22	12.85	30.07	16.78	14.36	31.14
	30	9.66	12.97	22.63	10.76	22.33	33.09
	45	6.16	6.58	12.74	20.95	20.22	41.17
Mussoorie rock phosphate	15	7.88	11.68	19.56	12.82	20.34	33.16
	30	5.63	14.97	20.60	12.09	18.16	30.25
	45	5.59	13.31	18.90	3.39	16.01	19.40
Control	0	4.52	7.49	12.01	4.67	7.32	11.99
SE		0.86	1.52	1.41	1.69	2.14	4.44
CD		2.54	4.53	4.19	5.01	6.35	9.33

Table - Ag. 10. **Total P uptake by cover crops (mg/pot)**

Treatments	Levels (kg P_2O_5/ha)	*Mucuna bracteata*			*Pueraria phaseoloides*		
		I crop	II crop	Total	I crop	II crop	Total
Maton rock phosphate	15	10.33	18.33	28.66	26.33	25.67	52.00
	30	12.00	20.00	32.00	22.67	19.33	42.00
	45	11.00	16.00	27.00	35.67	19.33	55.00
Partially acidulated Maton rock phosphate	15	27.33	22.33	49.66	41.00	22.67	63.67
	30	17.67	24.33	42.00	35.67	44.33	80.00
	45	11.67	12.33	24.00	51.67	40.67	92.34
Mussoorie rock phosphate	15	14.67	18.00	32.67	25.00	40.33	65.33
	30	11.00	23.33	34.33	25.33	40.00	65.33
	45	15.00	24.33	39.33	11.00	23.33	34.33
Control	0	10.00	9.00	19.00	8.00	11.00	19.00
SE		2.91	3.03	3.89	2.22	4.36	4.19
CD		6.51	7.43	11.55	6.60	10.69	12.45

Table - Ag. 11. Effect of different P sources on diameter of rubber seedlings

Treatment	Diameter (mm)
No Phosphorus	11.65
Mussoorie RP	14.29
Gafsaphos	13.84
Maton RP	14.69
Jordan RP	13.78
Rajphos	13.48
Meghaphos	14.03
SE	0.53
CD	1.56

10.6 Effect of nitrification inhibitors

With a view to study the effect of neem cake on increasing the efficiency of urea, an experiment was initiated on mature rubber. The treatments are : (1) 30 kg N as urea in two splits, (2) 30 kg N as urea and neem cake at 1/5th quantity of urea in two splits, (3) 22.5 kg N as urea in two splits, (4) 22.5 kg N as urea in two splits + Neem cake at 1/5th quantity of urea, (5) 15 kg N in two splits, (6) 15 kg N as urea + Neem cake at 1/5th quantity of urea in two splits, (7) 30 kg N as urea mixed with neem cake as single application and (8) No nitrogen.

The treatments were imposed and monthly yield recording started.

11 DRIS approach for interpretation of foliar analytical values

The study is being continued. The data bank was updated with inclusion of leaf analytical values from 1995-96 also. The values were grouped clonewise and further steps to use DRIS approach for formulating fertilizer recommendation is being undertaken.

12. Standardisation of analytical methods

12.1 Seasonal variation in leaf nutrient status in rubber

A study was initiated on clone RRII 105 during 1995 to study the variation in leaf nutrient status with respect to age to explore the possibility of widening the leaf sampling period. Leaf samples were collected at 15 days interval from 15 mature trees and yield recorded at monthly intervals. Soil samples were also collected at monthly interval. The analysis of the samples is in progress.

13. Advisory service

Rubber Research Institute of India is continuing the advisory services to the estate sector and small holders. Site and situation specific fertilizer recommendation to rubber is offered through soil and leaf analysis. During 1995-96 analysis of 958 soil samples and 700 leaf samples were carried out and 930 individual fertilizer recommendations were offered to large estates. In the small holding sector 12330 soil and 2000 leaf samples were analysed and recommendations offered utilising the facilities available in the division and at the eight Regional Laboratories and four mobile testing units. Software package was developed for computerised fertilizer recommendation in consultation with Statistics and Planning Division.

14. Collaborative studies

The division collaborates with the Plant Physiology Division in the studies on physiology and biochemistry of yield stimulation. Studies were made to estimate removal of potassium, magnesium and copper through latex serum in ethrel stimulated trees.

BIOTECHNOLOGY DIVISION

Somatic embryogenesis

Plant regeneration by somatic embryogenesis from various explant sources was tried. A new plant regeneration pathway via somatic embryo formation using immature inflorescence as the initial explant has been developed. However it requires several refinements in order to increase the efficiency of the system and to reduce the time span required. This protocol can be utilised for (a) transgenic plant synthesis, (b) isolation and culture of protoplasts. Various refinements have been brought about in the already existing somatic embryogenesis pathway where immature fruits are the initial explants.

Protoplast culture

Isolation of protoplasts from different sources was attempted in order to identify the best source which can produce constant high yields of viable protoplasts. After several standardisation experiments it has been observed that clean viable protoplasts which can retain their viability throughout the culture period can be isolated with considerably high yield from embryogenic calli. The purified protoplasts when cultured over appropriate media at optimal plating density gave rise to microcolonies. These microcolonies eventually gave rise to plantlets via somatic embryogenesis. This protoplast-to-plant system requires further refinements to optimise the culture conditions. After refinements this method may prove useful in genetic transformation experiments.

Shoot tip culture

The ongoing work for generating plants every year, utilising the existing plant regeneration pathway has been continued. About 200 plants were obtained. Refinement experiments were continued on variables influencing the reduction of mortality and increased frequency of rooting with an objective to enhance the productivity of this pathway.

Genetic transformation

Attempts to establish a transformtion system in *Hevea* using experimental marker genes have ben started. The natural vector system *Agrobacterium tumefaciens* was made use of in these experiments. Early, mid and late stage of embryogenic callus, somatic embryos at different stages of development etc. were used as target tissues. Many tissue specific expressions have been obtained. Experiments are going on with the objective of obtaining stable expression of the incorporated gene in different target tissues of *Hevea*.

RAPD analysis of TPD tolerant and susceptible genotypes

Two populations of TPD tolerant and susceptible plants derived from a seed propagated population were analysed for their RAPD profile with 25 random primers. An extra band has been identified in the zymogram of the tolerant plants which may presumably have some influence on the TPD expression. Further the polymorphism is to be confirmed with individual samples.

Changes in isozyme patterns during somatic embryogenesis

Preliminary screening was done using 23 isozymes out of which six isozymes showed marked differences during somatic embryogenesis of *Hevea brasiliensis*. De-

tailed work was done to find the minute changes in the zymogram pattern of each stage during somatic embryogenesis. Different callus types were selected for this experiment, namely; (1) explants, (2) early callus, (3) non-embryogenic callus, (4) embryogenic callus, (5) embryos, (6) intact stage three leaf of the fully grown tree. It has been observed that there is marked difference during the differentiation of non-embryogenic callus to embryogenic callus and finally to embryos.

BOTANY DIVISION

Botany Division continued research activities on genetic improvement through hybridization and ortet selection. Emphasis was also given for evaluation of promising clones. Investigations on propagation, anatomy and cytogenetics were also in progress.

1. Evolving high yielding clones for traditional area

1.1 Hybridization and clonal selection

Monthly yield recording and periodical recording of total volume of latex, DRC and plugging index were continued in the 1985 small-scale trial of hybrid clones. The eight hybrid clones which exhibited comparable or more yield than that of RRII 105 over the first two years of tapping continued to exhibit the same trend in the third year also. Pooled analysis over the first three years of tapping also exhibited a similar trend (Table- Bot. 1).

From the 1989 small scale trial, 36 clones which recorded 50 per cent or more yield than RRII 105 when test tapped at 42 months were selected for further multiplication and laying out large scale trials at RRS, Padiyoor during 1996-97. Similarly, 17 of the best selections from 1990 small scale trial based on juvenile yield at 52 months were selected for laying out large scale trials. Casualties were replaced in a small scale trial of 16 clones (1989 hybridization programme) laid out in 1994. Another 34 selections along with RRII 105 were planted in 1995. 43 hybrid clones of 1990 hybridization programme incorporating wild germplasm as male parents with RRII 105, RRIM 600 and GT 1 as female parents, were planted in 1995 in two small scale trials of 26 and 17 clones each along with parent clones.

Mean juvenile yield over 30 and 40 months in two clonal nursery evaluation trials revealed that among 15 clones in trial I, clones 68, 111, 44 and 50 recorded 41.42, 26.74 , 24.39 and 23.87 per 10 tappings in comparison to 12.3 g for RRII 105. Among 7 clones in trial II, clones 120, 79 and 178 are the top juvenile yielders which recorded a mean of 21.63, 21.25 and 20.05 per 10 tappings respectively in comparison to 11.67 g for RRII 105. Similarly, among two other clonal nursery evaluation trials of 35 and 10 clones each, mean yield over 24 and 34 months revealed 7 and 4 clones respectively recorded promising juvenile yield in comparison to RRII 105.

Eighty hybrid seedlings resultant of the 1993 hybridization programme were test tapped. Yield ranged from 0.21 to 4.88 g per 15 tappings. Sixteen seedlings from two families gave test tap yield greater than 2 g per 15 tappings.

A total of about 12,000 hand pollinations were done in 1996 in 15 cross combinations of parents selected based on yield

Table - Bot. 1. **Yield and yield attributes in selected hybrid clones and their parents in the mature phase**

Clones yield (g/tree/tap)	Dry rubber yield (g/tree/tap)	Total volume of latex (ml)	Plugging index	Girth at opening (cm)	No. of latex vessel-rows	Bark thickness (mm)
82/3	64.00	199.83	2.63	54.54	18.25	7.50
82/7	66.14	173.31	2.63	56.34	15.39	8.04
82/14	88.20	280.12	2.59	57.49	21.76	8.61
82/17	60.95	209.63	3.42	54.73	20.49	8.09
82/22	78.76	237.49	2.82	52.40	21.66	8.18
82/27	62.96	222.48	2.47	52.79	16.72	8.18
82/29	78.73	237.16	2.33	62.77	22.00	7.89
82/30	71.77	223.84	3.90	53.42	18.32	7.92
RRIC 100	38.15	121.40	3.59	50.78	15.55	7.11
RRII 105	58.55	185.76	3.60	49.04	15.21	8.17
CD (P=0.05)	17.59	55.23	0.83	6.50	4.27	0.93

components and genetic distance. A seedling nursery with 1147 hybrid seedlings was established.

1.2 Ortet selection

The trials at Cheruvally and Mundakayam Estate were opened for tapping. Monthly yield recording at Cheruvally Estate was initiated. From among 53 clones in these trials 11 clones which recorded higher yield than RRII 105 at an age of 60 months were multiplied for laying out large scale trials during 1996-97.

A small scale trial of 17 ortets selected from various small holdings was laid out at CES, Chethackal. Vacancy filling in 1994 small scale trial of ortets selected from an estate were carried out. 50 ortets selected from another estate were multiplied and established in polybags to lay out a small scale trial. Budwood of two ortets from Kasaragod District were collected and multiplied.

1.3 Special techniques in breeding

In the field trial on evaluation of selected clones resultant of mutation and polyploidy, girth recording was done. It was observed that two clones are more vigorous in growth than the control clone RRII 105.

Annual girth and monthly yield (g/tree/tap) were recorded from the 1985 clone trial of irradiated materials. Seven clones out yielding RRII 105 could be identified based on yield over four years.

2. Evaluation of clones

2.1 Large scale trials

Juvenile yield and girth at the age of four years were recorded from two clone trials at CES comprising nine and eight clones each. In trial I, among nine clones, PB 312 recorded the highest yield of 18.68 g per tree per tap followed by RRII 105 (12.08 g) and PB 235 (11.56 g). The vigorous clones as indicated by girth are PB 235 (37.21 cm), PB 260 (35.78 cm) and RRII 105 (32.76 cm). In trial II, among 8 clones, RRII 105 recorded the highest yield of 11.47 g per tree per tap followed by KRS 25 (11.05 g) and SCATC

88-13 (8.24 g). Girth was the highest in KRS 25 (36.57 cm) followed by RRII 105 (33.95 cm)and SCATC 88-13 (31.72 cm).

Monthly girth measurements were recorded from two multidisciplinary evaluation trials of 13 clones each. In trial I, mean annual girth over six years was the highest in RRII 118 (56.53 cm) followed by RRII 308 (51.14 cm) and RRII 5 (50.32 cm). In trial II, PB 235 recorded the highest girth (55.59 cm) followed by PB 314 and PB 280 (53.10 cm) in comparison to 50.48 cm for RRII 105.

The large scale evaluation of Sri Lankan clones with respect to girth and yield at the 11th year of tapping revealed RRIC 45, RRIC 102 and RRIC 52 to out -yield all the other clones with 50.02, 49.23 and 48.67 g per tree per tap respectively. RRIC 36 (36 g/tree/tap) recorded the lowest yield. As in the previous years, RRIC 104 and RRIC 52 recorded more girth (107.44 and 102.32 cm respectively) than the rest of the clones.

The clone PB 235 with a girth of 69.58 cm at the 13th year of planting was found to be the most vigorous in another large scale trial. In terms of yield PB 310 with 64.92 g per tree per tap was the best followed by PB 235 and RRII 105 with 63.82 and 62.13 g per tree per tap respectively.

2.2 On-farm evaluation

Among 11 clones planted blockwise at Malankara Estate in 1978, mean yield over 10 years was highest in RRII 105 (1975 kg /ha/ year) followed by GT 1 (1477 kg), RRIC 102 (1440 kg), RRIC 36 (1382 kg) and RRIM 703 (1332 kg). The 1988 trial of eight clones viz., RRII 5, RRII 203, PCK 1, RRIC 102, PB 260, PB 312, SCATC 88-13 and RRII 105 on the same estate was opened for tapping in 1996. Clones RRII 105 and RRIM 600 recorded a mean yield of 1858 and 1310 kg per ha per year over 15 years of tapping at Myladi. At the same location, in the 1993 trial, clones RRII 105 and PB 235 showed a mean yield of 1768 and 1690 kg respectively at the fourth year of tapping. Among 12 clones planted in Chithelvetty Estate, mean yield per hectare over the first three years was highest in RRII 1 (1529 kg) followed by PB 260 (1305 kg) and PB 311 (1293 kg) in comparison to 1100 kg for RRII 105. At Manikal, the block yield of RRII 105 was the highest (1110 kg) followed by that of PB 235 (1016 kg) over the first two years of tapping.

The block trial of eight clones at Koney Estate was opened for tapping. Girth recording was done in the block trials at Shaliacary Estate. Clone PB 280 recorded the highest girth (18.8 cm) followed by RRII 5 (18.2 cm) after two years' growth. At the third year of planting, PB 255 recorded the highest girth (24 cm) followed by SCATC 88-13 (19.9 cm) and PB 28/59 (19.42 cm).

3. Performance of clonal composites

Girth recording was carried out in the 1993 trial of multiclone blends planted both at CES as well as RES Nagrakata. The clones exhibited different girthing pattern under various combinations of blending. The girthing pattern of different clones varied with the locations too. In the case of 13 clones raised in a CRD with equal replications RRII 105 recorded a girth of 10.17 cm at RES Nagrakata in contrast to a girth of 18.96 cm recorded at CES Chethackal during the third year of planting. The girthing rate for all the clones were lower at RES Nagrakata. While the above trial recorded a general mean girth of 18.09 cm at CES, it recorded only 10.49 cm at RES Nagrakata.

4. Polycross progeny evaluation

4.1 Evaluation of progenies of prepotent clones

Observations on incidence of shoot rot in the progenies and parents included

in the experiment showed that the progeny of Ch 26 recorded the lowest incidence of the disease (18.65%). The highest incidence (46.67%) was in the progeny of PB 5/76.

4.2 Evaluation of prepotent clones in polyclonal garden

A polyclonal garden was laid out in a two dimensional crossing design with nine genetically divergent clones identified as prepotents based on seedling progeny analysis. The garden was laid out in an area of 9 ha at HBSS, Nettana.

5. Breeding clones for combining compact canopy with good yield

Morphological characterisation of the shoot and root system of the one year old seedling of the different morphotypes from the genetic variant and control was done. Mean number of lateral roots (62) and dry matter weight of the root (114 g) are more for the intermediate type. The control recorded comparatively less root growth in terms of lateral root (27g) and root biomass (80 g).

6. Breeding for drought tolerance

Hybrid seedlings resultant of the 1993 hybridization programme on breeding for drought tolerance were test tapped. Eighteen seedlings from seven cross combinations showed a promising test tap yield greater than 3 g per 15 tappings. Samples of bark and twigs have been collected from the promising hybrids for recording the number of laticifers and the extent of intraxylary phloem.

7. Breeding for powdery mildew resistance

Proper field maintenance of the 20 clones being established along with spreader rows of a susceptible clone (PB 5/51) was done.

8. Investigation on Genotype x Environment interaction

Multiplication of planting materials of 12 clones for five locations was completed. The locations are : Agartala, Nagrakata, Orissa, Kanyakumari and Padiyoor. Clones selected are RRII 105, RRIC 100, RRII 51, RRII 176, RRII 203, PB 217, RRIM 600, 82/14, 82/22, 82/30, 82/29 and 82/17.

9. Estimation of genetic parameters

9.1 Genetic studies

9.1.1 Variability, correlation and heterosis for yield and yield components

Analysis of mean performance of 23 hybrid clones resultant of the cross of RRII 105 x RRIC 100 over the first three years of tapping in the mature phase revealed significant clonal variation rendering better scope for selection. Scrutiny of yield and eight yield attributes of the above population revealed high genotypic and pheno-typic coefficients of variation, heritability and genetic advance for most of the characters (Table - Bot. 2). Highly significant early versus mature correlations for yield and yield attributes were recorded among the above population indicating possibility of early selection of potential hybrid clones (Table - Bot. 3).

9.2 Genetic analysis using molecular markers

A study on genetic analysis using RAPD markers was initiated under the World Bank aided training programme in the Institute of Plant Breeding, University of Gottingen, FRG. Protocols were standardised for extraction of DNA and RAPD assay. Total genomic DNA was extracted from 48 clones in the breeding pool. 42 informative decamer primers were used to screen 24 clones, which produced 80 repeatable and clearly scorable RAPD markers. These were used for estimation of genetic distance among clones. The results of the study reveal that

RAPD markers are suitable for genetic analyses in *Hevea*.

10. Cytogenetical investigations

Chiasma frequency studies of four clones viz., RRII 105, RRIM 600, GI 1 and GT 1 have been carried out. Chiasma frequency per cell ranges from 25.54 to 28.56.

Pollen germination studies on diploid and induced tetraploid RRII 105 were carried out. The diploid registered maximum germination (60 per cent) in 20 per cent sucrose with 100 ppm boric acid. The tetraploid recorded 31.5 per cent germination in the above medium. Mean tube length and width of the diploid was 13 µm and 12 µm while in the tetraploid was 73.18 um and 17.37 µm respectively. Wide range of abnormalities in pollen tube growth was noted in the tetraploid. Genome doubling had profound effect on the structure and germination of pollen grains in the tetraploid (Table - Bot. 4).

11. Floral biology and fruit set

Studies on floral biology and fruit set are in progress.

12. Anatomical investigations

12.1 Bark anatomical investigations

Bark samples were collected from grafted area on TPD affected trees and anatomical investigations are in progress.

12.2 Investigations on somatic embryos

Developmental stages of somatic embryos obtained from Biotechnology Division were subjected to anatomical studies.

Table - Bot. 2. **Range, mean, variance ratio and genetic parameters for yield and eight yield attributes in the mature phase of evaluation in rubber**

Character	Range	Mean ±	SE	Variance ratio (F)	GCV (%)	PCV (%)	Heritability (%)	GA % over mean
Dry rubber yield, g/tree/tap	20.21-88.20	51.68 ±	6.19	8.90**	33.65	39.53	72.49	58.63
Total vol. of latex, ml/t	63.65-280.12	165.71 ±	19.43	7.95**	30.91	36.98	9.85	52.57
Rate of latex, flow	15.50-53.00	32.15 ±	2.56	12.61**	27.17	30.48	79.46	49.59
Dry rubber content	27.10-36.74	32.13 ±	1.31	3.97**	7.02	9.96	49.71	10.05
Plugging index	2.33- 5.03	3.41 ±	0.29	7.02**	20.94	25.73	66.23	34.94
Girth at opening, (cm)	49.04-62.77	53.49 ±	2.29	2.27**	4.81	10.19	29.69	5.40
Girth increment rate on tapping, (cm/yr)	1.09- 4.79	2.70 ±	0.52	3.83**	32.09	46.11	48.39	45.56
No. of latex vessel rows	9.33-22.00	16.92 ±	1.50	4.13**	15.74	22.01	51.12	23.12
Bark thickness,(mm)	7.11- 8.67	7.83 ±	0.33	1.83**	3.79	8.15	21.62	3.69

** Significant at 1% level.

Table - Bot. 3. **Early (4 1/2 years of tapping) versus mature correlation of yield and yield attributes in a hybrid clonal population of RRII 105 x RRIC 100**

Character pair	Yearwise correlation coefficient			
	1st year	2nd year	3rd year	Mean over 3 years
Early Y vs Mature Y	0.913**	0.918**	0.811**	0.918**
Early X1 vs Mature X1	0.796**	0.881**	0.709**	0.844**
Early X2 vs Mature X2	0.671**	0.741**	0.567**	0.718**
Early X3 vs Mature X3	0.572**	0.392**	0.478**	0.541**
Early X4 vs Mature X4	0.787**	0.846**	0.612**	0.829**
Early X5 vs Mature X5	0.651**	-	-	-
Early X6 vs Mature X6	0.584**	0.582**	0.701**	0.999**
Early X7 vs Mature X7	0.696**	-	0.556**	-
Early X8 vs Mature X8	0.456*	-	0.209**	-

* Significant at 5% level
** Significant at 1% level
Y - dry rubber yield
X1 - total volume of latex/tap
X2 - rate of flow
X3 - drc
X4 - plugging index
X5 - girth at opening
X6 - girth increment rate on tapping
X7 - number of latex vessel rows
X8 - bark thickness

Initiation of the embryo was from unicellular centres on the surface of the callus mass. These initials underwent a series of divisions, and differentiated into heart shaped and horse-shoe shaped proembryos. Vasculature and laticifers developed at a later stage.

12.3 Evaluation of clones for structural components

Number of latex vessel rows and bark thickness at the mature stage of 15 clones from the clone trial area at Dapchari were recorded for the characterisation of clones (Table - Bot. 5).

Table - Bot. 4.**Pollen characteristics, germination and tube growth in diploid and tetraploid of RRII 105**

Character	Diploid (2x)	Tetraploid (4x)
	Mean ± SE	
Pollen germination, (%)	60.0 ± 0.25	31.50 ± 0.26**
Pollen tube length, (µm)	139.0 ± 10.82	73.18 ± 2.97**
Pollen tube breadth, (µm)	12.0 ± 1.58	17.37 ± 0.84**
Pollen stainability, (%)	92.8 ± 0.12	80.00 ± 0.35**
3-zonocolporate pollen, (%)	100.00	30.00 ± 0.82
4-zonocolporate pollen, (%)	Nil	50

** Significant at 1 per cent level

Table-Bot. 5. Anatomical parameters of 15 clones planted at Dapchari

Clone	No. of LVR	Bark thickness (mm)
RRII 5	10.72	5.38
RRII 6	12.50	5.74
RRII 105	11.93	5.20
RRII 208	8.97	5.00
RRII 308	12.92	5.62
RRII 605	10.19	5.94
PB 260	9.45	5.52
PB 310	8.94	4.62
PB 311	9.26	4.82
RRIC 52	7.74	5.54
RRIC 100	8.34	5.20
RRIC 102	8.31	5.42
RRIC 105	7.39	5.74
PR 255	11.74	6.04
PR 261	10.83	5.10
SE	1.759	0.404
CD	0.454	0.104

13. Wood anatomy

Physical properties of wood samples collected from ethrel applied rubber trees for a period of 3 1/2 years were studied. In a preliminary study conducted no significant difference in the physical properties of wood was observed. For a detailed study, trees were identified and monthly stimulation with ethrel was undertaken.

14. Studies on propagation

Growth and other secondary characters were recored from the trees in the trial on budding height and depth of tapping. Quarterly recording of yield was also undertaken. Girth data collected in 1995 were summarised. Among the deep planted plants those with more stem buried recorded more girth. However bag plants surpassed all other treatments in girth.

Benchgrafting with green buds was carried out and the budding success was noted. Benchgrafts opened after 40 days recorded maximum budding success of 80 per cent compared to 69 per cent of budding success when opened after 20 days. Nursery grafts recorded 71 per cent success.

Growth and other secondary characters of the trees in the evaluation trial of bench grafted plants were recorded. Bench grafts had only marginally higher girth (48.83 cm) than nursery grafts (48.38 cm). Percentage tappability in the area was calculated and was found to be 75 per cent. Arrangements were made to open the area for tapping.

Girth data from the trial on deep planting of two whorled bag plants were summarised. Deep planted plants in general recorded more girth (27.60 cm or more) than the normally planted control plants (26.80 cm).

To study the effect of delayed opening and pulling out on bud take and establishment (in polybags) of green budded stumps, one round of green budding was carried out and the budding success noted. Delaying the opening/pulling out adversely affected budding success in general, except in one treatment. In this treatment where pulling out was done after 25 days after opening the budding, delaying the pulling out enhanced budding success. Maximum budding success (91.76%) was obtained for this treatment. Percentage success for normal budding method (control) was 89.60.

Another experiment was conducted to ascertain the influence of the moisture content of rubber seeds on germination and initial growth of seedlings. Data is presented below (Table - Bot. 6). Storage under water was found to be superior to air storing , with respect to moisture content, total germination and height of plants. Seeds stored in water gave 45 per cent germination even after 20 days compared to total failure of germination of seeds stored in air for a similar period.

Table - Bot. 6. **Effect of seed storage on germination**

Treatment	Moisture content (%)	Total germination (%)	Height of 1 month old seedlings(cm)
T1 Control	38.86	91.30	80.00
T2 Storage in open air for 5 days	34.39	63.63	50.00
T3 Storage in open air for 10 days	22.40	20.00	10.00
T4 Storage in open air for 15 days	12.59	16.67	nil
T5 Storage in open air for 20 days	8.97	nil	nil
T6 Storage in water for 5 days	40.32	87.50	75.00
T7 Storage in water for 10 days	45.38	80.00	65.00
T8 Storage in water for 15 days	40.51	60.00	55.00
T9 Storage in water for 20 days	42.83	45.00	40.00
CV	2.18	2.04	4.55
CD	1.26	2.04	3.75
SE	0.42	1.77	1.24

15. Genetic basis of stock scion relationship

Yield and girth of the trees in the trial were recorded. Yield data collected during 3rd year of tapping were summarised and is given below (Table - Bot. 7).

Table - Bot. 7. **Yield of clones on various root stocks (g/tree/tap)**

Clone	Own stock	Assorted stock
RRII 105	65.19	64.23
RRII 118	33.38	32.60
RRII 203	41.84	38.88
RRII 208	44.15	41.66
GI 1	32.99	38.73
GT 1	27.33	26.62
RRIM 600	34.59	27.52
$\bar{X}$	39.92	38.61
SD	12.50	12.71
t test non-significant		

RRII 105 both on assorted stock and own stock recorded maximum yield. For RRII 203 growth was better on both own stock (64.94 cm) and assorted stock (65.19 cm). Stock in general did not influence the scion much. The same growth trend of RRII 203 was observed in another stock-scion combination trial.

16. Studies on early evaluation

16.1.1 Juvenile Vs. mature performance

The trial consisting of ten clones of high, medium and low yield potential was subjected to test tapping at an age of 40 months. Girth measurements were also made. High yielders in general recorded high juvenile yield. The data indicate that among each group juvenile yield in general is related to girth (Table - Bot. 8).

Table - Bot. 8. **Juvenile yield and girth among 10 clones of varying yield potential**

Clone	Mean yield (g/10 tappings at 40 months growth)	Girth (cm)
RRII 105	35.00	18.34
PB 235	53.92	22.20
PB 260	42.58	22.23
PB 217	33.67	21.17
RRIM 600	28.83	17.24
GT 1	19.67	17.64
PB 5/51	24.44	20.39
Tjir 1	11.93	11.57
RRII 33	9.50	19.48
RRII 38	11.09	17.28
GM	27.06	18.75
SE	6.65	1.69
t test	non-significant	

GERMPLASM DIVISION

1. Introduction, collection and conservation of germplasm

1.1 Wickham collections from secondary centres

Four *ex situ* germplasm conservation gardens established in 1977, 1979, 1981 and 1994 are being maintained with a population of 122 primitive, popular and elite clones of Wickham collection. The clones in Gardens I, II and III serve as parents in the hand pollination programmes of Botany Division. Annual girth data and monthly yield were recorded.

Vacancy filling in the newly planted Garden V with 20 clones was completed during the year. Observations on morphological characters such as plant height, girth and number of whorls of leaves per plant were recorded, one year after planting. The clone PCK 1 was the shortest (95.3 cm) while height of SCATC 88/13 was the tallest (194.5 cm). The control clone RRII 105 was 136.5 cm. The girth values had a range from 4.04 cm for RRIM 618 to a maximum of 6.49 cm for RRIC 100 while the control clone RRII 105 had a girth of 4.98 cm. The average number of whorls per plant varied from a minimum of 3.5 for RRII 27 to a maximum of 5.7 for the clone RRIM 609 while the clone RRII 105 had a value of 4.4 whorls per plant.

The anatomical observations on 35 clones in Germplasm Garden II has been completed. The bark anatomical studies of the samples collected from Garden III to study the genetic divergence are being undertaken.

Five IRCA clones, IRCA 130, IRCA 109, IRCA 111, IRCA 18 and IRCA 230 are being evaluated in a RBD at CES, Chethackal. During the year, data were collected for the characters (i) girth, (ii) girth increment, (iii) bark thickness, (iv) total number of latex vessel rows (TLVR), (v) density of latex vessels per mm circumference of the plant (DLV) and (vi) the average dry rubber yield. Analysis of the data revealed that all the characters had significant variation. The results indicated that all the characters except DLV had a higher value than that of the control clone RRII 105. Range, minimum and maximum values and the population means for each of the characters in comparison to the control clone RRII 105 is shown in Table - Ger. 1.

Table - Ger. 1. Range and mean values of the characters compared to control

Character	Range				Population mean	Control (RRII 105)
	Minimum	Clone	Maximum	Clone		
Girth (cm)	20.08	IRCA 18	25.07	IRCA 111	21.89	18.33
Girth increment (cm)	5.26	IRCA 230	8.43	IRCA 130	6.94	5.79
Bark thickness (mm)	2.90	IRCA 111 IRCA 18	3.50	IRCA 230	3.14	3.13
TLVR	5.20	IRCA 18	8.04	IRCA 109	6.22	5.74
DLV	26.80	IRCA 109	29.54	IRCA 111	28.50	31.02
Yield (g/tree/tap)	1.46	IRCA 18	3.47	IRCA 130	2.30	1.36

Table - Ger. 2 illustrate the estimates of variability, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV) along with heritability (H^2) estimates and genetic advance (GA) for each character. The total number of latex vessel rows showed the highest estimates of heritability and medium heritability values were observed for the other characters including yield.

1.2 Wild Brazilian germplasm from 1981 IRRDB collection

A total of 4539 wild genotypes of the Brazilian germplasm received at RRII during different years from 1984 to 1990 are planted in Seven Source Bush Nurseries at CES, Chethackal in 1x1 m spacing. All the genotypes are well conserved with proper identity and lay outs. Nurseries A, B & C have been cut back in order to raise enough budwood for evaluation trials. Four hundred and ninetyfive genotypes from Nursery C were selected for laboratory screening for *Phytophthora* resistance and the screening has been completed with the collaboration of Pathology Division.

1.3 Collection, establishment and exchange of germplasm from NERC

The list of the wild genotypes available at RRS, Agartala and RRS, Guwahati was finalised. These materials will be trasferred and established at RRII also.

2. Evaluation of germplasm

2.1 Preliminary evaluation of 1981 IRRDB collection

A total of 549 wild genotypes, on the basis of nursery level screening, were selected and put to seven preliminary evaluation trials during the year 1990, 1992 and 1994 in statistically laid out trials. Annual girth was recorded in all the trials. Eighty one genotypes of evaluation trial B were test tapped (in the third year after planting) for 10 days in 1/2Sd/2 pattern and yield was recorded for the last 6 tappings, as dry rubber yield in grams per tree per tap. Girth of the plants at the time of test tapping and bark thickness were recorded. Bark samples were collected for recording the anatomical traits. The population showed the following trend for girth and yield. The girth values varied from 9.62 cm in the genotype MT 1007 to 26.39 cm in RO 322 while the control clone RRII 105 had a girth of 17.71 cm. In general the wild genotypes RO 322, MT 1025, MT 1030, RO 894 and RO 379 were found to be vigorous clones with respect to their girth values. The dry rubber yield in grams per tree per tap showed a minimum value of

Table - Ger. 2. **Genetic parameters for the characters studied**

Character	Coefficient of variation		Heritability (H^2%)	GA over mean (%)
	Phenotypic	Genotypic		
Girth(cm)	15.50	9.90	43.36	15.89
Girth increment (cm)	26.98	15.55	33.23	18.34
Bark thickness (cm)	10.66	6.37	35.71	7.83
TLVR	20.21	16.40	65.82	27.39
DLV	7.54	5.07	45.24	7.02
Yield (g/tree/tap)	48.22	35.05	52.85	52.55

0.03 g for the genotype AC 426 while the maximum value was for the genotype MT 1057 (4.28 g) which was greater than the yield recorded for the control clone RRII 105 (2.3 g) (Table - Ger. 3). This trend in yield is similar to the earlier reports of the superior performance of Matto Grosso genotypes. Some of the promising wild genotypes with respect to yield are MT 1021, RO 399, RO 322, MT 1024 and MT 1025.

Table - Ger. 3. **Range and mean values for girth and yield in evaluation trial B**

Character	Range		Population Mean	Control RRII 105
	Minimum	Maximum		
Girth (cm)	9.62 (MT 1007)	26.39 (RO 322)	18.21	17.71
Yield (g/tree/tap)	0.03 (AC 426)	4.28 (MT 1057)	0.54	2.30

Quarterly observations on morphological characters like girth, number of leaves per whorl, number of whorls per plant and total number of leaves per plant were recorded for 73 wild genotypes in evaluation trials D, E and F planted in 1994 vacancy filling in these trials was completed.

2.2 Large scale evaluation of 1981 IRRDB collection

Based on the superior performance of the wild genotypes in the initial years in the preliminary evaluation trials, 81 promising genotypes were selected for large scale evaluation. The trial was laid out at RRS, Padiyoor in a simple lattice design with normal spacing. The planting was completed during the year.

3. Multidisciplinary evaluation

3.1 Studies on the variation in anatomical features related to stress, yield, disease etc.

Bark samples collected from 35 Wickham clones in Germplasm Garden II were observed for the characters *viz.*, total number of latex vessels, density of latex vessels and diameter of the vessels.

3.2 Maintenance of national accession register, herbarium specimens and clone museum

Completed the work of entering the relevant basic data about all the 4539 wild Brazilian genotypes received at RRII. Basic data includes the accession number, genotype code number, donor identification numbers, country of origin/collection, location, date of introduction, date of budding, date of polybag planting, date of transplanting, location of planting in source bush nurseries and number of plants available for each genotype in the nurseries. The details of those genotypes included in the various evaluation trials are also entered.

Herbarium-specimens of 200 wild genotypes were prepared during the year.

Clone museum-leaf samples and budwood of various clones were supplied to Biotechnology and Plant Pathology Divisions for various experiments on their request. The clone museum was well maintained with proper identity and lay out.

3.3 Micromorphological, histological and histochemical characterisation of the IRRDB germplasm of *Hevea*

One hundred wild genotypes of *Hevea* germplasm from the 1981 IRRDB collection were selected from the 1990 preliminary evaluation trial, for micromorphological, histological and histochemical characterisation. Bark and leaf samples were collected and preserved. The leaf tissues were processed and embedded in paraffin wax for serial sectioning.

3.4 Disease screening of wild *Hevea* germplasm (In collaboration with Pathology Division)

Four hundred and ninetyfive genotypes were selected and leaf samples were supplied for laboratory screening for *Phytophthora* resistance. The results are tabulated in Table - Ger. 4.

Table - Ger. 4. **Scores of wild accessions for *Phytophthora* resistance**

Accessions	Number of genotypes within each resistance group				
	0% resistance	1-25%	26-50%	51-75%	76-100%
Acre	61	71	82	45	34
Rondonia	27	31	27	22	12
Matto Grosso	6	14	6	6	4
Ortet	22	18	4	0	3

3.5 Genome analysis of wild *Hevea* germplasm

A laboratory is being established for genome analysis work.

MYCOLOGY AND PLANT PATHOLOGY DIVISION

1. Abnormal leaf fall disease

Heavy premonsoon showers during April/May caused severe leaf fall in many areas even before the annual spraying operations commenced. This resulted in high build up of inoculum of *Phytophthora* spp. and consequent heavy disease incidence during the monsoon period. Only less than one fifth of the total area under rubber in the traditional rubber growing tracts could be protected partly due to the acute shortage of helicopters.

The evaluation of mancozeb as an alternative fungicide for copper oxychloride (COC) for the control of abnormal leaf fall disease was continued during the disease season. Two formulations of mancozeb were tested at the dosages specified (Table-Path .1). In contrast to the results obtained during the last year, the control achieved using mancozeb was not satisfactory. The fungicide provided 50 per cent leaf retention only in GT 1, a relatively less susceptible clone, but was inferior to copper oxychloride.

The new spray oils tried were found to be as effective as the spray oils now recommended. However, the leaf retention was not satisfactory in any of the treatments except in one location (Table- Path. 2). In a small scale testing of two new spray oil

Table - Path. 1. **Comparative efficacy of Mancozeb and copper oxychloride**

Location	Malankara	Chemoni	Boyce	Kumarankudy		Central Experiment Station	
Clone	RRIM 600	RRIM 600	RRIM 600	RRIM 600	RRIM 600	GT 1	
Type of spraying	Dose (kg/ha)	micron	aerial	aerial	micron	micron	micron
Indofil 70% powder	5.00	39.88	8.08	5.12	20.00	10.00	49.46
Indofil 50% + COC 15% powder	5.00	—	—	3.79	—	15.65	—
Indofil liquid	10.00	9.81	—	—	—	—	53.88
COC powder	8.00	86.98	34.52	12.76	30.00	49.67	78.37

Table- Path.2. Evaluation of spray oils

Location/ treatments	Leaf retention (%)			
	Kulathu-puzha	Malan-kara	Cheru-vally	Kumaran-kudy
CRL oil 10 C (improved) oil	33.2	63.4	30.0	30.0
MPL oil	29.4	72.7	29.6	60.0
Control (Estate's oil)	24.4	85.8	39.4	50.0
	18.3	58.1	34.2	30.0

formulations one sample was found to be phytotoxic.

The leaf retention recorded in unsprayed plots were 19.16, 42.72, 61.20 and 66.78 per cent in RRIM 600, RRII 105, GT 1 and RRII 118 respectively as against the leaf retention of sprayed areas 49.67, 83.03, 78.37 and 76.97 per cent respectively. The crop loss recorded in clones RRIM 600 , RRII 105 and RRII 118 was 50.28, 5.54 and 18.14 per cent respectively, while no loss was recorded in clone GT 1.

In high rainfall area, heavy leaf fall was noticed in unsprayed block of RRII 105 (22.86% leaf retention) while the blocks sprayed with 4, 6 and 8 kg of COC per hectare had 52.53, 64.93 and 66.34 per cent leaf retention respectively.

2. Studies on high volume spraying

Two emulsifiers viz., Fynol 40 and Fynol AS 51 were used for mixing spray oil with Bordeaux mixture. Both emulsifiers were found non-phytotoxic. The mixing of oil and fungicide was better when Fynol 40 was used.

The high volume spraying was carried out using power sprayer with horizontal double piston pump. Percentage leaf retention is furnished in Table Path-3.

3. Evaluation of panel protectants/ wound dressing compounds

Large scale block trials were laid out

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

Treatments	Leaf retention (%)
Bordeaux mixture + 2% oil	67.0
Bordeaux mixture + 1% oil	77.0
Bordeaux mixture	77.0
COC in oil - micron spraying	29.0

Table- Path.4. Control of black stripe disease

Treatments	Dose	Disease index (%)
Akomin, 40%	2 ml/l	29.80
Indofil M 45, 75%	5 g/l	24.40
Karmar, 10.5%	2 g/l	31.46
Phosjet, 40%	2 ml/l	32.68
CD (P = 0.05)		4.06

to evaluate four fungicides for black stripe disease in a disease prone area in RRIM 600. Minimum disease incidence was recorded using Indofil M 45. Other fungicides also gave satisfactory control (Table- Path.4).

4. Pink disease management by prophylaxis

Prophylactic premonsoon application of Bordeaux paste and lime with Copper sulphate were tested for the control of pink disease in high ranges. Both treatments reduced the intensity of pink disease of rubber. An improvement in girth on application of lime mixed with Copper sulphate was also noticed.

4.1 Curative fungicide treatment

Field experiments were initiated in three year old plants with treatments detailed in Table - Path. 5. A comparison of two carriers *viz.*, Vinofan compound and Rubberkote was made and the percentage recovery of plants is presented.

Table - Path. 5. **Pink disease management**

Treatment	Dosage	% recovery Vinofan	Rubberkote
Myclobutanil (Systhane)	4 g	70	20
Hexaconazole (Contaf)	4 ml	60	30
Validacin	20 ml	80	60
TMTD (Thiride)	10 g	60	30
Tridemorph (Calixin)	12.5 ml	30	40
Bordeaux paste	100 g	30	

4.2 Effect of carriers on pink disease

In another experiment three carriers viz., Dipicol, Vinofan and Rubberkote were compared for pink disease control. The fungicide used for this purpose was Propiconazole (Tilt) at 0.1% ai. The results are given in Table - Path. 6. The disease survey initiated in 1995 season was continued.

Table - Path. 6. **Effect of carriers on pink disease**

Treatment	Recovery of plants, (%)
Tilt in Dipicol	64.0
Tilt in Vinofan	73.0
Tilt in Rubberkote	59.0

5. Control of shoot rot disease

Results of the treatments tried in clone RRIM 600 at Manikal Estate, Mundakayam are presented in Table - Path. 7.

Table - Path. 7. **Control of 'shoot rot disease'**

Treatment, %	Dosage %	Mean disease index, %
Kaarmar,	0.2	12.0
Kaarmar,	0.4	10.5
Protect,	0.2	13.5
Phosphorous acid,	0.16	4.0
Bordeaux mixture,	1.0	6.0
CD (P = 0.05)		4.65

6. Studies on leaf spot diseases

The field trial of *Gloeosporium* leaf spot disease with weekly and fortnightly application of Ridomil Mz (0.2%), Indofil M 45 (0.2%), Bavistin (0.05%) and Bordeaux mixture (1%) was continued. Indofil M 45 and Ridomil Mz were significantly effective than Bordeaux mixture in controlling the disease. No significant variation was observed between weekly and fortnightly applications (Table - Path. 8).

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

	Application	Disease index(%)
Bordeaux mixture, (1%)	W	23.58
	F	30.58
Indofil M-45, (0.05%)	W	15.75
	F	19.17
Bavistin, (0.05%)	W	19.58
	F	21.83
Ridomil Mz, (0.2%)	W	14.58
	F	16.16
CD (P = 0.05)		5.16

In the field trial of nitrogenous fertilizer on the incidence of *Corynespora* leaf spot disease on rubber seedlings, the disease incidence was observed to be correlated to nitrogen fertilisation. Growth of the plants and size of the leaves also increased with increase in nitrogen fertilisation.

7. Biological control of root diseases

Trichoderma spp. was found to inhibit two root disease pathogens *viz.*, *Botryodiplodia theobroma* and *Pythium selerotrichum in vitro*. Both these pathogens were observed to cause collar rot of seedlings in rubber nursery.

For mass multiplication of *Trichoderma harzianum* and *T. viride*, saw dust was observed to be a good medium. Detailed studies are in progress.

8. Prefelling pressure injection for rubber wood preservation

After seven and half years of treatment with copper sulphate rubber wood showed resistance to the attack of borer beetle and sapstain fungi. A study on the effect of different wood extracts injection on wood preservation was initiated.

9. Studies on physiology of disease resistance

In vitro studies on the effect of different doses of Nitrogen on toxin production by *Corynespora cassiiola* was attempted. A difference in inhibition zone between filtrates of culture grown in different doses of Nitrogen was observed. Total degradation of IAA by the *Corynespora* under *in vitro* condition was found to take 10 days.

Chromatographic separation and quantification of phenols and aminoacids in the healthy and *C. cassicola* inoculated rubber seedlings at different levels of Nitrogen fertilizer was also carried out.

10. Root disease control by soil drenching of fungicides

In the root disease control trial, third and fourth round of fungicide application have been completed and monthly observations were made on the health of the plants. Most of the plants which showed yellowing at the beginning of the experiment have dried except two. But all the neighbouring plants remained healthy. Soil samples were collected for examining microbial population after fungicide treatment.

11. Multidisciplinary evaluation of clones

A general observation on leaf retention was made after the incidence of abnormal leaf fall disease in Trial I and II.

12. Screening of germplasm material and HP selections

A total of 223 genotypes were screened for resistance against *P. meadii* by artificial inoculation. Genotypes were observed for their natural susceptibility in the field during the disease season. It was found that MT genotypes showed reasonable tolerance as compared to others. 12 AC and 4 MT genotypes showed tolerance both under field as well as controlled conditions.

13. Crown budding for protection against abnormal leaf fall disease

The intensity of abnormal leaf fall was less in crown budded area compared to other areas of the same clone (PB 311). No marked difference with regard to powdery mildew disease was noticed.

14. Non symbiotic nitrogen fixing organism

Azotobacter spp. showing different colony characters were isolated from rubber growing soils. Three isolates were multiplied and introduced to acid soil for studying their ability to survive. Initial studies revealed that *Azotobacter* spp. survives upto 3 months.

A field trial was started to study the effect of acid tolerant *Azotobacter* sp. on growth of rubber seedlings at graded levels of nitrogen application.

15. Improvement of phosphate uptake of rubber and cover crops through microorganisms

In the experiment on the effect of phosphobacterial inoculation was repeated. Periodic observations showed that phosphobacterial incoulation can reduce the level of rock phosphate application. Seedlings inoculated with VAM isolates *viz.*

Acaulospora laevis and *Glomus fasciculatum* were uprooted at intervals of 10 days upto 50th day. Shoot weight, root weight, nodule number and nodule weight, root colonisation by VAM etc. were found to increase progressively upto 50th day.

16. Studies on symbiotic nitrogen fixing organisms

120 isolates of *Bradyrhizobium* sp. were tested for nodulation and nitrogen fixation in *Mucuna bracteata*. Among these, 10 isolates were found to favour nodulation and growth of *M. bracteata*. Dipping the *M. bracteata* cuttings in 50 ppm citric and ascorbic acid favoured in quicker establishment and survival.

Dual inoculation of *Bradyzhizobium* sp. and Beijerinckia sp. in Pueraria phaseoloides showed an increase in soil nitrogen status and microbial population.

Microbial population of soil collected from the plots with Mucuna bracteata, Pueraria phaseoloides, weed free and weed infested area showed that soil under M. bracteata contained comparatively more bacteria, fungi, phosphate solubilising organisms and non-symbiotic nitrogen fixing bacteria, followed by the soil under P. phaseoloides and under weeds.

17. Mushroom production and composting using rubber wood saw dust

Shitake mushroom growth on rubber wood saw dust produced sporocarps. These sporocarps were malformed and dark in colour. Continued the cultivation of summer mushroom (Calocybe indica) on saw dust. Application of field soil mixed with sand and Calcium carbonate at 2.5 cm thick layer on 20 days growth of mycelium on saw dust reduced the time taken for mushroom development. Addition of gram powder and oats meal resulted in lesser yield due to contaminations.

18. Problems and prospects of wastes generated from rubber industries

A 3 m^3 Deenbandu model biogas plant was installed and filled with sheet processing effluent and mushroom compost at 10% level. Sheet processing effluent is fed daily to this plant. The biogas is found to contain 1-5 per cent Hydrogen sulphide. Pellets of Sodium hydroxide, Calcium hydroxide and Iron oxide were filled in a special gadget fabricated and installed with biogas plant and they were found to absorb the Hydrogen sulphide. Pilot plant studies with other rubber processing liquid effluent for the biogas generation is in progress.

19. Control of termites

In a field experiment, Fenvalarate 0.04%, Chlorophos 0.4 per cent and Chlorpyriphos 0.2 per cent were effective and on par for control of termites. Fenvalarate 0.02 per cent, BHC 0.4 per cent and BHC 0.2 per cent controlled the infestation to a range of 44.15 to 48.09 per cent respectively (Table - Path. 9).

Table - Path. 9. **Control of termite infestation on rubber tree**

Treatment	Reinfestation percentage after one month	Reinfestation percentage after 3 months
BHC 0.2	48.16	48.09
BHC 0.4	47.87	49.57
Chlorpyriphos 0.2	29.62	29.79
Chlorpyriphos 0.4	22.67	21.77
Fenvalerate 0.02	45.79	44.15
Fenvalerate 0.04	19.08	19.17
Control (untreated)	85.54	95.26
CD (P = 0.05)	13.55	9.68

20. Control of bark feeding caterpillar

The infestation of bark feeding caterpillar was very severe on mature rubber trees. Three insecticidal dusts viz., Fenvalarate 0.4 D, Endosulfan 4 D and Methyl

parathion 2 D were dusted at the rates of 7 kg and 10 kg per hectare in the first round of dusting. In the second round, Endosulfan 4 D at the rates of 7 kg and 10 kg were dusted after 15 days. Because of the severity and unsatisfactory control, a third round of dusting was done with Methyl parathion 2 D at the rates of 7 kg and 10 kg after 30 days.

In the first round Methyl parathion 2 D (10 kg) was most effective, giving 64.65 per cent control of caterpillars, followed by Endosulfan and Fenvalarate at 10 kg per hectare giving 62.86 and 57.54% control. After the second and third round dusting, it was found that Methyl parathion 2 D, Endosulfan 4 D and Fenvalerate 0.4 D were effective at an interval of 15 days for control of severe infestation.

21. Crickets damaging rain guard plastic and their control

There were six treatments in this study *viz.*, Carbaryl 0.2, Neemgold 10 ml/l. of water, Neem oil 10 ml/l. of water, Malathion 0.1, Fenvalarate 0.005 and control. The insecticides were mixed with 0.75 per cent Dithane M-45 and 100 g of china clay. This solution was applied on the tapping panel region at weekly interval from May to October. The results of this study showed that all the insecticides tested brought down the damage of rain guards due to cricket attack. (Table - Path. 10).

Table - Path. 10. **Effect of different insecticides on control of crickets**

Treatment	Mean percent affected tree
Carbaryl 0.2%	23.02
Neem gold 10 ml/ht	21.37
Neem oil 10 ml/ht	18.60
Malathion 0.1%	18.44
Fenvelerate 0.005	20.67
Control (untreated)	43.67
CD at (P = 0.05)	7.76

22. Maintenance of *Apis mellifera* bees in rubber plantations

Studies on nectar and pollen collection by European honey bees, *Apis mellifera* were carried out. They were found to visit the extrafloral nectary glands of rubber plants from February-April. They also found to visit and collect nectar and pollen from trees like *Callistemon lanceolatus, Antigonon leptopus, Pongamia glabra, Manihot glaziovii, Cocos nucifera, Eucalyptus* sp., *Tamarindus* sp. and *Thunbergia* sp.

Application of sulphur proved effective in controlling parasitic mites of bees. Predators such as Wasps (*Vespa* sp.) and bee birds (*Merops* sp.) are on the increase at RRII.

TSBV resistant colonies of *A. cerana indica* were screened. At present ten colonies are present at RRII and CES Chethackal, which showed tolerance to TSBV disease, reasonable quantity of honey has been extracted from them.

23. Nematode management with plant products

Relative efficacy of soil amendments of green leaves of *Pongamia glabra, Azadirachta indica, Mucuna bracteata* and spent compost of mushroom cultivation on rubber wood saw-dust were evaluated against *Meloidogyne incognita*. The experiment was conducted in mud pots (24 x 27 cm) by amending naturally infested soil with the green leaves of test plants at the rate of 6 g/kg of soil raised with nematode susceptible cover crop, *Pueraria phaseoloides*. The pretreatment population of soil nematodes per 250 g soil was also recorded. Root galls in the host plant and the nematode population in the soil were evaluated after 150 days. *P. glabra* was potentially effective against root-knot nema-

todes with 75 per cent mortality followed by *A. indica* (58%) and *M. bracteata* (51%).

A pot culture study to evaluate the pathogenecity of *M. incognita* is in progress.

24. Vermi compost using wastes of rubber plantations

Three earthworms spp. *viz.*, *Eisenia foetida*, *Eudrillus euginiae* and *Perionix sansibaricus* were cultured in the laboratory. The worms were introduced in the plastic basins with decaying leafy materials, green leafy vegetable wastes, rubber wood saw dust with cow dung etc. The worms were found to feed on these materials and excrete the fine pellet like vermi casts within a period of 2 months. It was necessary to sprinkle water over the material and also to introduce a minimum population of 30 nos. per sq. ft., the more the number, the faster the rate of the process of vermi composting.

In a lab trial for converting rubber wood saw dust into vermicompost, available nitrogen, phosphorus, potassium and microbial counts of various fungus, phosphobacteria, *Actinomycetes*, *Azotobacter* etc. were determined.

25. Rubber wood preservation

Screening of antifungal agents to sapstain, *Botryodiplodia theobromae* ,*Fusarium* sp., *Aspergillus* sp., *Pencillium* sp. and *Trichoderma* sp. were done. Chemicals like benzylon 2 PW 20 per cent, benzylon DW 33 per cent, propiconazole 25 per cent and hexaconazole 5 per cent were used. These fungicides at 100, 250, 500, 1000 ppm were compared with water dipped and untreated by using diffusion method.

No growth of *Botryodiplodia theobromae* was seen on wood treated with benzylon DW 33 per cent, Propiconazole and Hexaconazole except benzylon 2 PW 20 per cent. Growth of *Fusarium* sp. and *Aspergillus* sp. in the treatment of Benzylon DW 33 per cent and Hexaconazole were noticed. Growth of *Fusarium* sp. was observed in the treatment of Benzylon 2 PW 20 per cent and *Aspergillus* sp. in Propiconazole.

PLANT PHYSIOLOGY AND EXPLOITATION DIVISION

1. Ecophysiology of *Hevea*

1.1 Influence of field drought and high temperature

To analyze the effects of moisture stress, high temperature and low atmospheric humidity on growth and development of *Hevea*, a field study was taken up at RRS, Dapchari in the North Konkan region of Maharashtra where extreme conditions prevail in the field during summer. There is practically no rainfall between November and May in this area, with maximum temperature touching 38-41°C and the atmospheric relative humidity falling as low as 25-30 per cent. The present study was undertaken in a nine year old plantation of the clone, RRIM 600. In summer, one plot (250 trees) was irrigated while the second was not, and a comparative analysis of growth and growth attributes were made (Table - Phy. 1).

Table - Phy. 1. **Growth and growth attributes in *Hevea* grown under irrigated and unirrigated conditions**

	Irrigated	Unirrigated	% Change from irrigated
Girth (cm)**	59.2	47.3	-20
Total bark thickness(mm)*	3.52	3.05	-13
Soft bark thickness(mm)*	1.42	0.81	-42
LAI*	6.5	4.3	-33
Light under the canopy (µmol/m/s)**	185	944	
Light interception (%)**	87	37	
Total biomass (kg/tree)**	219.8	120	-45

** significant at 1% probability
* significant at 5% probability

Leaf area index, which is an indicator of the size of the carbon assimilation source, varied from 6.5 in the irrigated to 4.3 in the rainfed trees. The intensity of sunlight that reached the ground inside the unirrigated plantation was 944 µmol $m^{-2}s^{-2}$, but it was only 185 µmol $m^{-2}s^{-1}$ in the rainfed plantation indicating sparse canopy. About 20 per cent reduction in girth was seen in the rainfed trees. Total standing biomass per tree after nine years of growth was 219.8 kg/tree in the irrigated plot and 120.5 kg/tree in the unirrigated plot, showing 45per cent decrease in the total biomass. The total bark thickness was 3.52 and 3.05 mm and the inner soft bark thickness was 1.42 and 0.81 mm in the irrigated and rainfed trees respectively. About 40 per cent of the total bark was soft bark in the irrigated trees, but was only 27 per cent in the rainfed trees. This suggest that the number of laticiferous cells could also be more in the former than the latter. Due to the better growth and development characteristics described above, the irrigated trees came to tapping in the eighth year, but the rainfed trees did not reach tapping stage even after nine years. Studies on leaf gas exchange, xylem sap flow, leaf and latex water relations and tissue biochemistry are in progress.

1.2 Relationship between membrane stability and drought tolerance in field

Five clones viz., SCATC 88/13, RRII 105, RRIM 600, Haiken 1 and PB 260 were screened for multiple stress (low tissue water potential and high temperature) tolerance in the lab using a modified method of

Sullivan, based on cell membrane thermostability as measured by electrolyte leakage from leaf discs exposed to the stresses. To evaluate the field performance of these clones during summer, a few physiological parameters related to drought were measured on field grown plants in the month of March. Leaf wax content, chlorophyll content, photosynthetic rate, leaf water potential and the latex vessel turgor, latex solute potential were measured at 09.00 hrs and 14.00 hrs. Rate of photosynthesis varied from 3.2 µmol /m^2/s in RRII 105 to 6.3 µmol $m^{-2}s^{-1}$ in Haiken 1 at 09.00 hrs. Turgor pressure was the highest in SCATC 88/13 and the minimum in PB 260 at 09.00 hrs and 14.00 hrs respectively. Latex solute potential and leaf water potential did not show much variation among the clones. None of these measurements reflected the trend in membrane stability obtained in lab studies. However, percentage injury was related to percent reduction in photosynthesis (between 09.00 hrs and 14.00 hrs) and percent drying of leaf area (in summer) in RRII 105 and RRIM 600. There was more membrane damage, reduction in photosynthesis and drying of leaf area in RRII 105 than RRIM 600. This suggests that the clone RRIM 600 is more drought tolerant than RRII 105.

1.3 Influence of chilling winter conditions on growth and yield

In the North Eastern states of India, the chilling winter conditions can often be stressful to rubber plants. A new study was initiated during January 1996 in a standing plantation of RRIM 703 and RRII 105 which were planted in 1979 at the Regional Research Station, Agartala, Tripura where the winter temperature can be as low as 5°C in the night, with the days very bright (about 1600 µmol /m^2/s) and reasonably warm (about 20°C). Physiological and biochemical analysies of the various tissues were carried out during the winter of 1996.

2. Physiology of growth and yield

2.1 Characterization of *Hevea* clones

The clones RRII 105, PB 235, PB 215, PB 217, Ch 4, UT, Ch 29, Pil B 84 and Tjir 16 were selected for the study. Yield and yield components (plugging index, turgor pressure, initial flow rate, percentage of dry rubber content and tree girth) were recorded at monthly intervals for three years with a view to characterise these clones.

Mean maximum PI was noticed in clone Pil B 84 (7.5), Tjir 16 (7.3) in the month of March (dry month). Here turgor pressure varied from 8.9 (Tjir 16) to 10.1 bars (RRII 105). Lowest PI was recorded in clone PB 217 (2.2) in the month of December. Clones PB 235 and PB 215 maintained higher drc in March. Lowest drc was noticed in clone Tjir 16 in the month of December. On an average, clones like RRII 105, PB 215, PB 217,

Table - Phy. 2. **Characterization of *Hevea* clones based on their performance in summer (March 1994)**

Clone	TP	IFR	PI	DRC	% yield depression
CH4	0	0	-3	-2	+17
Pil B 84	-4	-36	+33	+1	+35
PB 215	+7	-9	-23	+5	-22
RRII 105	+3	+27	-10	+2	+32
PB 235	-8	-27	-18	+3	+26
PB 217	+9	+82	-15	-1	-27
Tjir 16	0	-9	+21	-1	-50
CH 29	+2	-36	+42	-5	-1
GT 1	-3	0	-25	-2	0
Mean	9.1	0.11	5.7	42.1	33.0

Each number is the % increase (+) or decrease (-) from the mean value computed from the data collected from all the nine clones

PB 235, GT 1 maintained higher drcin latex (40 to 41%) than clones like Tjir 16 and Ch 20 (30 to 35%). High initial flow rate was recorded in clone RRII 105 (0.16 15ml/cm/min) in the month of June (wet season). Clones like RRII 105 and PB 215 maintained higher initial flow rate (0.1344 and 0.1434 ml/cm/min) than the clones like Tjir 16 and Ch 29 (0.0779 and 0.0596 ml/cm/min). Clone PB 217 was the high yielder with 17.5 kg/tree/year. The lowest yield was recorded in clone CH 29 (2.9 kg/tree/year).

The clones were characterized on the basis of yield and yield paramters measured during dry and wet seasons. The per cent decrease or increase from the mean value is shown in Table - Phy. 2. The clone PB 217 was characterized with high turgor, high initial flow rate, low plugging index, high drc and low yield depression in summer.

2.2 Elevated CO_2 studies to increase the initial growth rates of *Hevea* seedlings

It is well established that growing plants in an atmosphere with elevated CO_2 concentration increases the biomass production in C_3 species. Elevated relative humidity (RH) increases the leaf expansion rates. A mild increase in temperature with high concentration of CO_2 and high RH helps in enhancing the growth. A combination of these three parameters was obtained using an indigenous technique and employed to enhance initial growth rates of young *Hevea* plants grown in polybags.

In this technique, trenches were made in an open space and well decomposed organic matter was spread on the floor of the trench. Bud grafted polybag plants of *Hevea* were arranged in the trench. Trenches were enclosed with a polythene mounted on a metal frame between 3.30 Am and 10.30 Pm. On closing the trenches, CO_2, RH and temperature were increased and remained at high levels in the immediate surroundings of the plants until the polythene structure was removed on the following day. On an average, the CO_2 concentration was maintained at 725 to 750 ppm and RH nearly 100 per cent inside the polythene structure. The temperature inside was approximately 1.2°C warmer than the ambient air. Two *Hevea* clones viz., RRIM 600 and RRII 105 were exposed to elevated CO_2, RH and temperature for 90 days. Both the clones showed better growth (Table - Phy. 3). In RRIM 600, the mean stem diameter, leaf area, leaf number, height and biomass per plant showed 17.5, 46.5, 43.9, 54.1 and 26.5 per cent increase respectively in plant exposed to elevated CO_2 over the ambient air grown plants. In RRII 105, biomass increased by 21 per cent and stem diameter, leaf area, leaf number and plant height showed 20, 13.4, 5 and 0.7 per cent increase respectively over ambient air grown plants. It was

Table - Phy. 3. **Growth of *Hevea* clones grown for ninety days under ambient and elevated CO_2**

Clone	Treatment	Dry matter (g/plant)	Girth (cm)	plant height (cm)	Leaf area per plant (cm2)	Leaf no. per plant
RRIM 600	Ambient	37.65	0.94	94.1	1589	18.5
	Elevated	51.19	1.14*	107.15*	2971**	33**
RRII 105	Ambient	37.31	1.13	80.6	2611	30.5
	Elevated	47.25	1.42*	90.21*	3015**	32(ns)

** Significant at 1% probability
* Significant at 5% probability

evident that the combination of elevated CO_2, RH and temperature increases the initial growth rates of the young *Hevea* plants.

2.3 Physiological and biochemical regulation of yield

The intrinsic capacity of *Hevea* to synthesize rubber is different in different clones and is modified by the prevailing environmental factors. The present study was conducted with the objective to understand the role of physiological and biochemical parameters in regulating the yield. The variation in yield of ten different *Hevea* clones in three different seasons of the year in relation to the physiological and biochemical parameters that regulate the *in situ* regeneration of rubber an flow of latex were studied.

2.4 Biochemical regulation of latex regeneration

This study was carried out in the clone RRII 105. Yield was recorded periodically. Total and reducing sugar concentrations in laticiferous tissues were analyzed. The data indicated that the high yield in this clone is related to high sugar conversion efficiency (defined as the ratio of drc to sucrose concentration). Detailed study on the interconversion of basic metabolites into isoprene units and rubber biosynthesis is in progress.

2.5 Mechanism of ethrel action

Experiments were conducted aimed at understanding the fundamental effects of ethrel on lutoid membrane functions in relation to its biochemistry and water relations. In a field study, ethrel was applied on virginbark of clone RRII 105 and changes in physiological and biochemical parameters associated with latex flow and regeneration are being studied. In a laboratory study to investigate the effect of ethylene on lutoid stability, *in vitro* bubbling of ethylene through lutoid suspension for 0, 15, 30, 45, 60, 90 and 120 min. was found to increase the bursting index (BI) of lutoids. But ethylene did not exert any direct effect on bursting index of latex. Studies on ATPase activity of lutoids of control and stimulated trees are in progress.

3. Tapping panel dryness syndrome

3.1 Long term field studies under the IRRDB program

The monitoring of trees of clone RRII 105 for biochemical composition (sucrose, thiols and inorganic phosphorus, PI) of the latex and for the occurrence of TPD were continued. Six trees showed symptoms of partial dryness and one tree became completely dry during this period. A comparison of the data for a tree which went fully dry with the mean data for ten randomly sampled healthy trees is given in Table Phys-4. The concentrations of PI and sucrose in the latex were higher in the affected than the normal trees before the onset of TPD. No clear pattern was observed for thiols. The occurrence of high concentrations of sucrose in the affected trees before the onset of TPD suggests that the supply of photosynthates for rubber synthesis was probably not the primary cause for TPD. It could rather be due to inhibition in the metabolic conversion of sucrose into rubber due to impaired energy status in the laticiferous tissues of the trees that are being affected by TPD. Experiments are being planned to examine this hypothesis.

3.2 Biochemistry of TPD

Bark samples collected from seedling population of *Hevea* plantation were used for biochemical analysis. Several components like soluble proteins, sugars, phenol, glutathione and a few enzymes like peroxidase, polyphenol oxidase etc. were analysed in the laticiferous tissues of both normal and TPD affected seedling plants.

Table - Phy. 4. **Concentration of thiols, sucrose and Pi in the latex of TPD affected and normal trees**

Date	TPD affected tree*			Normal trees**		
	Thiols (mg/100g)	Sucrose (mg/100g)	Pi	Thiols	Sucrose	Pi
26.06.95	10.37	311.14	66.57	8.80	264.30	58.70
10.07.95	12.31	327.97	79.23	12.40	220.60	68.90
24.07.95	14.29	302.08	77.30	12.60	180.20	69.60
07.08.95	11.89	190.33	84.49	12.60	170.90	69.70
11.09.95	12.47	533.69	97.32	10.30	238.80	71.90
09.10.95	16.28	441.42	99.95	13.23	274.78	64.36
30.10.95	10.40	415.22	77.48	8.00	240.32	48.28
16.11.95	14.12	668.20	83.72	11.53	378.68	57.29
11.12.95	10.64	811.76	54.76	8.27	451.49	38.94
09.01.96	13.43	678.12	36.04	10.22	824.82	38.89
13.02.96	10.44	238.65	44.97	8.26	184.32	52.42
12.03.96	8.14	449.75	36.38	8.59	127.40	27.10

* TPD affected tree became 50% dry on 909.10.95 and completely dry after 12.03.96.
** Mean values from ten normal trees

Significant differences were noticed in the peroxidase enzymes and glutathione levels between the two. The enhanced peroxidase enzyme activities in TPD affected plants may be the result of biochemical regulation of enzyme and/or the effects at transcriptional or translational levels. In a monoclonal population (RRII 105) the biochemical analysis showed that TPD affected trees had comparatively higher levels of sugars, phenols, soluble proteins, peroxidase enzyme activity and HMG CoA reductase activity in the bark tissue. However, polyphenol oxidase activity was comparatively low. The higher peroxidase activity in TPD affected trees may be related to the loss of functional integrity of the membrane system.

3.3 Growth regulators and TPD

Methods were standardized for the direct ELISA to quantify the t-zeatin riboside with the polyclonal antibody raised against t-ZR BSA conjugate. The laticiferous tissues from both normal and TPD affected plants were used for the assay of cytokinins. There was less t-ZR in the laticiferous tissues of TPD affected than normal plants of *Hevea* clones. A reduction in t-ZR was related to increased peroxidase activity in the laticiferous tissue of TPD affected trees. Experiments are in progress to evaluate the physiological significance of this relationship.

4. Stock-scion interaction studies

4.1 Effects of root-stock on scion

Observations on growth, physiologi-

Table - Phy. 5. **Root cation exchange capacity of own-rooted, seedlings (ungrafted) and budded plants of three clones**

Root type	CEC (meq/100g dry root)		
	RRII 105	RRIM 600	GT 1
Own-rooted	37.26	26.08	34.33
Seedlings (ungrafted)	32.18	34.75	31.44
Budded plants	39.27	27.47	38.76

cal and biochemical parameters in five clones viz., RRII 105, RRII 208, RRIM 600, GT 1 and GI 1 budgrafted on polyclonal seedlings were recorded to evaluate the influence of stock on scion and *vice versa*. In order to assess the extent the growth of the rootstock at the time of budding has affected the scion, various growth parameters such as height, diameter, total number of leaves, total leaf area, above ground biomass etc. measured on rootstock seedling at the time of budgrafting were correlated with the measurements made on the scion 18 months after budding. The results indicated that the height and diameter of the scion were positively correlated with the height and diameter of the rootstocks at budding. The total number of leaves on the scion showed a positive correlation with that in the root stock, but the mean leaf area and specific leaf weight did not show any appreciable correlation.

To evaluate the influence of rootstock on some of the physiological aspects of the scion, leaf photosynthetic rate, stomatal conductance and transpiration were studied before and after budding. Only photo-rate of scion was positively correlated with that of the rootstock before budding.

Rootstock induced polymorphism in the scion leaves was studied in five clones. Polymorphism in three enzymes viz., peroxidase, catalase and esterase was analyzed. Rootstock induced changes of the isoenzymic pattern in the scion was observed in one or more of the six budded plants propagated from single mother plant. The soluble protein concentration in the leaf extracts was also analyzed and found that irrespective of the concentration of the protein in the leaf there were specific bands present or absent in these plants. This indicates genetic polymorphism in the scion to be induced by the rootstock.

4.2 Comparison of own-rooted and budded plants

An experiment was carried out to compare the root CEC and mineral elements in own-rooted and budded plants of three clones of *Hevea*. The following observations were recorded in seedlings, own-rooted plants and budded plants of three clones of *Hevea viz.*, RRII 105, RRIM 600 and GT, 1. Studies on the root CEC of seedlings before budding after one year of budding and own-rooted plants revealed that CEC is a clonal character and the scion appears to be controlling the CEC of the roots irrespective of the CEC of the rootstocks (Table - Phy. 5).

Foliar N, P, K, Ca, Mg, Fe and Mn of one year old own-rooted and budded plants of the above three clones were also studied. It was found that budded plants of all the three clones had higher foliar N content than the own-rooted plants (Table-Phy. 6). In general, Ca and Mg contents

Table - Phy. 6. **Comparison of foliar N, P, K, Ca, Mg, Fe and Mn in three clones (dry weight basis)**

Clone	N (%)		P (%)		K (%)		Ca (%)		Mg (%)		Fe (ppm)		Mn (ppm)	
	O	B	O	B	O	B	O	B	O	B	O	B	O	B
RRII 105	2.20	3.12	0.17	0.19	0.86	0.95	0.98	0.91	0.27	0.17	1298.37	657.13	174.36	104.90
RRIM 600	2.31	3.16	0.19	0.19	0.92	1.01	1.002	0.76	0.24	0.17	584.60	560.77	160.80	89.50
GT 1	2.66	3.32	0.20	0.20	1.21	0.92	1.04	0.55	0.28	0.21	483.98	659.83	202.98	93.27

O : Own-rooted B : Budded plants

Phy. 6). In general, Ca and Mg contents were higher in own-rooted plants than in budded plants. Fe content of own-rooted plants of RRII 105 was very high indicating the high absorption of that element. But in the budded plants of RRII 105 the Fe content was comparable with that of the other two clones indicating the influence of the rootstock.

4.3 Induction of two-tier root system

An attempt was made to induce rooting at the base of the scion portion of budded plants in addition to the usual stock roots. This experiment was carried out with an assumption that these plants with the 'two-tier' root system may dilute the influence of rootstock to some extent. A preliminary study was conducted in five clones viz., RRII 118,RRII 208, GT 1, PCK 2 and PB 260 showed that profuse root growth (both stock and scion roots) could be induced in these plants.

5. New tapping experiment on upward tapping in inclined panel parallel to the angle of inclination of latex vessels - inclined upward tapping (IUT)

The experiment started in 1993 was continued and data on yield, bark consumption, spillage after fixing guide and brown bast incidence are being recorded.

RUBBER CHEMISTRY PHYSICS AND TECHNOLOGY DIVISION

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

1. Studies on drying of raw natural rubber

Performance evaluation of the 96 sheets capacity solar-cum-smoke dryer under different seasons and loadings was continued. The quantity of sheets dried and the consumption of firewood are being monitored to assess the overall performance of the dryer.

Action to install three solar-cum-smoke dryers of 1200 sheets capacity at different locations for evaluation was initiated.

Preliminary experiments on sun drying of sheet rubber showed that, drying is faster if same day sheeting is done. When the coagulum is left over night, drying is delayed. The raw rubber properties of sun dried sheets are found to be comparable to smoke dried sheets.

2. Studies on different forms of natural rubber

Due to low Po and PRI the quality of rubber produced from field coagulum often fails to meet the specifications of a particular grade. A study has been initiated to improve the Po and PRI of ISNR produced from field coagulum. Studies indicated that hydrazine hydrate and tetraethylene pentamine (TEP) treatments were more effective than sulphamic or phosphoric acid treatments in improving Po and PRI.

Excessive mastication and exposure to different ageing conditions reduce the plasticity of rubber. In a study to compare the effect of these conditions on vulcanizate properties, crumbs of fresh and dry field coagula were given different ageing conditions such as sunlight exposure, treatment with pro-oxidants and other chemicals. Sun drying by eight days exposure in summer reduces plasticity values drastically. Copper contamination adversely affects the ageing properties compared to iron and manganese of similar concentration. The

physical and ageing properties of oven dried crumbs masticated to different extent were better than sun dried crumbs of similar plasticity values.

Popular forms of NR such as RSS 4, ISNR 20 and EBC 1X showed considerable difference in breakdown characteristics during initial trials. Hence, the study was extended by collecting more samples from different locations. Studies on effect of mastication on processing and vulcanizate properties of ISNR 5 and ISNR 20 were initiated. The effect of different peptisers on the mastication behaviour of ISNR 5 is under investigation.

3. Development of epoxidised natural rubber

Second stage modification of epoxidised natural rubber with sulphamic acid has been attempted to introduce new crosslinking site. The reaction was carried out with ENR 10 and ENR 25 at the latex stage as well as in dry rubber stage. Characterisation of the products did not show expected reaction.

Due to the presence of more than 10 ppm of iron in field latex, epoxidation using H_2O_2/HCOOH system leads to premature coagulation of latex, degraded products and reduced epoxy content. Complexing the iron for arresting the interaction can be done *in situ*. Two complexing agents which would work effectively at lower pH and at high temperature (60°C) for epoxidation reaction are being tried.

In a swelling study of NR, NBR and ENR gum vulcanizates in seven vegetable oils, butterfat and six carboxylic acids at 70°C, abnormally excessive swelling of ENR gum vulcanizate in carboxylic acids was noticed similar to partially hydrolysed rice bran oil. But swelling in esters of carboxylic acid like methyl acetate and methyl propionate at 28°C was in the order NBR>ENR>NR.

4. Blends of natural rubber with other elastomers and thermoplastics

To improve the ageing resistance of NR latex products, blending of NR and SBR at latex stage was initiated. Blending of creamed and prevulcanized SBR latex with NR latex compound and then postvulcanizing the film gives better properties. Blends of NR and SBR at 80 : 20 proportion improved the ageing resistance.

Blending of NR with PVC adversely affects the properties of NR. A preliminary study on ternary blends of NR/ENR/PVC and NR/NBR/PVC was initiated.

5. Natural rubber technology

Prevulcanization of field latex followed by concentration (creaming) was compared with the conventional process of concentration followed by prevulcanization. The films exhibited comparable strength properties, but prevulcanized field latex required more ammonia for the creaming process and when creamed, the viscosity of the latex was comparatively high. Study on the effect of fillers on prevulcanization characteristics are in progress.

To reduce environmental problems and to conserve natural rubber, recycling can be adopted. Therefore, a study on the effect of devulcanized and untreated tyre crumbs on properties of retread compounds was taken up. Devulcanized tyre crumbs were prepared using a recently commercialised devulcanizing agent "Delink R". It was observed that use of up to 20 phr of devulcanized tyre crumbs in retread compound maintained most of the properties of the control compound, with the added advantage of lower heat build up and cost, but

reduced the cure time and scorch safety of the compound. Addition of untreated tyre crumbs affects the abrasion loss, heat build up and flex resistance.

6. Composites based on natural rubber

In a study on the preparation of rubberised bitumen using different sources of NR optimum properties for the rubberised bitumen were obtained when bitumen was heated at 160°C for 4 h with micro crumb or buffing powder and 1.5 h for powdered waste latex products.

Among the different forms of rubber used as encapsulant for commercial urea, skim rubber and reclaimed rubber showed better results. The volatilization loss and hygroscopicity of rubber modified urea are practically negligible compared to commercial urea. Leaching experiments showed that rubber modified urea has release characteristics.

AGRICULTURAL ECONOMICS DIVISION

The Agricultural Economics Division concerned with studies relating to economic aspects of is natural rubber cultivation, processing, marketing and end uses. Studies on different aspects of ancillary sources of income and by-products are the other important areas of research. Collaborative projects are also undertaken to evaluate economic viability of the findings of other divisions.

1. Evaluation of planting materials under commercial cultivation.

This is a continuous study undertaken by the division since 1974 to generate information on the commercial yield of prominent clones. A data base has been built up covering field-wise yield and related information on a monthly basis for 30 clones covering 65 estates.

2. Operational efficiency of rubber plantations at different levels of management

The reconnaissance survey has been completed. The units for the main survey have been identified.

3. Census of planting materials used by small growers

The study assessed the quinquennial trends in the adoption of planting materials by small growers covered in the RPD scheme during the years 1984-85, 1989-90 and 1994-95. A strong preference for RRII 105 was observed during the reference years. An increase in multi-clonal planting with RRII 105 to the tune of 6.22 percentage between 1989-90 and 1994-95 was observed. The relative shares of clones such as RRIM 600, PB 235, GT 1 and PB 311 had declined and a marginal increase in the share of PB 260 was noticed. Share of RRII 105 increased in Nagercoil, Central and Northern Kerala, but there was a decline in its share in South Kerala. An inverse relationship existed between the extent of monoclonal planting and holding size.

4. Monitoring of the ancillary products

The estimated production of rubber wood during 1995-96 was 1.5 million m^3. The end use pattern of the stem wood constituting 60 per cent of the total is shown

in Table-Age. 1. The production of rubber seed and cake were estimated as 3340 MT and 6200 MT respectively during 1995-96. The rubber honey sector had shown signs of recovery and the estimated production during 1995-96 was 1000 MT.

Table-Age. 1. **Pattern of rubber wood consumption in India (1995-96)**

Industrial use	Volume of consumption ('000 m^3)
Packing cases	503
Plywood & veneers	185
Safety matches	54
Furniture, panelling and consumption components	140
Others	18
Total	900

4.1 Economics of rubber wood production : Cost-benefit analysis

This study assessed the comparative profitability of different combinations of yield of NR and timber at different life cycles of plantations and the specific case of planting rubber for timber without the option of tapping. The timber yield required to offset a 20 per cent loss in NR yield was more than seven times of the normal, which may not be technically feasible. Under the same NR yield profile, a shift from 25 to 20 year life cycle would give comparable returns only if the timber yield is 60 per cent higher than that of the 25 year life cycle. The possibility of growing rubber trees for timber alone was found not viable even if the stand was increased to 600 trees per ha or the cost of NR is 30 per cent lower. Under the prevailing conditions, it may not be advisable to popularise timber latex clones (TLC) in India.

4.2 Primary processing of rubber wood in Kerala

This study was focused on the status of primary processing sectors of rubber wood *viz.*, sawmilling and peeling. A field survey was undertaken covering 94 saw milling and 25 peeling units. In the primary market, in 1980s there was the emergence of intermediaries operating at the level of growers and auction centres. The farm gate price realised by the grower was only 55 per cent of the terminal market price. The annual average procurement of the sawmilling and peeling units were 2100 MT and 4266 MT respectively.

The estimated capacity utilisation was 68 per cent for sawmilling and 53 per cent for the peeling sectors. While packing case materials (slabs, boards and shooks) formed 70 per cent of the sale of sawmills, 80 per cent of the sales volume of the peeling units consisted of veneers of 2.5 mm thickness. Technological upgradation in these processing industries was found to be the prerequisite to maximise recovery rates and value addition.

4.3 Commercial exploitation of rubber honey in India

A status report of the rubber honey sector was prepared on the basis of a field survey covering 29 major bee keeper's societies and collection centres during the period 1993-94. The rubber honey production showed signs of recovery due to the immunity gained gradually by the Indian Bees (*Apis cerana indica*), the introduction of the disease resistant Italian bees (*Apis mellifera*) and the promotional activities of the societies. The Italian bees produce five times the yield of Indian bees. But this bee has become popular only in Central Kerala. The average processing cost of honey is Rs.16.50 per kg. The sale of honey is mainly through Khadi shops (39%) and for ayurvedic pharmaceutical uses (26%). The rubber plantation sector of India has a potential to produce 66,230 MT/annum from bee keeping and the estimated annual gross income is Rs.8325/ha.

5. Other studies

Studies such as the role of rubber producers' societies in the adoption of improved cultural practices, time-series analysis of natural rubber price in India, performance of Indian automotive tyre industry, an evaluation of the trends in the subsidy to the rubber plantations in India and a study of labour in the unorganised sector are under different stages of progress.

RESEARCH COMPONENT OF WORLD BANK ASSISTED RUBBER PROJECT

The research component of the World Bank assisted rubber project of the Rubber Board, to be implemented by the Rubber Research Institute of India, is aimed at providing research and technical back-up for the implementation of the proposed rubber project and also the long term development of the rubber plantation industry in India. As the RRII at present does not have sufficient infrastructural facilities to undertake need based research back-up to the project, a few research and infrastructural development activities are envisaged. This includes, clone identification, conducting exploitation and clone evaluation studies in traditional and non-traditional areas, strengthening of biotechnology, germplasm evaluation and genome analysis projects, strengthening of regional and satellite laboratories for soil and leaf analysis and descriminatory fertilizer recommendation systems, conducting studies on rubber based sustainable farming systems in the non-traditional areas, studies on quality improvement of raw rubber, training and exchange of scientists, and strengthening of computer facilities and support services.

1. Exploitation studies

The objectives of the project are to evolve low frequency tapping in popular clones under different climatic conditions, maximising the production in later years of the life of the trees, to study the crop losses due to rains and latex diagnosis studies for optimising the tapping systems. Twelve field experiments on low frequency tapping systems have been laid out in an area of 163 ha comprising large estates and medium holdings in different districts of Kerala and Kanyakumari district of Tamil Nadu. Periodic growth measurements and TPD scoring were carried out. Stimulation treatments were imposed in various experiments. Under d/4 system of tapping, RRII 105 gave an average yield of 1000 kg/block (400 trees) over 10 months period while GT_1 gave 700 kg, RRIM 600, 600 kg over a period of 8 months. Experiments on controlled upward tapping is also in progress.

For latex diagnosis studies to fix base values of latex diagnosis parameters like sucrose thiols and inorganic phosphoruous per tree per tap yield, dry rubber content and block yield of clone RRII 105 under two tapping systems in two panels (B1 and B2) were recorded.

2. Clone evaluation

The objective is to study region-wise performance of various clones through scientific experimentation and survey in existing plantations, thereby identifying suitable clones for various agroclimatic regions. Growth characters were recorded in three field trials in Kanyakumari region. Preparation of planting materials for a large scale clone evaluation trial at the RRS,

Padiyoor and 3 block trials are in progress. Survey work in estates and small holdings was initiated with the help of the Rubber Production Department.

3. Biotechnology/Tissue culture

Studies such as *in vitro* plant regeneration, somatic embryogenesis and transgenic plant synthesis are in progress. Survey of clones belonging to category I, II and III for *in vitro* response has been done. Trials with 12 clones showed that the nutritional requirement of the media is clone specific and separate media needs to be developed for each of the commercial clones.

In a collaborative effort with Nottingham University, successful somatic embryos were developed using protoplasts. Incorporation experiments with a reporter gene ('GUS' gene) into rubber was attempted.

4. Germplasm

For Hot Spot screening of Brazilian germplasm for drought and cold tolerance, a field trial using a number of clones has been envisaged at the Research Station, Sukma (Madhya Pradesh). Planting materials have already been raised and maintained in polybags. For genome analysis studies, a laboratory is being set up at Rubber Research Institute of India.

5. DRIS fertilization

In order to strengthen the soil and tissue testing facilities in the Regional and Satellite laboratories, a number of equipments have been procured. The laboratories were reorganised for efficient functioning of various units. In order to computerise the fertilizer recommendations, personal computers have been installed at three regional laboratories and the Central Lab at RRII. Mobile soil camps were organised and on the spot fertilizer recommendations given wherever possible.

6. R&D activities on rubber processing

Projects such as improvement of drying conditions of sheet rubber in small holdings, basic studies on drying of rubber, techno economic survey on different forms of processed rubber and modified forms of NR were in progress. Evaluation of ready made smoke house modified as solar-cum-smoke drier, has shown that there is a definite reduction in firewood consumption compared to unmodified one. The quality of sheets was also found to be comparable to that of smoke dried sheets except that it had lighter colour. In a comparative study of electric and oil fired dryers it was observed that although the PRI tends to be higher in the case of diesel drier, the breakdown properties were not influenced by the type of drying. Swelling behaviour of ENR in vegetable oils, butter and six different carbolic acids was assessed, in comparison with NR and nitrile rubber (NBR). The order of swelling was found to be NBR>ENR>NR.

7. Rubber based sustainable farming systems

The project could not be initiated since scientific staff is not positioned.

8. Studies on copper residue in rubber growing soils

Detailed project proposals received from the Kerala Agricultural University, Trivandrum was submitted to World Bank for approval.

9. UPASI component

UPASI R&D Centre, Kottayam was selected as NGO Centre for soil and tissue analysis. An MOU was executed and an advance of Rs.1.4 million was given. Essential equipments are being procured by the centre and analytical staff are being positioned.

10. General

A proposal for restructuring of the World Bank Project has been submitted and the progress of work was evaluated by the Mid Term Supervision Mission during the last week of March, 1996. Out of the 28 posts sanctioned by the Govt. under the Research component, 25 positions have been filled up.

CENTRAL EXPERIMENT STATION, CHETHACKAL, KERALA

The Central Experiment Station of the Rubber Research Institute of India covers an area of 254.80 ha. Long term field experiments have been laid out in this station by the divisions of the RRII. Over 4000 genotypes of wild Brazilian germplasm received from the Malaysian centre and 122 clones of Wickham materials have been established and maintained.

During 1995-96 period an area of about 4.5 ha was replanted for different experimental purposes. The total crop production during the period was 124875.94 kg.

There were 207 permanent and 189 casual workers on rolls, during the period and the total mandays engaged were 70684.

The dispensary in the station provided medical services for 10539 cases.

REGIONAL RESEARCH STATION, GUWAHATI, ASSAM

The Regional Research Station in Assam concentrated mainly on evaluation of clones, nutritional requirement, diseases and pest management.

1. Multidisciplinary evaluation of clones

In the 1985 clone trial, maximum girth was recordedin RRIM 600 (59.67 cm) followed by PB 86 (59.08 cm) and RRII 118 (59.06 cm). Girth was least in PB 5/51. RRIM 600 had the highest yield (29.37 g/tree/tap) followed by PB 235 (24.38 g). In 1986 clone trial, maximum girth was recorded for RRIC 102 (62.34 cm) followed by RRII 118 (61.08 cm) and PCK 1 (59.09 cm) while minimum girth was recorded for RRII 105 (53.18 cm). The maximum average yield was recorded in PB 311 (24.35 g) followed by PB 310 (20.73 g).

2. Nutritional studies (immature phase)

Two trials on nutritional requirement of young *Hevea* with clone RRII 105, one at Nayekgaon and with RRIM 600 at Mendipather, were started in 1987 and 1986 respectively. Higher doses of N showed positive response in terms growth whereas no trend was observed for P and K. Tapping commenced in with the trials.

3. Interaction between K and Mg

In the trial at Sorutari, it was observed that a combination of highest doses of K (40 kg/ha) with higher dose of Mg (7.5 kg/ha) gave highest absolute girth (46.7 cm). Whereas at Nayekgaon, combinations of higher doses of Mg with no K showed highest absolute girth (49.3 cm). The trees at Nayekgaon attained tappable girth earlier than those at Sorutari.

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

The objective of this trial is to compare the efficiency of different sources of phosphatic fertilizer. Highest absolute girth (54.7 cm) recorded in rock phosphate treatment may be due to the residual rock phosphate mineralised and made available to plants. The trees are under tapping and the effect of different treatment combinations on yield is being monitored.

The trial at Nayekgaon was started in the year 1987 with seven treatment combinations. Among the treatment combinations, water soluble phosphorous (60 kg/ha) continues to record the highest absolute girth (50.6 cm) compared toother treatments. Yield data are being recorded for further evaluation.

5. Survey of diseases and pests

Pest and disease survey was carried out in 50 locations covering 12 different rubber growing tracts in Assam, Mizoram, Tripura and eastern region of Bengal.

Powdery mildew disease was noticed in most of the locations surveyed. High intensity of the disease was noticed in some locations at Topatoli, Baithalangsoo, Kolasib and Nagrakata which caused repeated premature defoliation and die-back of twigs and drying of flowers.

The incidence of leaf disease caused by *Colletotrichum gloeosporioides* was noticed during June to September in some of the locations. Both mature trees and nursery plants were found to be affected in some areas.

Leaf blight caused by *Periconia heveae* was noticed on tender leaves during November to March in nursery plants which caused severe defoliation and die-back of shoots in some locations in Assam. Leaf blight was also observed on nursery plants in RRS Farm at Kolasib.

Brown root rot disease caused by *Phellinus noxius* was noticed in some plantations at Bithalangsoo, Topatoli, Tuichuhen, Purba-Mirza and Dumduma. The intensity of brown root disease at Dimduma plantation (Tripura) was about 7.5 per cent.

Infestation of scale insects, termites, slugs and snails were noticed in mild form in some plantations in Assam.

6. Control of powdery mildew disease

For evaluation of economic efficacy of control of powdery mildew disease a trial on dusting of agricultural grade sulphur was initiated in mature areas of rubber in RRS farm Sorutari. The requirement of sulphur powder for 5 rounds of dusting was found to be 100 kg per ha which has effectively controlling the incidence of powdery mildew disease.

7. Control of powdery mildew disease using zinc

A trial to control *Oidium* in seedling nursery plants was carried out in Sorutari farm by spraying Chelazin (liquid and powder), Bavistin alternate with wettable sulphur and agricultural grade sulphur powder on leaves. Plants treated with Chelazin liquid at the lower concentration (5 ml/l of water) recorded maximum height and diameter at the collar region (1.29 cm) although there was some *Oidium* disease incidence (10.0%) in this treatment. The control plots recorded 100per cent disease incidence with very high severity. There was no disease in the sulphur treated plots, but the growth of seedlings was less than Chelazin treated plots (Table- Nea. 1).

Table- Nea. 1. **Incidence and severity of powdery mildew disease in *Hevea* seedlings treatments**

	Treatments											
	C	S	WSB	A1	A2	A3	A4	B1	B2	B3	B4	CD (P = 0.05)
Disease incidence (%)	100.0	0	17.5	100.0	93.75	10.0	8.75	100.0	100.0	40.0	37.5	6.23
Severity	5.0	0	0.35	4.9	4.4	0.18	0.16	5.0	4.8	2.7	2.2	0.25
Height (cm)	83.61	100.28	97.37	100.6	101.33	126.88	128.03	94.56	96.33	102.48	97.53	4.52
Diameter (cm)	0.75	0.97	0.94	0.96	1.06	1.29	1.28	0.93	0.91	1.00	1.01	0.06

8. Performance of polyclonal material

Out of 250 polyclonal seedlings 114 trees were tapped (1/2S d/2) and data on yield recorded. Girth was also recorded twice a year. Performance of some polyclonal seedlings was found to be promising.

9. Introduction and evaluation of germplasm

Among the 650 Brazilian germplasm lines maintained, 500 were opened for test tapping. Evaluation of yielding pattern is in progress.

REGIONAL RESEARCH STATION, AGARTALA, TRIPURA

This station is well equipped to undertake research work performing to the disciplines of Agronomy in Soils, Botany and Plant physiology. The research farm of about 85 ha is located at a distance of about 20 km from Agartala. Majority of the research projects are undertaken in this farm. The station also has a mobile soil and tissue testing laboratory which caters to the needs of rubber growers in the entire north eastern region.

1. Nutritional trial

1.1 A 3^3 factorial trial with 3 levels of B N (0, 30, 60 kg/ha); P (0, 30, 60 kg/ha); K (0, 30, 60 kg/ha) was laid out with clone RRIM 600. Observations on half yearly girth and monthly mean yield were recorded during the year.

Increased dosage of N and P shows a positive influence on yield. However, there is no significant difference in girth due to treatments.

1.2 Immature phase (polybag plants)

This trial was started to study the effect of higher doses of nutrients and to compare the efficiency of different sources of phosphatic fertilizers. The trial was laid out in a randomised block design with 6 treatments replicated thrice. The clone used is RRIM 600. Half yearly girth and monthly tree-wise yield (g/tree/tap) is being monitored.

Table- Net. 1. **Average yield (g/tree/tap) at different levels of fertilizer**

	Fertilizer		
Nutrients	0	1	2
N	34.22	37.65	37.87
P	34.02	37.06	38.66
K	36.41	36.80	36.53

Table- Net. 2. **Mean girth (cm) for the year**

Treatment	Mean girth (cm)	
	Aug. '95	Feb. '96
30:30:30	51.30	52.24
30:30(15):30	51.66	52.94
60:60:60	54.03	55.13
60:60(30):60	53.17	54.51
90:90:90	52.53	53.85
90:90(45):90	53.09	54.10

2. Density-cum-nutritional trial

The trial was laid out in 1987 in a split plot design with 4 replications. The main treatment consists of 3 densities viz., d1 - 420 trees/ha; d2 - 606 trees/ha and d3 - 824 tress/ha). Three fertilizer levels in the ratios 40:40:20 (m1); 60:60:30 (m2) and 80:80:40 (m3) of N, P and K/ha respectively were imposed as sub plot treatment and two clones RRII 105 (c1) and RRII 118 (c2) were used as the sub sub plot treatment.

3. Forms and placement of fertilizers

3.1 Phosphatic fertilizer (immature phase)

The trial was laid out in 1986 to compare the efficiency of different sources of phosphatic fertilizers with the clone RRIM 600. Since there was no significance in growth or yield due to treatments, the trial was discontinued.

3.2 Mode of fertilizer application (N & P)

This is an on-farm trial at Tulakona in 1990 with the clone RRIM 600 laid out. The treatments consists of 2 forms of P (MRP and SSP) along with MOP and three methods of application viz., band application, 15 and 30 cm deep pocket application respectively. It has been observed that a combination of Ammonium sulphate and rock phosphate applied as band gave the highest mean girth (44.16 cm) followed by ammonium sulphate and Single super phosphate combination applied as band application (43.96 cm).

4. Agro-ecological and socio-economic impacts

4.1 Litter fall, accumulation and decomposition

Monthly litter fall, standing crop, litter decomposition and nutrient content in a 14 year rubber plantation of clone RRIM 600 has been monitored. The data is being processed.

4.2 Influence on soil physico-chemical properties

Profile soil samples were collected from different plantations like rubber, sal, accacia, cashew along with its adjacent field following 'jhumming' practice. The micronutrients like Zn, Cu and Fe and available macronutrients like P, K, Ca, Mg (mg/100 gm soil) and organic carbon (%) were determined. Available water storage capacity of rubber area (15 years) was higher than all other forest plantations.

5. Clone trial

5.1 Clone trial (1995)

The yield from A panel showed the following hierarchy : PB 235; RRIM 600. RRII 105, RRIM 703 and RRII 203. A combination of yield and stability factors when considered together revealed RRIM 703 as most stable among all clones, yielding highest during November. Pb 235 gave highest yield from mid October to the early November. Data on yield components from B panel is being analysed.

5.2 Clone trial (1987)

Though this trial was extensively damaged by tropical winds, growth and yield performance of six clones (RRII 208, RRIM 600, PR 107, SCATC 88-13, SCATC 93-114 and Haiken 1) are being monitored on quarterly and monthly basis respectively.

6. Performance of polyclonal seedlings

In the trial, initiated during 1987, about 190 seedlings which attained tappable girth were opened and yield evaluation is being done on the basis of individual dry rubber yield. A few promising trees are selected for multiplication and evaluation.

7. Recombination breeding and selection

7.1 Full-sib progeny evaluation

Twenty seven cross combinations of hand pollination programme (1991, 1992 and 1993) were multiplied for evaluation in comparison with parents. These genotypes are borne from crosses involving six clones viz., PB 86, SCATC 88-13, GI 1, RRIM 600 and RRII 105. The plants are ready for field planting.

7.2 Half-sib progeny evaluation

This trial was formulated to find out useful recombination on open pollination and for evaluating their own progenies. Fortynine recombinants along with fifteen female parents were laid in a trial following two dimensional lattice design. Data on morphological parameters is being collected.

8. Germplasm conservation, evaluation and maintenance

From 366 clones of Amazonian prospection, 104 genotypes were selected for multiplication and evaluation, of which 81 genotypes were brought under a comparative trial for yield evaluation with RRIM 600 as control. The growth observations were periodically monitored.

9. Effect of different tapping systems in combination with tapping rest during winter

An experiment on different tapping system in combination with winter tapping rest commenced before last winter with the clone RRIM 600 to formulate approximate exploitation system suitable for this region. Split-plot design has been adopted for this experiment using 1/2 S d1, 1/2S d2 and 1/2S d3 as main treatments and temperature regimes of 20-20°C, 15-15°C and 10-10°C for tapping rest as the sub treatments. Other weather parameters viz., windspeed, soil moisture, evapo-transpiration, intensity of sunshine, etc. are also taken into consideration. The preliminary data shows that the occurrence of TPD is higher in 1/2S d1 continuous tapping system followed by 1/2S d2 and 1/2S d3 respectively. This phenomenon is sequentially followed in the tapping rest system also. The computation of data on yield recorded on weekly basis is underway. The yield pattern of plants as well as occurrence of TPD in different tapping systems after the winter rest are being observed.

10. Effect of low temperature on growth

It was been observed during the cold months in all the clones, there was a gradual decline in photosynthesis, stomatal conductance and transpiration along with a significant accumulation of intercellular carbon dioxide.

REGIONAL RESEARCH STATION, TURA, MEGHALAYA

The regional research station, Tura conducted experiments mainly in Ganolgre and Darachkgre farms.

1. Field experiments at Ganolgre

1.1 Multidisciplinary evaluation of clones

In 1985 multiclonal trial, PB 235 attained the highest girth (58.67 cm), followed by RRII 203 (58.55 cm) and RRIM 600 (58.10 cm). In 1986 clone trial, the highest girth was recorded in RRIC 105 (62.0 cm) followed by RRII 208 (58.10 cm) and PB 311 (56.75 cm).

1.2 Performance of polyclonal seedlings

The polyclonal seedlings have attained an average girth of 17.91 cm. The overall growth of the seedlings is quite satisfactory.

1.3 Rubber based cropping system

The growth of tea and rubber (RRIM 600) were found to be quite satisfactory, while the orange plants were showing retarded growth. Tea leaves were harvested regularly.

1.4 Block plantation

In a block plantation of RRIM 600 the average growth recorded at the lower side of the plantation was 48.07 and 46.37 cm respectively. The growth of the plants were found to be satisfactory.

2. Field experiments at Darechikgre

2.1 Multidisciplinary evaluation of clones

The growth of the 45 surviving plants planted during 1985 was found to be very much retarded due to the high elevation (1100 MSL) of the area.

2.2 Intercropping with perennial crops

The tea plants are growing well at the high altitude of Darechikgre, while the orange plants as well as polyclonal seedlings of rubber have completely perished.

3. Experiments in plant pathology

3.1 Plant diseases

No serious outbreak of diseases was recorded in the rubber plantations in the Garo Hills District except the incidence of powdery mildew. The disease was controlled by timely dusting of sulphur.

3.2 Mushroom culture

Only about 40 packets of spawn could be prepared. Wheat grains were used for preparation of spawn.

3.3 Weedicide trial

The application ofe l. glyphosate/ha was found to be quite effective in controlling Lalang grass in the rubber plantation, while 4 l. Paraquet/ha was required to control the growth of the grass. The experiment will be repeated for confirmation of results.

3.4 Litter decomposition

The rate of decomposition of rubber leaf-litter was found to be rapid and only 20.3 per cent of weight remains after a period of seven months. A number of fungi were found to be associated with the process of decomposition. The hemicellu-lose component degraded faster followed by lignin.

3.5 Microbiological studies of forest soils

A comparative ecological study on soil microbial population revealed that the

total counts of microflora exhibited a decreasing trend along with the increase in soil depth. No marked variation was noted in the qualitative composition of fungal taxa among the forest stands. Only few species were isolated frequently with a high percentage of relative abundance and the fungi like *Penicillium spp., Aspergillus spp., Cladosporium* and filamentous yeasts were quite common.The types and the age of forest did not seem to alter the species composition.

4. Experiments in plant physiology

4.1 Effect of wintering

During the winter (Nov-March), growth of plants are almost static. Early defoliation was noticed in almost all the clones. Refoliation occurred in the month of March when minimum temperature rose above 15°C.

4.2 Effect of different aspect of slopes

The aspect of slopes was found to be having an effect on the growth of the plants (RRIM 600). The plants growing in WSW aspect of slope performed better as compared to those on NNE aspect of slope. The air and soil temperature also varied and was found to be higher on the WSW aspect of slope.

4.3 Effect of low temperature on the growth

The observation on sprouting of each of the 5 clones as well as height, girth, number of leaves, number of whorls and leaf area etc. were carried out in polybag plants both at RRS Guwahati and Tura farm. Besides this meteorological data also was recorded at different time intervals. So far it has been noticed that all the five clones are performing better at low altitude (Guwahati) than at high altitude (Tura).

4.4 Evaluation of yield of *Hevea*

Yield data have been recorded in 8 clones from clonal trial and various physiological paramteres have been studied. The total latex volume (ml/tree/tap) was found to be maximum during September to November in RRIM 600 followed by PB 235, RRII 118 and the least in RRIM 605. DRC and TSC were found to be highest in RRIM 605, PB 235 and RRIM 600 during summer and winter seasons. The plugging index was least during September to November in all the clones, and was highest during summer season. During this year tapping was initiated in RRIC 102 and RRII 118.

4.5 Block plantation, Jengitchakgre

Growth of RRII 105 clone is satisfactory. Seventy percent plants have attained tappable girth.

REGIONAL RESEARCH STATION, KOLASIB, MIZORAM

1.1 Multidisciplinary evaluation of clones (1985)

This trial was started in the year 1985 with 10 clones. The average girth of the different clones are as follows :

Table- Nez. 1. Growth of different clones

Clone	Girth (cm)
RRII 105	56.42
RRII 118	66.60
RRII 203	62.19
RRIM 600	62.10
RRIM 605	62.92
PB 86	51.00
PB 235	67.97
PB 5/51	57.95
GI 1	56.72
GT 1	59.64

Out of existing 175 trees, 120 trees were brought under tapping during the month of June 1995.

The clone PB 235 has highest absolute girth at 150 cm from the bud union followed by RRII 118 and RRIM 605. The annual girth increment who highest for RRIM 605 (5.72 cm) followed by GT 1 (4.66 cm) and GI 1 (4.47 cm).

2. Polyclonal seed garden (1988-89)

The average girth recorded in January '96 is as follows :

Table- Nez. 2. Growth of clones in polyclonal garden

Clone	Girth (cm)		
	a	b	c
RRII 105	46.77	41.19	44.20
RRIM 600	41.63	38.82	45.80
SCATC 93/114	53.02	52.24	53.23
RRII 300	48.35	48.81	46.80
RRII 118	51.24	49.71	51.18
GT 1	47.73	51.82	48.07
PB 235	51.80	48.96	49.80

a - Foothill b - Mid hill c - Hill top

The clone SCATC 93/114 has highest girth on all the slopes (foot hill, mid hill and hill top) followed by PB 235 in foot hill, GT 1 in mid hill and RRII 118 in hill top. The annual girth increment during the year 1995-96 was highest in PB 235 at foot hill (8.10 cm) and hill top (10.03) and clone GT 1 at mid hill (7.77 cm).

3. Influence of aspect of slope on growth of *Hevea*

Plants in the eastern slope has the absolute highest girth. The highest girth increment was recorded on western aspects (9.28 cm) followed by 8.46 cm, 6.13 cm and 4.54 cm of eastern, southern and western aspects respectively (Table-Nez. 3). The trees damaged due to the fire during March and vacant area have been replanted with polyclonal seedling stumps during August/ September 1995.

Table- Nez. 3. **Influence of aspect of slope on girth**

Aspect	Girth (cm)
North	30.34
South	35.05
East	39.50
West	39.32

4. Weed management

It was observed that 5.1 glyphosate/ha followed after 50 per cent weed regeneration with 4.5 l Gramaxone per ha as blanket spray, 5.1. glyphosate/ha followed by spot application with 4.5 l. Gramaxone/ha as and when necessary or 7.5l. glyphosate/ha gives effective control and which can save Rs.1018.00, Rs.1374.13 and Rs.1174.50 respectively per ha over manual weed control.

Table- Nez. 4. **Influence of splits of nutrients on growth**

Treatments	Girth (cm)	Height (cm)
T1 - 50:50:25 in 2 splits	24.7	24.32
T2 - 50:50:25 in 4 splits	22.53	22.37
T3 - 75:75:37.5 in 2 splits	24.66	24.37
T4 - 75:75:37.5 in 4 splits	20.42	21.43
T5 - 100:100:50 in 2 splits	21.84	21.95
T6 - 100:100:50 in 4 splits	23.89	22.81

5. Nutritional trial

It was observed that treatment T1 (50:50:25 in two splits) gave highest absolute girth and annual girth increment (24.71 cm and 10.74 cm) followed by T3 (75:75:37.5 in two splits) in girth and T6 (100:100:50 in four splits) in annual girth increment (24.66 cm and 10.68 cm) respectively Table-Nez. 4).

Plant height and branch height were highest in T3 (24.37 feet and 15.56 feet) followed by T1 (34.32 feet and 15.42 feet) respectiely. Routine cultural operations were carried out and fertilizer application was done as per treatment schedule.

6. Cover crop establishment

The objective of this trial is to study growth of rubber in relation to ground cover management. The average girth and height of rubber recorded in January 1996 (Table-Nez. 5).

Table- Nez. 5. **Influence of ground cover on growth**

Treatments	Girth (cm)	Height (m)
T1 - Cover crop seed in single strip	19.02	6.12
T2 - Cover crop seed in double strips	17.99	6.08
T3 - Cover crop seed in patches (1 m area)	18.74	6.09
T4 - Cover crop cuttings in single strip	18.92	5.85
T5 - Cover crop cuttings in double strips	16.89	4.14

From the above data it is observed that when cover crop is used in single strips highest absolute girth and height of rubber is obtained.

7. Low input agrotechnology

There are two on-farm experiments included in this. One is to find the most suitable planting material and other to optimise the pit size. The survival of plants in each trial was recorded.

REGIONAL RESEARCH STATION, NAGRAKATTA, WEST BENGAL

Nine trials are going on in this regional station out of which two trials are on nutritional studies, four on multidisciplinary evaluation of clones and one each on exploitation system, clone blend and weed control.

A total area of 24.45 ha has been planted with rubber for these experiments.

1. Nutritional studies

In the experiment laid out in 1989 under Terai Soil of West Bengal with four levels of nitrogen (0, 20, 40 and 60 kg/ha) and there levels of P and K (0, 20 and 40 kg/ha) in factorial RBD to assess the nutritional requirement of rubber, application of nitrogenous fertilizers showed significant response with 60 kg/ha recording significantly higher girth (46.16 cm). Application of Phosphorous and Potassium showed no response. Interaction effect between P and K and N, P and K showed significant effect with 60:40:0 combination recording higher girth (48.36 cm). Trees are expected to come to tapping during October 1996.

In another experiment laid out in 1993 with four different schedules of fertilizer application to find out the appropriate number of split application needed for optimum growth of rubber in the region. Two split application in a year recorded significantly higher girth (14 cm) and plant height (4.96 m) over single application (12.6 cm and 4.52 m), but was on par with three and four split applications in a year.

2. Multidisciplinary evaluation of clones

2.1 Clone trial (1990a)

Variation in girth among different clones was significant. RRII 118, RRIM 703, RRII 300 and PB 311 recorded significantly higher girth over GT 1, SCATC 83/113 and PB 5/51. However the clone SCATC 83/113 recorded higher annual girth increment (8.24 cm) and rate of girth increment/year (20.09 %).

2.2 Clone trial (1990b)

Girth recorded from different clones showed no significant difference. However, the RRIM 605 and RRIM 612 recorded comparatively higher girth. Annual girth increment was more in RRIM 612 (7.46 cm) followed by RRII 105 (6.91 cm).

2.3 Clone trial (1990c)

The RRIC 102 clone followed by RRIM 612, RRIM 600 and PB 310 recorded significantly higher girth over PB 235, RRII 208 and PR 107. However, higher annual girth increment and rate was recorded in PB 86, RRIC 102, PB 235 and CH 1.

2.4 Clone trial (1993)

Among the 11 clones included in this trial RRIM 600 recorded maximum girth (13.4 cm) followed by RRII 105 (11.8 cm) and RRII 308 (11.2 cm). Annual girth increment was significantly higher with RRIM 600

(3.74 cm), RRII 308 (3.58 cm) and CH 2 (3.73 cm) whereas PB 235, PCK 2 and PB 280 recorded significantly lower girth increment.

3. Clone blend

A multilocational trial on performance of different clone blends in comparison to monoclonal population of RRII 105 has been laid out. Girth of the plants were recorded. The performance of these clone blends shall be evaluated at maturity.

4. Exploitation system

The trees planted for this trial in 1991 are growing well. Treatments will be imposed at the tapping stage.

5. Weedicide trial

A trial has been started to find out the effect of spray additive on efficacy of Glyphosate in controlling weeds.

REGIONAL RESEARCH STATION, DAPCHARI, MAHARASHTRA

The Regional Research Station located at Dapchari concentrated its research activities on physiological aspects, irrigation, clone evaluation and evaluation of suitable agrotechnology for this region.

1. Irrigation systems

Unirrigated control trees (RRII 105) recorded reduced growth and physiological activities due to severe soil moisture deficit during summer. The plants under basin irrigation showed comparatively good growth and yield performance then drip system (Table-Dap. 1). The plants under 0.5 ETc level of irrigation were comparable to plants under 1.00 ETc saturated irrigation for their growth, physiological and yield parameters. Control plots have not yet reached tappable girth indicating that irrigation reduced the immature period of rubber by 3-4 years in Konkan region.

Table- Dap. 1. Effect of irrigation on growth and yield

Treatment	Mean Girth (cm)	Dry rubber yield (g/tree/tap)
Control (No irrigation)	43.13	No tapping
1.00 ETc Basin	56.13	36.0
0.75 ETc Basin	55.93	34.9
0.50 ETc Basin	54.33	32.1
0.75 ETc Drip	53.90	33.6
0.50 ETc Drip	54.60	32.6
0.25 ETc Drip	51.00	29.6
SE	1.62	
CD (P = 0.05)	3.54	

2. Effect of irrigation on yield and yield components

The clones, RRII 105 and RRII 118 were treated with three different levels of irrigation (1.00, 0.75 and 0.5 evopotranspiration level of crop). The clone RRII 118 recorded better growth, as indicated by girth, than RRII 105 in all irrigation treatments. On the contrary RRII 105 recorded better yield and yield component characters in all treatments (Table- Dap. 2).

3. Physiological evaluation of clones

This trial was started in 1982. Among the eight clones RRIM 600 and RRIM 501 recorded maximum yield of 2200 and 1890 kg/ha per year respectively. Various physiological parameters such as bark turgor, latex, leaf solute potential, plugging characters were studied. Initial latex flow revealed that high yielding clones are stable in their physiological characters during summer months also. The clones GT 1 and

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

Treatment	Girth (cm)		Dry rubber yield g/tree/tap	
	RRII 105	RRII 118	RRII 105	RRII 118
Control (no irrigation)	47.3	52.0	29.7	26.4
1.0 ETc	58.0	64.9	46.7	34.6
0.75 ETc	56.5	68.1	41.8	40.9
0.5 ETc	54.7	58.6	40.7	30.2
SE (for irrigation treatment)		± 4.25		± 4.48
CD (P = 0.05)		10.41		10.96
SE for clones		± 1.57		± 0.86
CD (P = 0.05)		3.62		1.98

GL 1 recorded the lowest annual yield of 910 and 950 kg per ha respectively.

4. Clone trial

Among the fifteen clones, RRII 208, RRII 6 and RRII 52 were performing better than other clones. The clones such as PCK 1, PCK 2 and PB 260 recorded poor growth. Maximum girth was recorded in clone RRII 208 (52.8 cm).

5. Polyclonal seedlings for selection

Already two different sites are under tapping. During this report period a total 615 seedlings from another two sites were opened for tapping. The growth and yield data were pooled and stable high yielders were identified for further selection.

6. Cost evaluation

Tapping was started in irrigated trees (Mean girth 56.6 cm) since May 1994 whereas unirrigated trees have not attained tappable girth (Mean girth 42.0 cm). Expenses incurred towards various inputs, farm practices and irrigation were monitored.

7. Soil and water conservation

Various frequency of silt pits with or without saw dust are maintained in a polyclone seedling area since June 1995. Soil moisture and girth increment of seedlings were recorded at monthly interval. On the basis of ten months data treatments with 150 pits/ha and 200 pits/ha + 10 kg saw dust/pit were found to be effective in soil moisture conservation and favoured further growth of rubber during post monsoon period.

REGIONAL RESEARCH STATION, DHENKANAL, ORISSA

The Regional Research Station located at Dhenkanal, Orissa concentrated on research in agromanagement techniques and clone evaluation for specific drought prone areas in the central Orissa.

1. Experimental planting

In the clone trial planted in 1987, maximum girth was recorded in clone RRIM 600 followed by GT 1 and the lowest girth was noticed in clone RRII 105.

2. Polyclonal seedlings

In the polyclonal seedlings area, planted during 1988, regular observations were taken. The plants having girth of 50 cm or above have been marked for further studies and tapping.

3. Clone evaluation

Among the ten clones of 1990 planting RRIM 600 and SCATC 93/114 continued to record higher girth followed by PB 310, RRII 208 and RRII 5. The lowest girth was recorded in PCK 1.

In the 1991 trial, the clones GT 1, RRIM 600 and the polyclonal seedlings performed

well showing drought tolerance. The lowest girth was noticed in PCK 11.

4. Organic manures

In the trial laid out in 1993 with cake-o-meal and varying doses of FYM, routine cultural operations were carried out and life saving irrigation was given during the summer season. There is no significant difference in the mean girth of plants among the treatments.

5. Budwood nursery

In the budwood nursery of this station a total of 440 points of 20 genotypes are maintained. During the period of report mulching and life saving irrigation were given.

6. Screening of germplasm

6.1 Juvenile characterisation of germplasm

Selected genotypes of Brazilian germplasm together with a few modern clones were planted in polybag nursery during June/July 1995. The sprouting behaviour varies greatly between 20 per cent (RO 25) to 100 per cent (AC 762). The genotypes under polybag nursery showed large variation in growth behaviour at one year age with the maximum height and girth for SCATC 93 and AC 623 respectively.

6.2 Field evaluation

The existing germplasm showing large variation have been planted in field during July 1996 to screen the genotypes for drought conditions.

6.3 Budwood nursery

Budwood nursery of selected genotypes have been established in August 1996.

REGIONAL RESEARCH STATION, SUKMA, MADHYA PRADESH

The Regional Research Station concentrated on following research projects to evolve drought tolerant genotypes and to identify location specific clones.

1. Multidisciplinary evaluation of clones

The trial was started in the year 1990 with clones RRII 105 and RRIM 600. The average girth recorded was 37 cm in RRIM 600 and 33 cm in RRII 105. Highest girth of 45 cm was recorded for RRIM 600.

2. Genotype x Environment interaction

Twelve clones were planted in polybags during June 1995. Polybag plants of all the clones showed good growth and more than 90 per cent survival was observed for all clones. RRIM 600, 82/14, 82/29 and RRII 203 showed better growth. In the polybag nursery, RRIM 600, 82/14, 82/29 and RRII 203 are performing well.

REGIONAL RESEARCH STATION, PADIYOOR, KERALA

The Regional Research Station at Padiyoor, Kannur District, covering an area of 40 ha was started in the year 1994-95. Field trials have been laid out in an area of 4 ha in 1995. Long term field experiments on screening and evaluation of Brazilian germplasm, investigation on genotype x environment interaction in *Hevea* and experiments on evaluation of potential hybrid clones have been laid out. A budwood nursery also has been established.

HEVEA BREEDING SUBSTATION, NETTANA, KARNATAKA

The station has completed planting of its entire 50 ha area by this year. Eight major field trials are in progress. Besides an agrometeorological observatory a budwood nursery of modern and pipeline clones comprising of 109 clones are being maintained.

1. Trial on growth, yield and exploitation systems

This includes two field trials, planted in 1987 and 1988 with five clones each. The 1987 trial had attained tappability. In this trial, PB 235 recorded highest mean girth of 53.68 cm, and RRII 300 (44.78 cm) the lowest while in 1988 trial, RRII 118 the (47.5 cm) performed well and PCK 1 (35.99 cm) had poor growth. The increment in girth during the period (Jan - Apr.,) was generally low. PB 311 and RRIC 36 showed highest girth increment and the lowest increment for PB 260 and RRII 118 respectively for 1987 and 1988 trials. The girth increment in other periods are comparable. The percentage contribution of annual growth during dry period was 8.05 (1987 trial) and 5.63 (1988 trial) (Table-Kar. 1).

Incidence of a leaf spot disease caused by *Corynespora cassiicola* was observed during dry season. In the 1987 trial, RRII 105 was severely affected. Infection was relatively mild in 1988 trial.

2. Evaluation of ortet clones

This trial consists of three experiments planted during 1988. Two trials have 17 clones each and 14 clones were included in third. RRII 105, RRIM 600 and GT 1 are used as standards in all the experiments. Among the standards, GT 1 recorded highest girth in all the three experiments while RRIM 600 recorded the least. All together 9 ortet clones showed better growth than GT 1.

This trial were pleets severely affected by *Corynespora* leaf spot disease. Selection 043 was found highly susceptible. Other selections which showed serious infestation are C3/10, 038, 030 and the standard clone RRII 105.

Table- Kar. 1. **Performance of clones in 1987 and 1988 trials**

Clone	Mean girth (cm)	Percentage girth increment			
		I quarter	II quarter	III quarter	IV quarter
1987 trial					
PB 235	53.68 a	0.72	3.23	3.43	2.68
PB 260	52.39 a	0.43	2.30	2.88	2.43
PB 311	47.42 b	0.90	2.52	2.20	2.88
RRII 105	47.02 bc	0.64	2.45	2.33	2.59
RRII 300	44.78 c	0.82	2.66	2.70	2.70
Mean (X)	49.06	0.70	2.63	2.71	2.66
Annual % contribution	-	8.05	30.23	31.15	30.57
1988 trial					
RRII 118	47.51 a	0.54	4.08	6.10	2.51
PCK 2	42.04 b	0.70	2.99	4.76	1.95
RRIC 45	38.50 bc	0.72	5.30	4.00	2.35
RRIC 36	36.86 c	0.81	4.19	6.25	2.51
PCK 1	35.99 c	0.58	4.66	2.18	2.30
Mean (X)	40.16	0.67	4.24	4.66	2.32
Annual % contribution	-	5.63	35.66	39.20	19.51

SE : 1.305 (1987 trial 1.901) (1988 trial)

Clonal means followed by same alphabets are not significantly different by least significant difference test at P = 0.05

3. Clone trials

3.1 Clone trial 1989 & 1990

There are two trials, one planted in 1989 with fourteen clones and the second planted in 1990 with fifteen clones including five pipeline clones and their parents. RRII 203 performed well with an average girth of 44.25 cm where Haiken 1 (28.33 cm) recorded poor growth in 1989 trial. PB 260 recorded maximum mean girth of 34.75 cm, and GI 1 the lowest (23.62 cm) in 1990 trial (Table-Kar. 2).

Table-Kar. 2. **Growth performance of clones in large scale trials**

1989 trial		1990 trial	
Clone	Girth (cm)	Clone	Girth (cm)
RRII 105	34.97 cde	RRII 105	28.81 c
RRII 203	44.25 a	HP 185	27.59 c
RRII 300	40.37 ab	HP 187	27.81 c
RRII 308	35.70 b-e	HP 204	27.32 c
RRIM 600	34.58 de	HP 223	28.74 c
PB 255	39.51 a-d	HP 372	29.76 bc
PCK 1	31.63 ef	PB 217	28.31 c
PCK 2	36.10 b-e	PB 235	30.62 bc
KRS 25	37.01 b-e	PB 260	34.75 a
KRS 128	39.91 abc	PB 311	29.73 bc
KRS 163	38.10 bcd	Hil 28	29.98 bc
SCATC 88-13	32.00 ef	Mil 3/2	28.77 c
SCATC 93-114	32.61 ef	GT 1	32.57 ab
Haiken 1	28.33 f	GI 1	23.62 d
Tjir 1	27.32 c		
Mean	36.08	29.04	
SE	1.66	1.05	

Mean separation by DMRT (5% level)

3.2 Clone trial 1991

These trials planted in 1991, are designed to evaluate many clones together in smaller scale. There are three experiments, the first with 36 clones and the second

and third with thirteen clones each. Average girth was 25.23 cm for the first, 23.68 cm for the second and 22.49 cm for the third experiment. The mean girth ranged from 31.08 cm (RRII 203) to 20.66 cm (RRIC 36) in the first experiment. RRIC 102 (27.09 cm) recorded maximum growth in the second experiment while PB 5/139 (20.95 cm) recorded the lowest. In the third, mean girth ranged from 28.22 cm (HP 83/224) to 19.77 cm (AVROS 49). No serious incidence of disease was noticed.

4. Estimation of genetic parameters

This experiment consists of 12 clones and their half-sib progenies planted during 1990. Periodic girth data of parents and progenies were recorded. Among the parents PB 235 and among the progenies those of GT 1 performed well.

5. Polyclonal garden

A polycross garden involving nine pre-potent clones was laid out during this year in an area of 9.0 ha. The plants have established while cover crop is getting established.

HEVEA BREEDING SUB-STATION, PARALIYAR, TAMIL NADU

Studies on floral biology, hybridisation and clone evaluation were the thrust areas of activities.

1. Evolving high yielding clones

A small scale clone trial was initiated during the year under report consisting of 16 potent mother trees selected during 1994. A total of 282 hybrid seedlings belonging to 8 parental combinations of 1994-95 breeding programme were raised in a seedling nursery. Hand pollination was continued during the flowering season in 1996 also.

2. Clone evaluation

Out of 15 clones grown under the agro-climatic condition of Kanyakumari District, PB 260 has exhibited the maximum vegetative growth followed by RRIC 105 at the 6th year. Growth performance of PCK1 was very poor.

3. Floral biology and fruit set

Detailed studies on wintering pattern, floral biology and anthesis of 25 popular clones have been completed. Most of the high yielding clones have exhibited partial leaf shedding during winter season. The intra-clonal differences in the maturity of male and female flowers were found to play a major role in the prevalence of outcrossing in *Hevea* clones. GT 1 was identified as a clone least affected by climatic changes followed by RRII 5 and RRIM 600.

Oidium infection was found to be an important factor responsible for low seed setting. Exposure to harmful solar radiations and low atmospheric humidity were also found to contribute to low fruit setting. Damage caused to panicles by emasculation and injury caused to the flowers during pollination and post pollination plugging of flowers were noticed to affect fruit setting in hand pollination. Insufficient transfer of pollen to stigma was identified as a major drawback of the conventional method of hand pollination.

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Seedlings raised from monoclonal seeds of different clones were planted separately in earthern pots for evaluation of tolerance to soil moisture stress and water logging created artificially.

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AGROMETEOROLOGY UNIT

1. Weather at various stations

The weather elements recorded at six locations during the year 1995 are summarised in Table-Agromet. 1.

The highest mean maximum temperatures and lowest mean minimum temperatures were recorded at Dapchari during April and January respectively. Lowest relative humidity was also observed at Dapchari especially during the afternoon hours.

2. Studies on suitable agrometeorological parameters for rubber cultivation

Variability of rainfall can be understood by probability estimates. 75% and 90% probability rainfall was worked out for all the months and seasons. Analysis of weekly rainfall probabilities were also carried out.

Using the CROPWAT (software) crop evapotranspiration (ETc) and effective rainfall were computed.

3. Crop-weather relationships

The data recorded automatic weather station data indicate that difference in temperature and humidity was higher at 0900 - 1000 hours between inside the plantation (under the canopy) and in open air. This difference was more pronounced during the wet season. Studies on the weekly variations of the above parameters also supported the findings of the diurnal variation.

Table-Agromet. 1. **Weather recorded at observatories in traditional and nontraditional areas (1995)**

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Rainfall													
Dapchari	9.5	0.0	0.0	0.0	0.0	79.6	1291.0	307.2	255.0	75.7	0.0	0.0	2018.0
Nettana	2.0	0.0	6.8	33.3	300.1	519.8	1535.5	759.7	460.1	210.2	274.3	0.0	4001.1
Kottayam	0.0	0.0	21.2	407.4	539.7	569.8	678.9	540.7	334.4	269.3	325.6	0.0	3687.0
Mundakayam	0.0	41.5	30.2	235.8	723.6	493.7	682.1	698.4	361.0	501.6	286.8	0.0	4104.7
Chethackal	62.4	69.6	53.7	326.8	580.1	552.6	802.8	615.9	375.4	397.9	296.7	0.0	4133.9
Paraliar	58.8	0.9	57.2	126.9	466.6	155.1	155.0	153.1	175.0	265.9	278.0	111.4	2003.9
Maximum temperature (°C)													
Dapchari	29.5	31.7	*	37.1	35.9	34.4	29.8	29.8	30.1	32.9	32.5	31.8	
Kottayam	33.2	33.2	34.3	33.6	31.8	30.0	28.5	29.2	29.6	30.9	30.7	32.4	
Mundakayam	*	34.0	35.5	33.5	32.4	32.2	31.8	Nil	Nil	Nil	Nil	Nil	
Chethackal	34.6	35.3	35.8	33.3	32.4	30.9	29.0	29.8	30.9	32.0	32.1	34.5	
Paraliar	32.6	34.8	36.5	34.8	32.4	31.0	30.3	31.0	31.0	31.4	30.9	30.6	
Minimum temperature (°C)													
Dapchari	13.2	15.8	*	22.3	26.2	26.9	25.2	24.9	24.6	23.5	17.8	15.2	
Kottayam	22.3	23.4	23.7	23.8	24.0	24.2	23.5	23.0	23.5	23.4	22.1	19.9	
Mundakayam	*	20.5	21.1	21.5	22.2	21.8	21.9	21.7	Nil	Nil	Nil	Nil	
Chethackal	20.9	22.0	22.5	22.7	23.4	23.5	22.8	22.7	22.6	22.7	22.0	19.0	
Paraliar	22.1	22.3	22.0	23.8	24.5	24.8	24.2	24.0	23.4	23.1	22.5	20.8	
Morning Relative humidity (%)													
Dapchari	81.0	81.0	73.0	72.0	72.0	80.0	91.0	91.0	92.0	85.0	85.0	87.0	
Nettana	91.0	90.0	93.0	95.0	96.0	96.0	95.0	94.0	93.0	90.0	93.0	82.0	
Kottayam	85.0	91.0	92.0	93.0	90.0	97.0	98.0	97.0	97.0	97.0	95.0	85.0	
Mundakayam	*	97.0	97.0	97.0	96.0	96.0	85.0	97.0	89.0	97.0	96.0	89.0	
Chethackal	83.0	84.0	84.0	93.0	94.0	93.0	93.0	94.0	94.0	94.0	92.0	76.0	
Paraliar	90.0	88.0	92.0	93.0	90.0	92.0	78.0	78.0	94.0	97.0	97.0	94.0	
Evening - Relative humidity (%)													
Dapchari	29.0	35.0	28.0	45.0	45.0	55.0	82.0	73.0	80.0	56.0	42.0	41.0	
Nettana	51.0	34.0	35.0	61.0	78.0	87.0	82.0	81.0	63.0	60.0	55.0	29.0	
Kottayam	48.0	49.0	54.0	66.0	70.0	81.0	82.0	84.0	68.0	65.0	71.0	47.0	
Mundakayam	*	63.0	62.0	61.0	54.0	64.0	72.0	76.0	58.0	63.0	61.0	38.0	
Chethackal	44.0	43.0	43.0	58.0	67.0	75.0	76.0	76.0	71.0	66.0	67.0	41.0	
Paraliar	53.0	47.0	45.0	66.0	70.0	75.0	71.0	71.0	69.0	73.0	70.0	64.0	

* Data not recorded

LIBRARY AND DOCUMENTATION CENTRE

195 new books and 2010 bound volumes of journals were added to the library during the current year. The total books and periodicals in the library were 21,205 and 19,391 respectively. 158 journals and 8 dailies were subscribed and about 103 other journals were also received in the library as either gift or exchange.

Four issues of *Documentation list*, four numbers of *Rubber Alert*, hundred issues of *SDI Bulletin* and one issue of *List of New Additions* were compiled and distributed. As part of database development 13,000 documents have been indexed during this period. About 1.5 lakh photocopies of information materials were made by the reprographic section.

The library has actively participated in the sales promotion of *'Indian Journal of Natural Rubber Research'* *'Rubber Wood : Production and Utilization'*, 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 were also allowed to utilise the library facilities.

ANNUAL EXPENDITURE

Expenditure at a glance 1995-96

Head of Account	Expenditure (Rs. '000)
Non Plan	
General charges	252.42
Schemes	31.36
Projects - CES	75.89
Department of Training	3.67
Total Non Plan	363.34
Plan	
General charges	45.12
Schemes	120.07
NERDS Research Component	73.32
Total Plan	238.51
World Bank Project	
Schemes	44.14
GRAND TOTAL	646.09

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* *Under World Bank Scheme*

** *Under World Bank Scheme on working arrangement*

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

The research supporting sections include Library and Documentation, Instrumentation, Statistics 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 Tripura, Guwahati in Assam, Tura and Darechikgre in Meghalaya and Kolasib in Mizoram. The RRII has also set up regional research establishments at Dapchari (Maharashtra), Dhenkanal (Orissa), Nagrakata (West Bengal), Sukma (Madhya Pradesh), Paraliar (Tamil Nadu), Nettana (Karnataka) and Padiyoor (Kerala).

Regional soil testing laboratories have been established at Mangalore, Thaliparamba, Calicut, Trichur, Muvattupuzha, Palai, Kanjirappally, Adoor and Nagercoil. Mobile units for soil and leaf analysis are available at the Calicut, Muvattupuzha and Nagercoil laboratories, apart from that at head quarters.

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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