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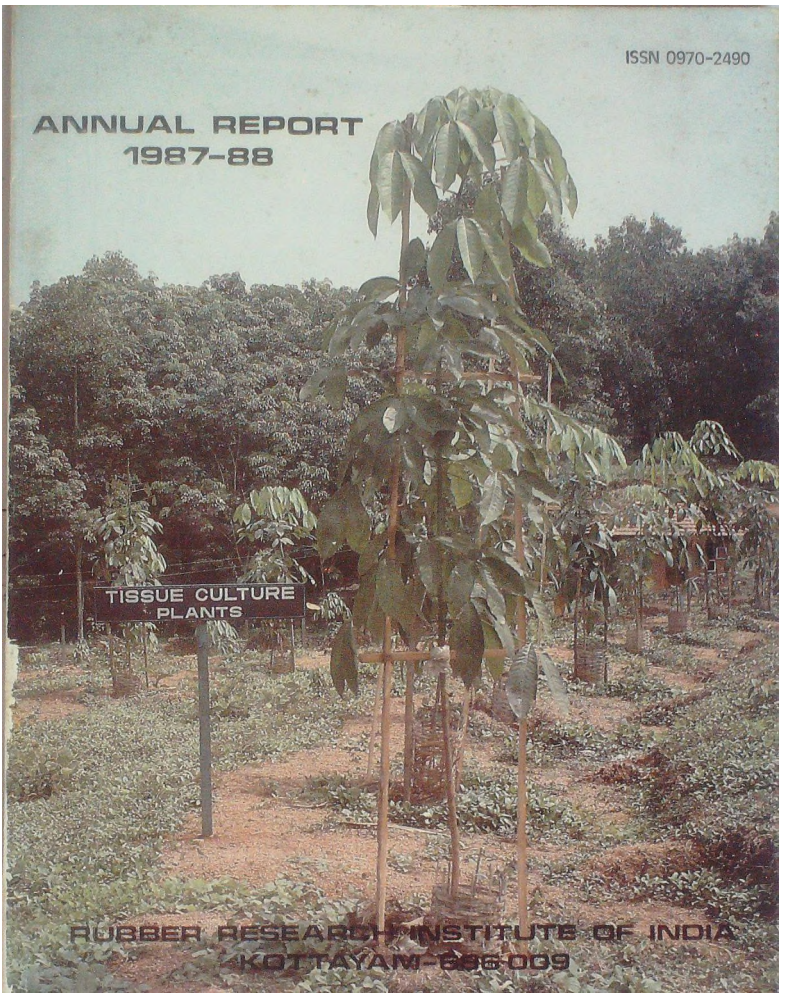

RUBBER RESEARCH INSTITUTE OF INDIA
KOTTAYAM-686 009

ANNUAL REPORT
1987-'88

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

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M. R. SETHURAJ,
DIRECTOR,
RUBBER RESEARCH INSTITUTE OF INDIA,
KOTTAYAM-686 009,
KERALA, INDIA.

JULY 1989

CONTENTS

THE RUBBER BOARD

The Indian Rubber Board was constituted under the Rubber (Production and Marketing) Act, 1947. This Act was passed on the recommendation of an ad-hoc committee appointed by the Government of India in 1945, and came into force on 19th April, 1947. The Rubber Production and Marketing (Amendment) Act of 1954 made certain changes in the constitution of the Board and shortened its name to the Rubber Board. This Act came into force on 1st August, 1955. The Rubber Act of 1947 was further amended by the Rubber Amendment Act 1960 which made certain alterations in the rate and procedure of collection of cess on rubber. The Act was again amended by the Rubber (Amendment) Act, 1982.

Organisation

The Chairman is the principal executive officer and he exercises control over all departments of the Board. There are six main departments, viz. Administration, Rubber Production, Research, Rubber Processing, Finance & Accounts Training.

Chairman

P. C. Cyriac, IAS.

Rubber Production
P. Mukundan Menon,
Rubber Production Commissioner

Research
Dr. M. R. Sethuraj,
Director

Administration
V. Bhaskara Pillai,
Secretary

Rubber Processing
C. M. George,
Project Officer

Finance & Accounts
K. S. Varma,
Financial Advisor

Training
P. N. Radhakrishna Pillai,
Joint Director

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I. Agronomy & Soils

1. Dr. N. K. Jain, Coordinating Director, CSIR Complex, Palampur-176001, H. P.
2. Dr. M. Velayudham, Asst. Director General (Soils), ICAR, Krishi Bhavan, New Delhi - 110012.
3. Prof. B. Datta, Dept. of Agricultural Engineering, IIT, Kharagpur - 721 302.

II. Genetics & Plant Breeding

4. Dr. S. Kedarnath, (Retd. Director, Kerala Forest Research Institute) 12-A, First Cross Road, Ramalinga Nagar, V Layout, K. K. Pudur P. O., Coimbatore - 641 038.
5. Dr. C. A. Ninan, Dean, Faculty of Science, Kerala University, Trivandrum - 695 581.

6. Prof. V. Gopinathan Nair, Professor of Plant Breeding, College of Agriculture, Vellayani - 695 522, Trivandrum.

III. Plant Physiology & Exploitation

7. Prof. S. K. Sinha, Water Technology Centre, IARI, New Delhi - 110 012.
8. Prof. V. S. Rama Das, Dean, Faculty of Science, Sri Venkateswara University, Tirupati - 517 502.

IV. Biochemistry

9. Prof. P. A. Kurup, Head, Dept. of Biochemistry, University of Kerala, Trivandrum-695 581.
10. Prof. T. Ramakrishnan, Microbiology & Cell Biology Lab., Indian Institute of Science, Bangalore - 560 012.

V. Mycology & Plant Pathology

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

VI. Chemistry, Physics & Technology

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

VII. Agrometeorology

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

Director's Review

Thrust areas of research of the Rubber Research Institute of India are:

(a) research activities aimed at increasing productivity to fill up the gap between consumption and production in the country, and

(b) product improvement aimed at increasing service life and thereby optimising the use of natural rubber.

In traditional regions, evaluation of potential clones, studies on the physiology of production, methods of disease and pest control and investigations on nutritional requirements under different situations formed the priority areas. It would now be possible for the Institute to release many more high yielding clones with desirable characteristics as on-farm large scale experiments. The Institute recognises the need to introduce a number of clones to avoid the danger of monoclonal growth in the plantation industry and to face the varying climatic constraints experienced in different agroclimatic regions effectively. The proneness of most of the high yielding clones evolved at RRII and elsewhere to 'brown bast' is a serious problem necessitating intensified investigations on brown bast as well as in identifying clones with low incidence of this syndrome. A multi-disciplinary team has already been formed to study various unresolved aspects of brown bast. Another multi-disciplinary team has also been formed to develop methods for early prediction of yield potential and stress tolerance.

The traditional rubber growing tracts experienced an unusual drought in the year 1987. The soil moisture depletion was so severe that young plants dried and yield in mature plants dropped substantially. In response, an intensive study was launched on the water relations of *Hevea*. The knowledge already derived is rewarding and would pave a way to further elucidating the mechanism of drought tolerance.

Due emphasis was given to introduce new effective fungicides and pesticides to counter diseases and pests. It is to be admitted that some of these chemicals are not cheaper than the present recommended ones. However, the inadequacy of the present recommendations under certain situations warranted introduction of more chemicals to contain severe disease and pest incidence.

One of the most significant achievements during the period under report is successful production of rooted plants in tissue culture. These plants have been planted out in the field. This is the first time that tissue culture plants from shoot tip culture of high yielding clones could be produced and planted out in the field.

The discriminatory fertilizer recommendation system has now been widely accepted both by large growers and small holders. The four mobile laboratories have worked to their maximum capacity. The Institute, however, recognises the fact that accuracy of our recommendations can be further sharpened by constant review and follow-up investigations and accordingly a research programme has been initiated in this direction.

A solar-cum-smoke drier which could save upto 70 percent firewood was developed by the Institute and steps are being taken to establish such driers for commercial operation. Reaction parameters have been identified for the production of epoxidised NR. Development of formulations and processes for different types of rubber products is being explored.

The emphasis in all the Regional Stations have been to develop location specific technology for successful establishment of rubber plantations. It has been found that the most favoured clone RRII 105 does not perform well under stress situations as far as growth is concerned. RRIM 600, PB 235 and RRII 118 show much better stress tolerance. The stress tolerance of clones appear to overlap under drought and cold situations. Based on the results so far obtained, a new package of practices is being formulated for North Eastern Region. Specific recommendation for clones, fertilizer schedule and exploitation systems in stress-proned regions will be issued at the earliest possible time and all our investigations are concentrated to achieve this target.

A meaningful balance between basic and applied research has been maintained to ensure that the knowledge derived from our basic research would form the underpinnings for our efforts in the field of applied research in a sustained manner.

The Institute continued to maintain close liaison with the Member Institutes of International Rubber Research and Development Board. The Institute also maintained academic associations with different Universities and Research Organisations.

Botany Division

The Botany Division consists of five sections, dealing with breeding and selection, propagation techniques, cytogenetics, anatomy and germplasm. The main research activities include hybridisation, ortet selection, mutation and polyploidy breeding, clone evaluation, cytogenetics, anatomy, propagation, horticultural manipulation, floral biology, genetic studies, early evaluation and collection and conservation of germplasm.

1. HYBRIDISATION AND SELECTION

During the 1988 flowering season, a total of 9835 hand pollinations belonging to 34 cross combinations were attempted. The initial fruit count recorded 6.64% fruitset. Progenies resultant of the 1987 hybridisation programme were established in a seedling nursery. A selection of 14 families from the 1986 H.P. progeny were planted in a suitable layout for nursery observations on family wise performance. They were assessed for a set of growth characters viz., plant height, basal diameter, number of leaves and juvenile yield.

Table-Bot. 1: *Growth characters and juvenile yield of* 1986 *H. P. seedlings at the age of one year.*

Cross combination	Plant height cm	Girth cm	No. of flushes	Juvenile yield g
IAN 873 × RRII 105	240.37	6.24	8.54	0.08
RRIM 600 × RRII 203	248.38	6.43	9.48	0.12
RRII 105 × PR 107	257.57	7.02	8.94	0.07
PB 242 × RRII 105	277.63	7.86	8.50	0.11
PB 5/51 × RRII 208	293.61	7.46	9.36	0.06
RRII 105 × PB 5/51	262.87	5.84	8.66	0.08
PB 242 × PB 86	308.34	7.48	8.59	0.11
RRII 105 × RRII 118	269.46	6.81	9.15	0.08
RRIM 600 × RRII 33	250.54	5.42	8.79	0.06
RRII 105 × PB 217	242.57	6.11	9.10	0.08
RRIM 600 × PB 235	230.72	5.35	8.52	0.07
RRII 105 × PB 86	258.00	6.36	9.52	0.08
RRII 105 × RRII 208	265.23	6.49	9.32	0.10
RRIM 600 × GI 1	229.26	5.28	8.87	0.11
RRII 105 Control	245.71	5.92	9.01	0.07
S.E.	8.98	0.27	0.12	0.06

The combinations RRIM 600 × RRII 203, RRIM 600 × GI 1, PB 242 × RRII 105 and PB 242 × PB 86 recorded the highest juvenile yield. In general the latter two families were also more vigorous.

The progenies of the 1983 H.P. programme were vegetatively multiplied. Two hundred and twenty clones, including the parents as well as control, were raised in polybags at the Kerala Agricultural University Main Campus for laying out a small scale field trial.

The emphasis in all the Regional Stations have been to develop location specific technology for successful establishment of rubber plantations. It has been found that the most favoured clone RRII 105 does not perform well under stress situations as far as growth is concerned. RRIM 600, PB 235 and RRII 118 show much better stress tolerance. The stress tolerance of clones appear to overlap under drought and cold situations. Based on the results so far obtained, a new package of practices is being formulated for North Eastern Region. Specific recommendation for clones, fertilizer schedule and exploitation systems in stress-proned regions will be issued at the earliest possible time and all our investigations are concentrated to achieve this target.

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2. ORTET SELECTION

Ortet selection was continued in small holdings as well as large estates. Out of the 71 selections made from 211 potential mother trees from one large estate, based on one year observation of yield and secondary characters, 64 ortets could be cloned and established in the source-bush-nursery. Budwood harvested from the plants were being budgrafted for further multiplication and laying out a field trial.

From another large estate 213 apparently promising mother trees were identified. The trees were subjected to yield recording and observation of secondary characters and final selection. These resulted in identifying 55 promising mother trees. The selections are being cloned and attempts are on way to establish a source-bush nursery.

From a third large estate, a total area of 151.02 ha of seedling populations comprising 55821 trees of GG 1 and GG 6 origin were systematically screened and 199 genotypes were identified. One round of yield recording together with block yield was completed. *Phytophthora* tolerance of the clones was also assessed.

Girth measurements of ortet clones from two small holdings along with RRII 105 was recorded. In one case, yield recording was also done. Yield recording of an ortet clone planted at the CES was also continued.

3. SPECIAL TECHNIQUES IN BREEDING

Induction of polyploidy was initiated in 15 clones by the application of colchicine by cotton swab method. The colchicine treated shoots from VM 5 generation were showing morphological variations. Mutation studies were initiated in four clones, viz., PB 86, GT 1, IAN 873 and RRII 105 using EMS (Ethyl methane sulphonate) and Sodium azide. Twenty genotypes resulting from hand pollination, using UV and X-ray irradiated pollen, are being maintained in the nursery for further evaluation. The growth attributes of diploid, triploid and tetraploid from twenty plants each were studied at the age of 30 months. Foliage characters were recorded from the middle leaflet of twenty mature leaves selected at random from each cytotype. In the early stages of growth, the triploid appeared to be intermediate between the diploid and the tetraploid in growth and morphological features (Table Bot. 2).

Table-Bot. 2. *Morphological characteristics of diploid, triploid and tetraploid clones of Hevea brasiliensis.*

Character	Cytotypes		
	2x	3x	4x
Height (m)	4.97 ± 0.22	5.13 ± 0.23	5.31 ∓ 0.09
Girth (cm)	13.55 ± 3.67	14.43 ± 0.47	17.90 ± 0.86
Stomatal density	51.32 ± 2.39	34.67 ± 1.53	35.07 ± 5.80
Stomatal length (μ)	30.21 ± 2.78	39.73 ± 3.07	41.29 ± 4.74
Stomatal breadth (μ)	17.89 ± 0.93	30.11 ± 2.35	31.36 ± 2.50
Bark thickness (mm)	2.22 ± 0.20	2.36 ± 0.13	2.25 ± 0.42
Latex vessel rows	3.67 ± 1.35	5.58 ± 1.42	4.67 ± 0.62
Petiolar index	0.014	0.019	0.016
Leaf index	0.004	0.005	0.006
Stem index	0.029	0.036	0.036
Specific leaf weight	0.0073	0.0079	0.0092
Flower size (mm)	4.4 × 2.7	9.6 × 4.0	10.4 × 4.4
Pollen grain size (mm)	39.0 × 36.0	47.0 × 38.0	55.0 × 52.0

4. EVALUATION OF CLONES

The various field trials were properly maintained and observations were recorded. Among 22 clones preliminarily selected from the 1954 H.P. series, seven clones were evaluated in a large scale trial laid out in 1966. The yield performance and important characters of the clones such as girth at opening, girth increment on tapping, incidence of diseases, wind damage, etc were studied. Analysis of yield figures for a period of 5 years, 6th to 10th years and yield over 10 years showed significant difference among clones (Table Bot 3, 3(a), 3(b) and 3(c).). Analysis of girth data at opening, at 10th year of tapping and girth increment over 10 years also depicted significant differences (Tables Bot 4, 4(a), 4(b) and 4(c).). Response of clones to disease, wind damage etc are shown in Table Bot 5. Of all the clones evaluated, RRII 105 continued to be the highest yielder in the large scale trial.

Table–Bot. 3. *Mean yield of RRII clones in trial*

Clone	Parentage	Yield in gram/tree/tap ± S. E.		
		Yield for the first 5 years	Yield for 6th to 10th years	Yield over 10 years
RRII 101	Tjir 1 × AVROS 255	17.06 ± 1.81	16.54 ± 2.87	16.85 ± 2.13
RRII 102	Tjir 1 × Gl 1	23.81 ± 1.74	25.70 ± 2.77	24.89 ± 2.06
RRII 105	Tjir 1 × Gl 1	65.57 ± 1.57	68.19 ± 2.49	66.71 ± 1.85
RRII 106	Tjir 1 × Mil 3/2	17.73 ± 1.69	23.92 ± 2.68	20.92 ± 1.99
RRII 109	Tjir 1 × Mil 3/2	30.10 ± 1.69	49.79 ± 2.68	39.93 ± 1.99
RRII 110	Tjir 1 × Hil 28	36.31 ± 1.54	39.75 ± 2.45	37.95 ± 1.82
RRII 111	Tjir 1 × Hil 28	40.16 ± 1.59	38.67 ± 2.52	39.53 ± 1.87
Tjir 1	Control	30.93 ± 1.63	31.12 ± 2.60	31.08 ± 1.93
General mean		33.84	37.77	35.82

Table–Bot. 3(a): *C. D. Values at 5% level for yield of RRII clones for the first 5 years*

Clone	RRII 101	RRII 102	RRII 105	RRII 106	RRII 109	RRII 110	RRII 111	Tjir 1
RRII 101		4.92	4.69	4.84	4.84	4.66	4.71	4.78
RRII 102			4.59	4.75	4.75	4.56	4.62	4.68
RRII 105				4.51	4.51	4.31	4.37	4.44
RRII 106					4.67	4.48	4.54	4.60
RRII 109						4.48	4.45	4.60
RRII 110							4.34	4.41
RRII 111								4.47
Tjir 1								

Table–Bot. 3(b): *C. D. Values at 5% level for yield of RRII clones for 6th to 10th year*

Clone	RRII 101	RRII 102	RRII 105	RRII 106	RRII 109	RRII 110	RRII 111	Tjir 1
RRII 101		7.83	7.45	7.70	7.70	7.41	7.50	7.59
RRII 102			7.30	7.56	7.56	7.26	7.35	7.45
RRII 105				7.17	7.17	6.85	6.95	7.05
RRII 106					7.43	7.13	7.22	7.32
RRII 109						7.13	7.22	7.32
RRII 110							6.90	7.01
RRII 111								7.01
Tjir 1								

Table–Bot. 3(c): *C. D. Values at 5% level for yield of RRII clones over 10 years*

Clone	RRII 101	RRII 102	RRII 105	RRII 106	RRII 109	RRII 110	RRII 111	Tjir 1
RRII 101		5.80	5.52	5.71	5.71	5.49	5.56	5.63
RRII 102			5.41	5.61	5.61	5.38	5.45	5.52
RRII 105				5.32	5.32	5.08	5.15	5.23
RRII 106					5.51	5.28	5.35	5.43
RRII 109						5.28	5.35	5.43
RRII 110							5.12	5.20
RRII 111								5.26
Tjir 1								

Table–Bot. 4. *Mean girth of RRII clones in trial*

Clone	Mean girth in cm ± S.E.		
	Girth at opening	Girth at 10th year of tapping	Girth increment over 10 years of tapping
RRII 101	52.69 ± 0.95	68.67 ± 2.19	15.98 ± 1.66
RRII 102	49.26 ± 0.92	65.69 ± 2.12	16.43 ± 1.60
RRII 105	59.47 ± 0.83	74.54 ± 1.90	15.07 ± 1.43
RRII 106	56.41 ± 0.88	74.98 ± 2.02	18.58 ± 1.52
RRII 109	57.70 ± 0.91	92.98 ± 2.08	35.28 ± 1.57
RRII 110	63.59 ± 0.82	90.80 ± 1.87	27.20 ± 1.41
RRII 111	68.38 ± 0.83	100.91 ± 1.90	31.32 ± 1.43
Tjir 1	59.64 ± 0.88	82.03 ± 2.22	22.39 ± 1.52
General Mean	58.95	81.94	22.99

Table–Bot. 4(a): *C. D. Values at 5% level for girth of RRII clones at opening*

Clone	RRII 101	RRII 102	RRII 105	RRII 106	RRII 109	RRII 110	RRII 111	Tjir 1
RRII 101		2.60	2.47	2.54	2.58	2.46	2.47	2.54
RRII 102			2.43	2.49	2.53	2.41	2.43	2.49
RRII 105				2.36	2.40	2.28	2.29	2.36
RRII 106					2.47	2.35	2.36	2.43
RRII 109						2.39	2.40	2.47
RRII 110							2.28	2.36
RRII 111								
Tjir 1								

Table–Bot. 4(b): *C. D. Values at 5% level for girth of RRII clones at 10th year of tapping*

Clone	RRII 101	RRII 102	RRII 105	RRII 106	RRII 109	RRII 110	RRII 111	Tjir 1
RRII 101		5.98	5.69	5.84	5.93	5.66	5.69	5.84
RRII 102			5.58	5.73	5.82	5.54	5.58	5.73
RRII 105				5.43	5.52	5.23	5.27	5.43
RRII 106					5.68	5.39	5.43	5.59
RRII 109						5.49	5.52	5.68
RRII 110							5.23	5.39
RRII 111								5.43
Tjir 1								

Table–Bot. 4(c): *C. D. Values at 5% level for girth increment over 10 years of tapping*

Clone	RRII 101	RRII 102	RRII 105	RRII 106	RRII 109	RRII 110	RRII 111	Tjir1
RRII 101		4.51	4.29	4.40	4.47	4.27	4.29	4.40
RRII 102			4.21	4.32	4.39	4.18	4.21	4.32
RRII 105				4.10	4.17	3.95	3.97	4.10
RRII 106					4.28	4.07	4.10	4.21
RRII 109						4.14	4.17	4.28
RRII 110							3.95	4.07
RRII 111								4.10
Tjir 1								

Table–Bot. 5. *Incidence of wind damage and brown bast*

Clone	Wind damage (%)		Brown bast (%)	
	5th year	10th year	5th year	10th year
RRII 101	0	3.70	0	11.11
RRII 102	0	0	0	3.45
RRII 105	5.71	5.71	2.86	8.57
RRII 106	2.94	8.82	5.88	8.82
RRII 109	2.86	2.86	2.86	8.57
RRII 110	0	2.63	7.89	5.26
RRII 111	0	5.41	10.81	5.41
Tjir 1	0	5.88	2.94	8.82

Observations on yield and secondary characteristics of the Sri Lanka clones under trial were continued and the data for the first ten years were summarised. RRIC 104, RRIC 52 and RRIC 100 were the most vigorous (Table Bot. 6) at the time of opening. Clonal variation was also noted for mean annual girth increment on tapping, thickness of virgin bark, thickness of renewed bark, etc.

Table-Bot. 6. *Vigour and certain other secondary characteristics of Sri Lanka clones.*

Clone	girth at opening (cm)	Mean annual girth increment over 3 years after tapping (cm)	Thickness of virgin bark (mm)	Thickness of 3 year renewed bark (mm)	Incidence of pink disease(%)
RRIC 7	47	4.4	6.7	7.6	4.6
RRIC 36	45	3.9	7.2	7.7	17.7
RRIC 45	49	4.0	6.6	5.0	15.7
RRIC 52	58	5.6	9.0	7.7	9.8
RRIC 100	57	3.8	9.0	7.4	14.7
RRIC 102	55	3.6	8.1	7.1	1.7
RRIC 104	64	4.5	9.2	8.2	12.9
RRIC 105	56	3.0	8.1	7.3	8.8
Nab 17	51	3.3	7.4	8.1	8.2
GT 1 (control)	52	3.7	7.8	6.8	6.9

The yield per tree per tap was the highest for RRIC 100, followed by RRIC 36 (Table Bot. 7). Yield drop during summer months was most pronounced in RRIC 105. Among the clones, maximum wind damage was noted in RRIC 45.

Table-Bot. 7. *Yield and certain secondary characteristics of Sri Lanka clones.*

Clone	Mean yield of 3 years g/tree/tap	Yield depression during wintering (%)	Brown bast (%)	Wind damage (%)
RRIC 7	28.7	33	Nil	4.6
RRIC 36	34.9	14	Nil	6.4
RRIC 45	29.3	39	1.7	21.0
RRIC 52	21.3	32	Nil	8.2
RRIC 100	37.4	31	1.6	14.7
RRIC 102	33.9	44	Nil	10.5
RRIC 104	32.0	28	1.6	14.5
RRIC 105	26.0	49	1.4	7.3
Nab 17	34.0	36	1.6	13.1
GT 1 (control)	28.1	42	Nil	10.3

Performance of twelve clones under commercial conditions was under study. The yield data recorded from three estates (Kulathupuzha, Koothattukulam and Kinalur) were summarised and it was noted that RRII 105 gave the maximum yield. This was followed by RRII 208 (Table Bot. 8). RRII 208 showed susceptibility to *Phytophthora*, causing shoot rot during young stages.

Table-Bot. 8. *Yield performance of RRII clones.*

Clone	Parentage	Mean yield (5 year) kg/ha/year	
RRII 105	Tjir 1 × Gl 1	1562*	(3)
RRII 208	Mil 3/2 × AVROS 255	1226*	(2)
RRII 203	PB 86 × Mil 3/2	1143	(2)
RRII 118	Mil 3/2 × Hil 28	1145	(2)
RRII 107	Tjir 1 × Mil 3/2	1079	(1)
RRII 206	Mil 3/2 × AVROS 255	1104	(1)
RRII 113	Mil 3/2 × Hil 28	958	(1)
RRII 116	Mil 3/2 × Hil 28	921	(1)
RRII 109	Tjir 1 × Mil 3/2	882	(1)
RRII 114	Mil 3/2 × Hil 28	810	(1)
RRIM 600	Tjir 1 × PB 86	1104	(2)
GT 1	Primary clone	843	(2)

* Mean over 6 years.

Figures within brackets indicate number of estates.

In a blockwise trial of eleven clones in another estate (Malankara estate) RRII 105, RRIM 703 and RRIC 102 gave more than 1000 kg/ha/year during the second year of tapping (Table Bot. 9). RRIC 52, though the most vigorous one, recorded the lowest yield.

Table-Bot. 9. *Performance of clones during second year of tapping.*

Clone	Yield kg/ha/year	Girth cm
RRIM 703	1135	50.24
RRIM 707	778	53.10
Ch 153	904	55.14
Nab 17	915	52.56
Wagga 6278	577	49.90
RRIC 36	921	51.00
RRIC 45	911	45.62
RRIC 52	542	63.15
RRIC 102	1054	55.15
GT 1	863	52.66
RRII 105	1310	51.59

In a blockwise trial with GT 1 and Ch 153 yield during the fifth year of tapping was found to be more for Ch 153 (912 kg/ha) than that for GT 1 (856 kg/ha). Ch 153 was also comparatively more vigorous (61.65 cm and 59.55 cm respectively during the 12th year of planting).

Among the five RRII clones, planted in an estate (Desamangalam estate) in northern Kerala during 1981, RRII 3 and RRII 208 recorded comparatively better girth (30.26 m and 30. 24 cm respectively) during 1987. In the same estate among the four other clones planted in 1982, RRII 5 recorded a mean girth of 25.99 cm during 1987. In another location (Shaliacary estate) in central Kerala among the four clones planted in 1982, the girth of RRII 3 was comparatively better during 1987 (34.10 cm).

Clonal differences in vigour were noted in another blockwise trial of five clones planted in an estate in central Kerala. In another location in the same region, growth of PB 311 during the third year was better compared to that of PB 235 and RRII 300. Early growth of clones PB 260, PB 235, 018 and RRIC 52 was better among the twelve clones planted under blockwise trial in another location in the same region.

The selected clones were supplied to three estates for raising planting material and taking up blockwise trials. Arrangements have also been made for taking up an observational trial in another location where the climatic constraints are severe. Experimental clones are also being established in different regional research stations.

5. ESTIMATION OF GENETIC PARAMETERS IN *HEVEA*:

Recordings of juvenile characters of the progenies raised from open pollinated seeds belonging to ten families maintained at CES were made. The summary of observations is presented in Table Bot. 10.

Table-Bot. 10. *Juvenile characters of open pollinated progenies.*

Parental clones	Plant height (cm)	Diameter (mm)	No. of flushes	No. of leaves
PB 5/51	86.13	7.17	5.60	13.19
Tjir 1	78.02	6.56	5.22	15.06
IAN 45-873	89.71	7.28	6.19	17.63
PB 86	96.31	8.49	6.17	18.50
PB 252	85.15	7.05	5.56	16.32
PB 235	105.47	9.65	6.45	20.46
PB 213	101.15	9.90	6.19	23.27
RRII 105	116.09	10.25	6.33	20.24
GT 1	78.55	7.66	5.20	14.67
PB 242	79.91	6.56	5.89	14.69
General mean	91.65	8.06	5.88	17.40
S. E.	4.13	0.46	0.15	1.12

The progenies were planted in the field along with their parental clones, in short spacings, for studies on genetic parameters in the immature phase. Growth measurements of the three seedling families planted during 1986 were also recorded.

6. INTRODUCTION, COLLECTION AND CONSERVATION OF GERMPLASM

Two thousand clones of Brazilian germplasm were imported from Malaysia in two phases. In the first phase, of the 1000 clones, 974 could be budgrafted (Total number of budded stumps-7198) and established in polybags. In the second phase, of the 1000 genotypes 846 clones could be multiplied and the budded stumps (5027 nos) were planted in polybags at the CES, Chethackal. These plants are being maintained for establishing source-bush nursery.

7. EVALUATION OF GERMPLASM

Data on yield, recorded during the year from the first germplasm garden at the Central Experiment Station, Chethackal indicate that PB 235 and RRII 105 were the top yielders and PB 6/9 the lowest yielder among the 51 clones tested. Similarly the girth data indicated that PB 235 was the most vigorous clone and PB 6/9 the least vigorous one. The second germplasm garden was opened for tapping. Among the 35 clones, RRIM 605 recorded the highest yield during the first year (41.67 g) followed by RRIM 628 (39.2 g), RRIM 703 (37. 38 g) and RRIM 622 (36.76 g). The girth data indicates RRIM 623 as the most vigorous clone followed by RRIM 612 and RRII 105. The girth, recorded from the third germplasm garden during 1988, showed that RRII 203, RRII 118, RRII 206, PB 260 and RRII 6 were the most vigorous clones while RRII 44 was the least vigorous, among the 16 clones in the garden (Table Bot. 11).

Table–Bot. 11. *Girth in cm of clones in the 1981 germplasm garden.*

Clones	Mean girth cm
RRII 203	45.79
RRII 118	45.45
RRII 206	42.65
PB 260	42.03
RRII 6	40.40
PB 311	39.96
RRII 1	39.54
RRII 300	39.44
PB 310	39.27
RRII 3	38.69
RRII 2	37.95
RRII 208	37.22
RRII 5	35.41
RRII 308	33.66
RRII 4	30.84
RRII 44	29.72

Juvenile yield at an age of three years (by test tapping) and girth of one hundred Brazilian clones were recorded along with RRII 105. Among them RRII 105 recorded 4.28 grams per plant per tap, while the germplasm clones recorded in general very poor juvenile yield. Of the two provenances, Rondonia and Matto Grosso, clones of Matto Grosso origin recorded comparatively better juvenile yield (Table Bot. 12).

Table–Bot. 12. *Juvenile yield and girth of genotypes of Brazilian origin.*

Origin	No. of clones	Mean juvenile yield (g/plant/tap)	Mean girth (cm)
Rondonia	53	0.018	20.65
Matto Grosso	47	0.397	20.20
India	1 (RRII 105)	4.28	23.48

8. CYTOGENETICAL INVESTIGATIONS

Detailed investigations on the meiotic behaviour of induced triploid and natural triploid were carried out. *In vivo* studies on pollen tube growth have shown that pollen germination on the stigma and tube growth in the style are normal in *Hevea*.

Investigations on the floral morphology of *Hevea benthamiana* Muell. Arg. have revealed that it exhibited wide variation in the number of stamens, the range being five to eight (Table Bot. 13).

Table–Bot. 13. *Distribution of stamens in Hevea benthamiana*

No. of stamens	Percentage of occurrence
5	30
6	37
7	23
8	10

Hevea species, except *H. guianensis* Aubl., are reported to have ten stamens. Studies on the interspecific hybrids involving *Hevea benthamiana* have elucidated that the male flowers show variation in the number of stamens, the range being 8-10. Since the interspecific hybrids show variation in the number of stamens, the reduction in the number of stamens is a genetically controlled trait in *Hevea benthamiana*.

With a view to exploiting the genetic mutant, 1800 hand pollinations were attempted.

9. FLORAL BIOLOGY AND FRUITSET

Investigations repeated during the 1987 flowering season using different treatments and methods of hand pollination to improve fruit set in *Hevea* have revealed that one treatment, viz., application of Boric acid: Sucrose medium on stigmas prior to pollination gave a significantly higher fruit set percentage than the conventional method. A chisquare analysis was followed for comparing the eight treatments included in the study. A comparison of four of the treatments is given in table Bot. 14.

Table–Bot. 14. *Fruit set under four methods of pollination.*

Treatment	No. of flowers pollinated	Percentage fruit set	
		Initial	Final
Covering inflorescences with a butter paper bag following pollination	131	6.11	3.05
Boric acid: Sucrose	208	10.10	5.29
Removal of perianth of female flowers and dipping the stigma in dehisced anthers contained in a glass vial and covering with paper straw	143	6.99	3.50
Conventional method (control)	249	3.61	1.61

The experiment has been repeated in the 1988 flowering season and observations are in progress.

The experiment aimed at improving fruit set under open pollination was repeated with 16 treatments, comprising, spraying of nutrients and growth regulators. A randomised block design with 2 replications was followed, with three sprays at fortnightly intervals following refoliation, on selected trees of clone Gl 1. Data on fruit set for some of the treatments are given in the Table Bot. 15.

Table-Bot. 15. *Fruit set under natural pollination under different spray treatments.*

Treatment	Fruit set (percentage)	
	One month after cessation of flowering	Four months after cessation of flowering
Control-unsprayed	1.18	0.63
Borax	6.68	3.13
GA 3	0.31	0.23
Urea - 2%	2.29	1.02
Urea - 5%	2.01	0.73
Orthophosphoric acid - 2%	2.89	1.12
Urea + Orthophosphoric acid + Borax	2.09	1.64

Spraying with Borax was found to give the best results, with a final fruit set of 3.13%. The experiment has been repeated with some selected treatments and the observations are in progress.

10. ANATOMICAL (GENERAL) INVESTIGATIONS

Monthly variation in the number of cell layers in the cambial zone of eight clones was studied from samples of twigs collected every month. The mean values have been computed for different seasons (Table Bot. 16). In all the eight clones, the seasonal variations showed more or less similar pattern and were comparable to the result obtained in an earlier study on Gl 1.

Table-Bot. 16. *Seasonal variation in cambial activity.*

Clone	Mean number of cell layers in the cambial zone				
	May-July	Aug-Oct	Nov-Jan	Feb-Mar	Mean
RRII 101	4.50	4.73	5.34	5.90	5.12
RRII 102	4.22	4.83	5.41	5.42	4.97
RRII 105	4.64	4.87	5.37	5.54	5.11
RRII 106	4.70	4.80	5.41	5.79	5.18
RRII 109	4.40	4.79	5.33	5.68	5.10
RRII 111	4.66	4.92	5.44	5.84	5.22
PR 107	4.79	4.85	5.40	5.94	5.25
Tjir 1	4.58	4.84	5.38	5.60	5.10

Studies on intraxylary pholem were continued. The data obtained on the observations taken up with eight clones were analysed and the results are being compiled. The studies have been extended to ten more clones. Studies on stomatal characters are in progress.

11. BARK ANATOMICAL INVESTIGATIONS

Recording of bark anatomical traits of eight clones was completed and the data are being processed for examining the comparative aspects of virgin bark and renewed bark. Quantitative differences were indicated in certain anatomical features between virgin bark and renewed bark.

Recordings of yield, yield factors and secondary characters of ten clones have been completed and the anatomical observations are being continued.

Microscopic observations and data collection were continued for assessing the yearly variations of quantitative anatomical traits.

The number of laticifer rows and the thickness of virgin bark and renewed bark were observed in ten *Hevea* clones. Observations on the virgin bark were taken when the trees were of 18 years growth and those with respect to the renewed bark were taken when the regeneration was five years. The results (Table-Bot. 17) indicated differences among clones.

Table-Bot. 17. *Number of latex vessel rows and thickness of virgin bark and renewed bark.*

Clones	Bark thickness (mm)		No. of latex vessel rows	
	Virgin bark	Renewed bark	Virgin bark	Renewed bark
RRII 115	4.64	4.25	21.28	17.89
RRII 112	5.21	4.47	27.11	18.65
RRII 7	7.49	5.02	40.86	25.28
RRII 2	6.84	4.67	34.33	23.27
RRII 20	6.25	5.14	32.42	24.50
RRII 119	7.08	5.15	31.03	23.72
RRII 108	6.36	4.73	27.83	22.72
RRII 21	7.85	5.92	31.28	26.49
RRII 19	5.70	4.78	28.67	24.56
Tjir 1	8.59	6.38	26.28	23.62

12. WOOD ANATOMY OF *HEVEA*

Dimensional characters of wood fibres were studied using macerated and stained preparations. The following aspects were studied in one clone (PB 86).

(1) Average length and width of normal and gelatinous (tension wood) fibres within wood discs at different heights.

(2) Average length and width (disc average) of normal and gelatinous fibres at different heights along the tree trunk.

(3) Difference in length and width of normal and gelatinous fibres within wood discs at different heights.

(4) Difference in length and width of normal and gelatinous fibres at different heights along the tree trunk.

(5) Percentage frequency of fibre types in terms of length.

The average length of normal fibres was higher in the peripheral zone than the central and intermediate zones of wood discs sawn at 60 cm, 210 cm and 360 cm height levels. The average length of gelatinous fibres was lower in the central zone than the remaining zones of wood discs at 60 cm and 360 cm heights whereas at 210 cm height its length was lower in the peripheral zone than the central and intermediate zones. The average width of both fibres did not show considerable variation from central to peripheral zones at all height levels.

Comparative analysis of the average length of normal and gelatinous fibres at different heights along the tree trunk indicated a decrease in length at 210 cm when compared to 60 cm and 360 cm height levels. At all height levels the average fibre width was more or less comparable.

The normal wood fibres were longer and narrower than those of tension wood. The percentage frequency of short fibres (1000–1500 μm) was the highest and that of long fibres (1500–2000 μm) was the lowest in all height levels irrespective whether the fibres were normal or gelatinous.

To study the percentage area occupied by pores in wood discs at different heights, cross sectional area of pores from adequate number of wood sections were drawn and the data are being analysed. Studies on the anatomical variation between seedling trees and budded trees were initiated.

12(b) **Technical facilities and problems in rubber wood consuming units.**

The study was based on the data collected from a sample of 100 rubber wood consuming units selected randomly, from a list of 400 units. The rubber wood consuming units selected, were classified into different groups according to the line of manufacturing. The tea chest manufacturing units were ranked first among the total sample size followed by units manufacturing veneers and packing cases. The units manufacturing splints, seat and back and general plywoods accounted only for a lower percentage (Table Bot. 18).

The major technical problems, as revealed from the survey, were the occurrence of tension wood, tapping wound and consequent callus formation and wood damage, sap stain fungus infection, borer attack and discolouration. Only 16% of the surveyed units followed some form of chemical treatment of the finished products. The survey pointed out the necessity to improve the quality of the raw material as well as the final products.

13. PROPAGATION TECHNIQUES

The budding experiment at RRS, Tripura was continued during the year. Both green budding and brown budding were attempted as per the scheduled programme. The data collected are being summarised.

The trial on depth of planting was maintained properly and casualties were filled up. The vigour of the plants was recorded by measuring the scion height at 12 months. The data are summarised and given in Table Bot. 19.

Bag plants showed the maximum growth. The bag plants had an average scion height of 75 cm at the time of planting compared to nil for the other treatments.

The studies on bench grafting were repeated during this year by laying out another trial. Plants produced by this technique during the last year were properly maintained in bags and their growth characters like scion height, girth, number of leaf flushes and total number of leaves were recorded at ten months after budding. Data on scion height is furnished in Table Bot. 20.

Table-Bot. 18. *Pattern of consumption of rubber wood, duration of storage and recovery in sample units.*

Line of Manufacturing	Percentage of the total number	Average Annual consumption tonnes/year	Duration of storage (in days)		Average recovery (%) of the final product
			Raw material	Final product	
Packing case	23.65	1623.36	7–15	8–16	83.58
Veneers only	25.81	510.00	5–13	7–15	81.54
Veneers and splints	6.45	1445.00	–	–	–
Splints only	3.23	768.00	5–9	7–11	72.50
Tea-chest panels and plywoods	31.18	774.42	9–14	18–25	79.08
Seat and back for chairs	3.23	279.60	9–13	20–40	72.00
General plywoods	6.45	459.10	7–15	28–30	73.00

Table–Bot. 19. *Mean scion height at 12 months*

Treatments	Mean height (cm)
Normal budding 60 cm tap root	137.63
Budding 15 cm above collar	138.40
Budding 30 cm above collar	135.45
Budding 45 cm above collar	135.30
Normal budding; 45 cm tap root	128.49
Bag plants	276.22

Table–Bot. 20. *Scion growth at ten months after budding.*

Clone	Treatment	Mean height (cm)
RRII 105	Benchgrafts	82.13
	Normal budding	61.89
RRII 118	Benchgrafts	94.71
	Normal budding	65.10
RRII 203	Benchgrafts	112.25
	Normal budding	68.58
RRII 208	Bench grafts	91.22
	Normal budding	64.79
GT 1	Benchgrafts	82.67
	Normal budding	65.48

Benchgrafted plants generally showed better vigour indicated by height.

14. GENETIC BASIS OF STOCK–SCION RELATIONSHIP

Among the 14 different treatments with different stock-scion combinations, girth at the third year of growth (Table Bot. 21) indicates that among the stock-scion combinations, the scion RRII 203 on assorted seedlings and on own stock are the most vigorous ones.

Table–Bot. 21. *Growth of different stock-scion combinations.*

Treatments	Stock	Scion	Mean girth in cm
I	RRII 105	RRII 105	13.93
II	RRII 118	RRII 118	13.34
III	RRII 203	RRII 203	18.35
IV	RRII 208	RRII 208	14.05
V	GT 1	GT 1	14.17
VI	Gl 1	Gl 1	12.97
VII	RRIM 600	RRIM 600	13.67
VIII	Assorted	RRII 105	13.22
IX	Assorted	RRII 118	13.41
X	Assorted	RRII 203	19.21
XI	Assorted	RRII 208	13.77
XII	Assorted	GT 1	13.14
XIII	Assorted	Gl 1	12.40
XIV	Assorted	RRIM 600	13.20

15. HORTICULTURAL MANIPULATIONS

Bag plants raised for crown buddings were maintained well during the period. Crown budding was done on those which have attained the required growth. Budding success (Table Bot. 22) was noted after one month.

Table–Bot. 22. *Success of crownbudding on plants raised in polybags*

Treatment	Budding success (%)
Bag plants - green budded below the top flush	90
Bag plants - green budded below the second flush	68
Bag plants - green budded below the third flush	90
Plants raised in beds, crown budded below the top flush	93

Maximum budding success was obtained in the case of plants established in the ground. A stool with a side step, more convenient than ladder, was designed for crown budding.

16. STUDIES ON EARLY EVALUATION IN *HEVEA*

The trials on early evaluation for drought and yield were continued. Scion height, diameter of the scion at the base, number of flushes of leaves and the total number of leaves were recorded when the plants attained an age of six months and one year. In the trial on early evaluation for yield (Tables Bot. 23 and 24) clonal differences were apparent. Similar was the case with the trial on early evaluation for drought (Tables Bot. 25 and 26). At the age of six months, maximum scion height was noted for RRII 43 which showed the same trend at the age of 12 and 18 months also. In general clones RRII 43, RRIM 701, RRII 308 and RRIM 623 showed comparatively better vigour.

Table–Bot. 23. *Trial on early evaluation for yield: Growth characters at six months' age.*

Clone	Height		Diameter		Whorls (No)		Leaves (No)	
	x	SE	x	SE	x	SE	x	SE
RRII 105	59.71	4.47	8.26	0.48	2.42	0.12	18.55	1.63
RRII 300	56.10	4.27	9.15	0.46	2.35	0.11	20.32	1.56
GT 1	59.97	4.54	8.10	0.49	2.00	0.12	15.53	1.66
Tjir 1	59.17	4.62	7.91	0.49	2.24	0.12	19.62	1.68
RRII 6	74.68	4.54	10.00	0.49	2.40	0.12	20.50	1.66
RRII 38	71.97	4.62	10.18	0.49	2.31	0.12	17.28	1.68
RRII 118	63.08	4.54	9.5	0.49	2.40	0.12	21.83	1.66
RRII 208	60.95	4.7	8.58	0.5	2.07	0.12	19.61	1.71
RRIM 501	63.97	4.4	9.12	0.47	2.28	0.12	18.28	1.6
RRIM 600	81.08	4.62	9.02	0.49	2.55	0.12	23.79	1.68
RRIM 612	85.44	4.98	10.56	0.53	2.40	0.13	26.32	1.81
PB 311	95.67	4.4	11.12	0.47	2.69	0.12	25.38	1.6
HP 20	59.40	4.21	7.87	0.45	2.29	0.11	17.66	1.53

Table–Bot. 24. *Trial on early evaluation for yield: Growth characters at one year age.*

Clone	Height		Diameter		Whorls(No)		Leaves(No)	
	x	SE	x	SE	x	SE	x	SE
RRII 105	125.00	10.56	16.50	0.80	4.57	0.18	36.18	2.90
RRII 300	136.97	9.72	16.62	0.74	4.88	0.17	40.88	2.67
GT 1	152.63	10.20	16.32	0.77	4.97	0.18	49.86	2.85
Tjir 1	128.15	10.75	15.06	0.81	4.52	0.19	32.59	2.95
RRII 6	197.38	10.37	19.35	0.78	5.69	0.18	54.59	2.85
RRII 38	155.82	10.75	18.85	0.81	4.74	0.19	32.33	2.95
RRII 118	154.80	10.20	19.10	0.77	5.37	0.18	48.57	2.80
RRII 208	146.19	10.75	16.03	0.81	5.07	0.19	47.11	2.95
RRIM 501	136.09	9.87	16.42	0.74	4.97	0.17	33.94	2.71
RRIM 600	166.04	10.56	17.47	0.80	5.50	0.18	44.89	2.90
RRIM 612	186.1	10.75	19.41	0.81	4.89	0.19	46.52	2.25
PB 311	193.74	10.03	19.82	0.76	5.52	0.18	42.58	2.75
HP 20	129.29	9.58	14.88	0.72	4.53	0.17	33.35	2.63

Table–Bot. 25. *Trial on early evaluation for drought: Growth characters at six months' age.*

Clone	Height		Diameter		Whorls(No)		Leaves(No)	
	x	SE	x	SE	x	SE	x	SE
RRII 105	61.92	4.25	8.93	0.41	2.28	0.12	18.81	1.39
RRII 300	68.71	4.25	10.09	0.41	2.58	0.12	24.58	1.39
GT 1	59.56	4.58	7.96	0.44	2.45	0.13	19.84	1.50
Tjir 1	52.93	4.91	7.74	0.47	2.19	0.14	18.70	1.61
RRII 4	57.60	4.73	7.99	0.45	2.17	0.13	15.72	1.55
RRII 43	82.14	4.19	9.71	0.40	2.70	0.12	23.19	1.37
RRII 308	78.47	4.25	10.39	0.41	2.58	0.12	25.61	1.39
Gl 1	53.32	4.37	8.05	0.42	2.09	0.12	17.68	1.43
RRIM 623	71.13	4.65	9.05	0.45	2.40	0.13	22.27	1.53
RRIM 701	80.19	4.51	10.52	0.43	2.56	0.13	22.34	1.48

Table–Bot. 26. *Trial on early evaluation for drought: Growth characters at one year age.*

Clone	Height		Diameter		Whorls(No)		Leaves(No)	
	x	SE	x	SE	x	SE	x	SE
RRII 105	150.36	9.36	17.81	0.74	4.8	0.20	42.10	2.5
RRII 300	160.43	9.09	19.21	0.72	5.3	0.22	44.00	2.4
GT 1	135.93	9.98	16.75	0.79	4.9	0.20	46.20	2.7
Tjir 1	124.52	10.75	15.82	0.85	4.7	0.20	35.70	2.9
RRII 4	141.96	10.75	15.64	0.85	4.7	0.24	36.40	2.9
RRII 43	187.11	8.84	20.30	0.70	5.3	0.20	41.70	2.4
RRII 308	166.03	9.22	19.56	0.73	5.1	0.20	34.80	2.5
Gl 1	122.28	9.98	17.33	0.79	4.4	0.23	33.00	2.7
RRIM 623	163.52	10.75	18.09	0.85	5.3	0.20	42.60	2.9
RRIM 701	168.84	9.50	20.27	0.75	4.6	0.22	37.40	2.5

When the plants were at the age of one and a half years the percentage leaf retention was assessed soon after the drought season. RRII 300 and Tjir 1 showed numerically better leaf retention, while Gl 1 showed maximum leaf fall (Table–Bot. 27). The same set of observations taken from the trial on early evaluation for yield (Table–Bot. 28) also indicated clonal differences on the extent of leaves retained. The plants in these trials are being subjected to test tapping.

Table–Bot. 27. *Percentage leaf retention, height and girth during April* 1987*: Trial on drought studies.*

Clone	Percentage leaf retention		Height cm	Girth cm
	Mean ± S. D.	Range		
RRII 105	74.34 ± 7.8	55–90	267.7	7.22
GT 1	73.09 ± 7.88	60–95	276.42	7.13
RRII 4	70.50 ± 8.24	55–85	277.75	6.84
RRII 308	70.69 ± 5.63	60–80	278.61	7.00
Gl 1	68.73 ± 6.85	55–93	250.00	6.78
RRII 300	78.64 ± 7.6	65–95	291.58	7.63
Tjir 1	75.34 ± 4.99	70–85	257.34	6.86
RRII 43	73.75 ± 6.14	60–85	344.65	8.64
RRII 623	71.45 ± 7.44	55–95	299.34	7.57
RRIM 701	73.79 ± 7.07	60–85	308.47	7.53

Table–Bot. 28. *Percentage leaf retention, height and girth at* $1\frac{1}{2}$ *years: Trial on early evaluation for yield.*

Clone	Percentage leaf retention		Range	Height cm	Girth cm
	Mean	S.D			
RRII 105	72.93	5.59	65–80	274.9	7.19
RRII 208	71.02	5.06	60–80	294.77	7.06
RRII 300	74.52	5.06	65–85	297.00	7.23
RRIM 600	76.56	3.90	65–80	341.74	7.58
PB 311	73.48	4.92	55–80	363.21	8.17
GT 1	71.07	7.25	55–80	292.24	7.60
Tjir 1	73.46	4.64	65–80	259.52	6.90
RRII 6	80.34	6.11	65–95	381.16	8.79
RRII 118	79.03	7.24	60–90	325.34	8.52
RRIM 501	71.50	4.94	60–80	270.63	7.17
RRIM 612	74.38	5.64	60–80	299.76	7.50
RRII 38	73.67	4.54	65–80	286.57	7.63
HP 20	74.84	4.90	65–85	261.66	6.59

17. STUDIES ON INBREEDING

With a view to assessing the extent of inbreeding depression for different nursery as well as mature characters, a study was initiated during 1988 flowering season. Three different methods are being tried along with the observation on fruit set under natural condition (control), on five clones.

Biotechnology Division

Progress has been achieved in establishing a tissue culture propagation system for some important commercial rubber clones. This procedure is being further refined in order to make it a viable commercial propagation system. All commercial cultivars recommended for planting by the Rubber Board are being tried to suit this propagation system. Several clones have responded favourably to this *in vitro* manipulation. A few hundred plants were generated by shoot tip culture and after the hardening process about 150 plants are ready for planting in the field. It is visualised that the tissue culture derived rubber trees would have the following advantages:

(a) Adverse effects of traditional propagation system can be circumvented (eg: yield variability caused by the root stock-scion interaction).

(b) Since the tissue culture derived trees may resemble seedling trees, they may reach tappable girth earlier.

(c) Faster rate of propagation per unit time.

Anther culture is another area where significant advancement has been achieved. A few plants were regenerated by this techniques and some of their ploidy levels were established. By utilizing this system, trees with a new threshold of character combinations can be obtained, unattainable by the conventional plant breeding alone.

Agronomy and Soils Division

The thrust areas of research in the Agronomy and Soils Division are investigations on nutritional requirements of various high yielding clones of rubber at various stages of growth in different agroclimatic regions, studies on discriminatory fertilizer use and agromanagements practices like irrigation and moisture management, intercropping systems and crop combinations, weed management systems and soil conservation. The discriminatory fertilizer recommendation service has gained momentum with a large number of growers requesting for our service which is operating from three Regional Laboratories apart from the Central Laboratory and also deploying four Mobile Soil and Tissue Testing Laboratories.

1. NUTRITIONAL STUDIES (IMMATURE PHASE)

A. Nutritional requirements of different clones in different agroclimatic zones.

The objective of this project is to find out the nutritional requirements of various high yielding clones of rubber during the immature phase in different agroclimatic regions.

Four field experiments are in progress under this project involving two clones. One of the above experiments, which was started in 1986, has been discontinued due to poor establishment and large vacancies. Sites have been identified for starting two new field experiments with two clones during 1988 planting season.

The growth data for experiments at Punalur and Mundakayam started in 1985 and for experiment at Kanyakumari started in 1986 are given below.

i) **Experiment at Punalur (Clone PB 235)**

Table-Ag. 1. *Mean girth increment (cm)* (1987 *to* 1988)

Kg P_2O_5 ha^{-1}	Kg N ha^{-1} 0	30	60	Mean
0	8.55	8.92	8.43	8.64
30	9.18	9.21	8.83	9.07
60	9.17	9.63	9.62	9.47
Kg K_2O ha^{-1}				
0	8.38	8.94	9.23	8.85
20	9.70	9.99	9.12	9.60
40	8.81	8.83	8.53	8.72
Mean	8.96	9.25	8.96	9.06

A general evaluation of the above data indicates that there is a positive response to phosphate application upto 60 kg P_2O_5ha^{-1} level whereas in the case of nitrogen and potassium, there is no response beyond 30 kg N ha^{-1} and 20 kg K_2O ha^{-1} levels, respectively during 1987-88 which is the third year after planting.

ii) **Experiment at Mundakayam (Clone RRII 105)**

Table-Ag. 2. *Mean girth increment (cm)* 1987 *to* 1988

Kg N har^{-1} Kg P_2O_5 ha^{-1}	0	30	60	Mean
0	6.13	6.74	6.27	6.38
30	6.23	6.08	6.28	6.20
60	6.40	6.61	6.34	6.45
Kg K_2O ha^{-1}				
0	6.22	6.19	6.07	6.16
20	6.35	6.79	6.43	6.52
40	6.18	6.46	6.39	6.34
Mean	6.25	6.48	6.30	6.34

The above girth increment data for the third year after planting shows that there is response to nitrogen and potash at 30 kg N ha^{-1} and 20 kg K_2O ha^{-1} levels, respectively beyond which the response declines. The response to phosphate applications does not appear to follow a consistent pattern even though the highest level gave better girth increment,

iii) **Experiment at Kanyakumari (Clone RRII 105)**

Table-Ag. 3. *Mean girth as on January*, 1988 (*cm.*)

Kg P_2O_5 ha^{-1}	Kg N ha^{-1} 0	30	60	Mean
0	11.27	10.43	11.57	11.09
30	11.22	11.30	11.41	11.31
60	11.47	10.87	11.27	11.15
Kg K_2O ha^{-1}				
0	11.41	11.00	11.43	11.28
20	11.41	10.88	11.57	11.29
40	11.12	10.72	11.09	10.98
Mean	11.32	10.87	11.36	11.18

The above girth data taken one and a half years after planting did not indicate a clear response to any of the nutrients. However, the highest level of potassium at 40 kgK_2Oha^{-1} appeared to depress growth.

2. NUTRITIONAL STUDIES (MATURE PHASE)

A. Nutritional requirement of different clones of rubber in different agroclimatic zones.

This project is aimed at finding out the nutritional requirement of modern high yielding clones during mature phase in different agroclimatic zones with a view to achieve maximum yield by proper manuring.

Seven field experiments are in progress involving four high yielding clones. The yield and girth data relating to these experiments are summarised and tabulated. The salient results are given below.

i) **Experiment at Calicut (Kinalur Estate, Clone GT 1)**

In the first year of treatment imposition (1985-86) period, the simple effect of any of the nutrients did not appear to follow any definite pattern of influence. During the 1986-87 period, the yield did not seem to benefit from the application of nitrogen or potash. Application of phosphorus at both 20 and 40 kg ha $^{-1}$ significantly depressed the yield.

Table-Ag. 4. *Mean yield* (*g tree*$^{-1}$ *tap* $^{-1}$) 1986-87

Kg P_2O_5 ha^{-1} 0	20	40	CD (P = 0.05)
28.78	26.23	26.71	2.00

Application of nutrients did not influence the girth of trees in any of the years.

ii) **Experiment at Vadakkencherry (Vaniampara Estate, Clone GT 1)**

The mean yield during 1987 is given below.

Table-Ag. 5. *Mean yield (g tree^{-1} tap^{-1})* 1987

Kg P_2O_5 ha^{-1}	Kg N ha^{-1} 0	20	40	Mean
0	40.62	44.45	41.65	42.24
20	41.07	51.64	39.38	44.03
40	42.69	52.09	48.16	47.65
Kg K_2O ha^{-1}				
0	39.38	46.78	40.58	42.25
30	44.85	48.97	43.77	45.86
60	40.14	52.43	44.84	45.80
Mean	41.46	49.39	43.07	

Application of nutrients were effective and N at 20 kg ha^{-1} gave the highest mean yield during 1987, the first year of the commencement of fertilizer treatments. The yield showed a steady increase with phosphorus application. The yield also showed an increasing trend with potassium upto 30 kg K_2O ha^{-1}.

The mean girth of trees during 1987 and 1988 are presented below. There was a positive response to nitrogen upto the level of 20 kg ha^{-1}. However, application of N at 40 kg ha^{-1} significantly reduced the girth in both the years. The mean girth of trees was also influenced by phosphorus and at 40 kg P_2O_5 ha^{-1} it significantly increased the girth of trees.

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

Level of N(Kg ha^{-1})	Year 1987	1988	Level of P(Kg ha^{-1})	Year 1987	1988
0	52.80	54.54	0	53.07	54.80
20	55.11	57.38	20	53.04	55.20
40	53.11	55.02	40	54.90	56.94
Mean	53.67	55.65	Mean	53.67	55.05
CD(P = 0.05)	1.49	1.76	CD(P = 0.05)	1.49	1.76

iii) **Experiment at Thodupuzha (Malankara Estate)**

a) **Clone GT 1**

Table–Ag. 7. *Mean yield (g tree^{-1} tap^{-1})*1987

Kg K_2 Oha^{-1}	Kg P_2O_5 ha^{-1} 0	20	40	Mean
0	29.00	30.44	32.13	30.52
30	32.80	31.36	31.20	31.79
60	31.03	35.58	32.58	33.06
Mean	30.94	32.46	31.94	

The data presented above indicate that there was positive response in yield to application of both phosphorus and potassium during 1987, the first year of imposition of fertilizer treatment. The highest mean yield was obtained at 20kg P_2O_5 ha^{-1}, whereas, there was a steady increase in yield with potassium upto 60 kg K_2O ha^{-1}. The response to nitrogen application was inconsistent. No significant response was noticed in the case of girth and girth increment of trees due to application of fertilizers.

b) **Clone RRII 105**

Table–Ag. 8. *Mean yield (g tree $^{-1}$ tap^{-1})*1987

Kg P_2O_5 ha^{-1}	Kg N ha^{-1} 0	20	40	Mean
0	49.25	52.11	47.00	49.45
20	49.50	53.05	49.56	50.70
40	49.98	53.55	48.50	50.69
Mean	49.58	52.90	48.35	
Kg K_2 Oha^{-1}				
0	...	...	...	52.03
30	...	...	...	48.25
60	...	...	...	49.55
Mean	...	...	...	49.94

There was increase in yield due to nitrogen and phosphorus application upto 20 kg ha^{-1} level during 1987, the first year of treatment imposition. Application of potassium was seen to depress the yield in all levels tried.

The application of fertilizer did not significantly influence girth and girth increment of trees during 1987 and 1988.

iv) **Experiment at Kanyakumari district (New Ambady Estate)**

The two experiments were commenced during 1985 on clones GT1 and PB 28/59. The treatment imposition commenced from the year 1986.

a) **Clone GT 1**

There was no response in yield to application of the nutrients during 1986. During 1987 application of N at 20 kg ha^{-1} increased the yield, whereas, the increase was not appreciable at 40 kg N ha^{-1}. No response in yield due to phosphorus application was noticed. Potassium depressed the yield at both the levels.

Table-Ag. 9. *Mean yield (g tree^{-1} tap^{-1})* 1987

Kg K_2O ha^{-1}	Kg N ha^{-1} 0	20	40	Mean
0	26.69	26.76	28.45	27.30
30	25.61	26.91	24.80	25.78
60	24.27	27.56	25.71	25.85
Mean	25.52	27.08	26.32	

There was no response in girth of trees due to fertilizer application during 1985. However, there was significant difference in girth due to nitrogen application during the subsequent two years. Application of nitrogen at 20 kg ha^{-1} recorded the highest girth in both the years.

Table-Ag. 10. *Mean girth (cm)*

Level of N (kg ha^{-1})	Year 1986	1987
0	57.12	59.15
20	58.49	60.12
40	57.85	59.79
Mean	57.82	59.85
CD(P = 0.05)	1.02	1.02

b) **Clone PB 28/59**

Table-Ag. 11. *Mean yield (g tree^{-1} tap^{-1})* 1986

Dose(kg ha^{-1})	0	20	40
N	68.00	71.23	70.56
P_2O_5	71.22	69.67	68.89
K_2O	0	30	60
	67.19	67.83	74.76

Table-Ag. 12. *Mean yield (g tree^{-1} tap^{-1})* 1987

Kg P_2O_5 ha^{-1}	Kg N ha^{-1} 0	20	40	Mean
0	55.69	53.64	52.09	53.81
20	45.69	47.44	44.94	46.02
40	51.32	45.20	48.62	48.38
Mean	50.90	48.76	48.55	

During 1986, there was an increase in yield due to the application of nitrogen and the highest mean yield was obtained with 20 kg N ha^{-1}. But during 1987, application of nitrogen showed a depressing effect on yield. Application of phosphorus decreased the yield during both the years. During 1986, potash application appreciably increased the yield at 60 kg. K_2O ha^{-1}. This response was not so evident during 1987.

The general depression in yield noticed in the experimental area during 1987 was probably due to the prolonged drought experienced during that year.

The mean girth increment data for 1985-86 period presented below shows that application of nitrogen at 40 kg ha^{-1} recorded the highest increment compared to the lower levels when no phosphorus was applied, whereas, when phosphorus was applied at 40 kg ha^{-1}, application of nitrogen at both the levels significantly decreased the girth increment.The girth increment was not significantly influenced by fertilizer application during 1986-87 and 1987-88 periods.

Table-Ag. 13. *Mean girth increment (cm)*, 1985-86

Kg P_2O_5 ha^{-1}	Kg N ha^{-1} 0	20	40	Mean
0	1.27	1.32	1.70	1.43
20	1.67	1.46	1.38	1.39
40	1.66	1.25	1.34	1.41
Mean	1.42	1.35	1.47	

CD(P = 0.05) = 0.32

v) **Experiment at Trichur district (Pudukad Estate)**

The treatment imposition commenced from 1981. There was no response in yield due to application of fertilizers during 1987 and 1988.

The mean girth data for 1986 and 1988 are presented below. It was observed that application of phosphorus significantly increased the girth upto 20 kg ha^{-1} beyond which considerable reduction in girth occurred.

Table–Ag. 14. *Mean girth (cm)*

Level of P (kg ha^{-1})	Year	
	1986	1988
0	73.26	77.19
20	75.75	79.77
40	72.90	76.47
Mean	73.97	77.81
CD(P = 0.05)	1.32	1.43

The data presented below show that there is a significant response for mean girth increment due to the application of nitrogen.

Table–Ag. 15. *Mean girth increment (cm)* 1986–88

Level of N (kg ha^{-1})	Mean girth increment
0	3.59
20	3.82
40	4.12
Mean	3.84
CD(P = 0.05)	0.41

There was a progressive increase in girth increment (1986-88) with incremental levels of nitrogen. The response to phosphorus was seen only upto 20 kg P_2O_5 ha^{-1} beyond which there was a depressing effect. Potash application was useful for girth increment only at 60 kg K_2O ha^{-1}. The lower level of 30 kg K_2O ha^{-1} showed a negative effect on girth increment.

B. Effect of fertilizer application in relation to ground cover maintenance during immature phase on growth and yield of rubber

During the immature phase in one experiment, the leguminous cover crop *Pueraria phaseoloides* and in the other natural ground cover were maintained. The two experiments done at the Central Experiment Station, Chethackal, came to yielding during 1979.

Table–Ag. 16. *Mean yield (g tree^{-1} tap^{-1})*

Kg N ha^{-1}	Legume cover		Kg N ha^{-1}	Natural cover	
	1986	1987		1986	1987
0	46.96	49.03	0	51.40	48.19
20	52.94	50.90	40	48.76	53.20
40	53.37	49.96	80	54.00	57.02

Table-Ag. 17. *Mean girth (cm) 1988.*

Kg N ha^{-1}	Legume cover	Kg N ha^{-1}	Natural cover
0	77.77	0	73.97
20	82.38	40	85.98
40	81.07	80	86.91

The data on mean yield indicate that application of nitrogen above 20 kg ha^{-1} was not advantageous in the legume cover area. On the other hand in the natural cover area response in yield was noticed upto 80 kg N ha^{-1}. More or less a similar trend was also observed during 1988 in the case of mean girth of trees.

3. EFFECT OF DENSITY OF PLANTING OF RUBBER ON GROWTH AND YIELD

This project aims at finding out the optimum density of planting of rubber for early maturity and maximum yield. Two fertilizer treatments are also superimposed to study the response to fertilizers under different densities.

There is only one experiment under this project, started in 1985 on clone RRII 105. The mean girth of trees during 1988 and mean girth increment from 1985 to 1988 were worked out and the data are tabulated below. By 1988, the trees are in the third year after planting.

Table-Ag. 18. *Mean girth and girth increment (cm)*

Treatments	Girth (1988)		Girth increment (1985–88)	
	Manurial doses (kg)			
Spacings	40:40:16:6 NPKMg ha^{-1}	60:60:24:9 NPKMg ha^{-1}	40:40:16:6 NPKMg ha^{-1}	60:6024:9 NPKMg ha^{-1}
6.7 × 3.4m	16.70	16.67	7.35	6.75
6.7 × 3.0m	18.99	18.90	8.96	8.12
6.1 × 3.4m	17.14	16.81	6.99	6.89
6.1 × 3.0m	17.63	17.84	7.79	8.24
5.5 × 3.4m	17.81	17.29	8.03	7.47
5.5 × 3.0m	17.92	18.06	7.85	7.70
Mean	17.70	17.60	7.83	7.52

Table-Ag. 19. *Mean girth (cm)*

Spacing (m)	3.0	3.4	Mean
6.7	18.95	16.69	17.97
6.1	17.74	16.98	17.36
5.5	17.99	17.55	17.77
Mean	18.23	17.17	17.65

Table-Ag. 20. *Mean girth increment (cm*

Spacing (m)	3.0	3.4	Mean
6.7	8.54	7.05	7.80
6.1	8.02	6.94	7.48
5.5	7.78	7.75	7.77
Mean	8.11	7.25	7.68

The data in general do not indicate any additional nutrient requirement with increasing density of population. Row to row spacing does not seem to have affected either the girth or girth increment of trees. On the other hand, the lower plant to plant distance has given higher girth and girth increment irrespective of the row to row spacing.

The inter and intra row light interception was measured using Li-1800 spectro radiometer and Li-188 E integrating quantum radiometer on a grid system as a base for aligning rubber and intercrops for future studies.

4. IRRIGATION AND MOISTURE MANAGEMENT IN RUBBER

Irrigation could be a means of increasing the existing yield and reducing the rather long immaturity period in rubber cultivation. Water is a scarce commodity in rubber growing areas in summer months and application of irrigation water through water saving devices such as drip irrigation technique can mitigate the effect of drought during summer months.

A. Effect of irrigation on yield - mature phase

A field experiment was started at Cheruvally Estate, Kottayam district during 1985. Drip irrigation was given during summer months of 1986, 1987 and 1988.

The mean yield tree^{-1} tap^{-1} during the irrigation period (January to April) of 1987 is given below.

Table-Ag. 21. *Mean (g) yield tree^{-1} tap^{-1}*

Treatments	Pre-treatment yield of 1985	Post treatment yield January to April 1987	Wintering depression in yield
No irrigation	36.67	24.61	12.06
Drip 5 l tree^{-1} day^{-1}	30.21	21.21	9.00
Drip 10 l tree^{-1} day^{-1}	30.80	23.55	7.25
Drip 15 l tree^{-1} day^{-1}	28.88	21.16	7.72
Drip 20 l tree^{-1} day^{-1}	31.73	23.48	8.25

It is indicated that the wintering depression in yield could be offset to a certain extent by irrigation. The reduction in the unirrigated plots was 12 g tree^{-1} tap^{-1} while it was only about 8 g tree^{-1} tap^{-1} in the irrigated plots. Thus an increase of 4 g tree^{-1} tap^{-1} could be obtained with irrigation. This will work out to 60 kg ha^{-1} of extra dry rubber during the 4 month period of irrigation.

B. (1) Effect of irrigation on the growth of rubber - immature phase

This experiment was started in 1986-87 season. Irrigation was continued upto May 1987 and stopped with the onset of monsoon. Due to shortage of water, irrigation was possible only for two months during 1988. The data on diameter increment for a period of six months (7/1/87 to 9/7/87) showed that irrigation significantly influenced the diameter increment compared to no irrigation.

Table–Ag. 22. *Mean diameter increment (cm)*

Treatments	Mean diameter increment (cm)
No irrigation	0.625
Basin irrigation - 35 l week^{-1} plant^{-1}	1.093
Drip irrigation - 7.5l plant^{-1} day^{-1}	1.288
Drip irrigation 5.0l plant^{-1} day^{-1}	1.190
Drip irrigation 2.5l plant $^{-1}$ day^{-1}	1.305
SE – 0.067	CD:- 0.207 (P = 0.05)

(2) Effect of irrigation and split application of fertilizers on growth of immature plants

This experiment was started in Cheruvally Estate during the summer season of 1987-88 and treatment imposition and pre-treatment diameter recordings were made.

C. **Evaluation of micro and macro irrigation methods on immature rubber**

This experiment to evaluate the micro (drip) and macro (basin) irrigation methods on growth of immature rubber was started during January, 1988 in a small holding at Manjoor, near Ettumanoor.

Irrigation was started from Ist January, 1988 and continued upto the end of the summer season ie, April, 1988. A few summer showers were received during the irrigation period.

The preliminary indication of the effect of drip irrigation on plant girth increment (10/12/1987) to (5/5/1988) is encouraging as indicated below.

Table–Ag. 23. *Girth and girth increment of plants*

Treatments	Girth (cm)		Girth increment (cm)
	on 10/12/87	on 5/5/88	
No irrigation	8.52	9.13	0.61
Drip 5l plant^{-1} day^{-1}	8.92	10.15	1.23
,, 7.5 l ,,	9.13	10.54	1.41
Basin 32.5 l plant^{-1} week^{-1}	8.15	9.25	1.10
,, 52 l ,,	8.27	9.48	1.21

D. **Integration of plastic mulches and irrigation in seedling nurseries.**

In this experiment, high molecular high density black polythene sheets of 200 gauge thickness were used as the mulch material after providing holes by punching. The irrigation treatments could be imposed only for a period of one month during summer due to scarcity of water. The mean diameter increment of seedlings before and after mulching for six months is summarised below.

Table–Ag. 24. *Mean diameter increment of seedlings (cm)*

Treatment	Polythene mulch	Conventional leaf mulch	No mulch
Diameter increment	1.07	0.88	0.48

It is seen that mulching was effective and polythene mulch was better than conventional leaf mulch.

5. WEED MANAGEMENT SYSTEMS IN RUBBER

The objective of this project is to find out suitable herbicides, as well as herbicides in combinations with low cost additives, for effective and economic weed control in rubber plantations.

An experiment was done to evaluate the efficacy of different doses of a post emergent herbicide - Glyphosate - in conjunction with various low cost additives like kaolin, ammonium sulphate and muriate of potash.

The herbicidal effect of glyphosate was found to be enhanced by the addition of kaolin or ammonium sulphate. The effective dose of glyphosate could be reduced from 0.82 kg a.i.ha^{-1} (2l of commercial formulation ie; Weedoff/Glycel) to 0.62 kg a. i. ha^{-1} (1.5 l of commercial formulation) for controlling weeds in rubber.

6. STUDIES ON INTERCROPPING IN RUBBER

The objective of this project is to evolve cropping systems involving shade tolerant perennial and annual intercrops during immature and mature phases of rubber plantation in different agroclimatic regions.

Three field experiments are in progress. Two experiments are at Central Experiment Station, Chethackal representing the plains. One of these include intercrops viz; cocoa, pepper and three varieties of coffee planted along with rubber. The growth of the intercrops is satisfactory. The second experiment was started during the period under report in a rubber area expected for initiating tapping in 1988 at Chethackal. Coffee varieties Robusta and Caveri were planted in the inter rows of rubber which was planted adopting a space of 6.7 × 3.4 m. Their growth is satisfactory.

The third experiment is in high elevation condition (730 m above MSL). The intercrops envisaged are pepper, coffee and cardamom. Since the experimental site surrounds reserve forest, planting of rubber and intercrops can be done only after protecting the area from wild animals by erecting an electric fence. The planting materials of rubber and the intercrops have been raised and kept ready for field planting expected to be done during the planting season of 1988.

Site has been selected for starting a fourth experiment in immature rubber using intercrops like banana, pineapple, ginger and medicinal plants.

7. FORMS AND METHOD OF FERTILIZER APPLICATION

The project is intended to study the possibility of increasing the efficiency of nitrogenous and phosphatic fertilizers and also to explore the possibility of utilising waste products from rubber plantation industry. For this purpose laboratory, nursery and field trials are being undertaken.

A. Comparative study on the effect of water soluble and water insoluble forms of phosphatic fertilizers on the growth of *Hevea*

An experiment to evaluate two forms of phosphatic fertilizers, Mussoorie rock phosphate and Ammophos (water insoluble and water soluble, respectively), on the growth of immature rubber was started in Boyce Estate, Mundakayam during 1985. Two doses of phosphorus, 40 and 50 kg ha^{-1} were tried in 2 and 3 split applications. Soil samples were collected and analysed for available P using Bray II extractant. Leaf samples were also collected and analysed for phosphorus to compare the P uptake by plants.

Table-Ag. 25. *Girth increment for the period 1985 to 1988*

Treatments	Girth increment (cm)
Rock phosphate @ 40 kg ha^{-1} in 2 split doses	17.57
,, ,, ,, 3 ,, ,,	17.81
Ammophos @ 40 kg ha^{-1} in 2 split doses	20.30
,, ,, 3 ,, ,,	20.80
Rock phosphate @ 50 kg ha^{-1} in 2 split doses	18.50
,, ,, ,, 3 ,, ,,	19.66
Ammophos @ 50 kg ha^{-1} in 2 split doses	20.02
,, ,, 3 ,, ,,	20.35
No phosphate (Control)	17.52

The mean values indicate that application of Ammophos @ 40 kg ha^{-1} in 3 split doses gave a higher girth increment over all other treatments.

B. **Different sources of phosphate for rubber and associated crops**

The project is intended to assess the feasibility of using bowl sludge obtained from concentrated latex factories for manuring of rubber and cover crop, *Pueraria phaseoloides*.

Budded stumps were planted in polybags and 10:10:4:1.5 NPK Mg mixture was added. Phosphorus in the mixture was given in the form of super phosphate, mussoorie rock phosphate and bowl sludge. The plants were uprooted after one year. Before uprooting, the height and girth measurements were taken. The plants were dried and dry matter production estimated. The plant parts were analysed for estimating the total phosphorus uptake. The data on height, diameter, dry matter production and phosphorus uptake are furnished below.

Table-Ag. 26. *Effect of different sources of phosphatic fertilizers on growth, dry weight and P uptake*

Treatments	Height (cm)	Diameter (cm)	Total dry wt (gm)	Total P uptake (gm)
Super phosphate @30 kg ha^{-1}	72.00	1.24	141.15	8.12
Super phosphate @45 kg ha^{-1}	76.83	1.29	141.95	10.27
Mussoorie rock phosphate @30 kg ha^{-1}	66.05	1.15	147.93	9.61
Mussoorie rock phosphate @45 kg ha^{-1}	68.75	1.27	165.74	12.97
Bowl sludge @30 kg ha^{-1}	77.37	1.29	188.91	15.01
Bowl sludge @45 kg ha^{-1}	92.74	1.38	236.95	23.31
Control (No Phosphorus)	55.05	1.04	125.95	7.26

The results indicate that bowl sludge applied plants are significantly better in growth, dry matter production and phosphorus uptake.

An incubation study was also conducted to assess the availability of phosphorus from the phosphorus sources tried for the field study. Available phosphorus was extracted at 15 days interval from 15 to 90 days after application of phosphorus @ 20, 40 and 60 kg ha^{-1}. Moisture level was maintained at field capacity throughout the period of study. The results are given in the table below.

Table-Ag. 27. *Available phosphorus (mg/100gm soil) at various intervals of time from different phosphate sources*

Interval (days)	Super phosphate (kg ha^{-1})			Mussoorie rock phosphate (kg ha^{-1})			Bowl sludge (kg ha^{-1})			Control
	20	40	60	20	40	60	20	40	60	
15	0.12	0.23	0.24	0.24	0.30	0.33	0.09	0.18	0.18	0.03
30	0.12	0.27	0.30	0.27	0.33	0.39	0.11	0.23	0.33	0.07
45	0.15	0.23	0.24	0.24	0.30	0.33	0.09	0.18	0.30	0.09
60	0.22	0.25	0.27	0.27	0.33	0.37	0.20	0.23	0.27	0.08
75	0.35	0.37	0.40	0.37	0.40	0.45	0.37	0.40	0.47	0.10
90	0.30	0.32	0.33	0.29	0.27	0.39	0.24	0.29	0.32	0.12
Total	1.26	1.67	1.78	1.68	1.93	2.26	1.10	1.51	1.87	0.49

The results indicate that bowl sludge is as good as super phosphate with regard to the availability of phosphorus. The availability of phosphorus is found to be more from Mussoorie rock phosphate as compared to super phosphate and bowl sludge.

The study is being extended to field condition.

C. **Comparison of the efficiency of Ammonium sulphate and Urea as nitrogenous fertilizers for rubber seedlings**

The project is intended to study whether long term use of urea in rubber plantation will cause any sulphur deficiency in soil thereby affecting the growth of rubber.

The experiment is being repeated in the nursery for the third time. The height and diameter of the plants raised during the second season were recorded. The mean values are furnished below.

Table-Ag. 28. *Growth measurements - Second season*

Treatments	Height (cm)	Diameter (cm)
Ammonium sulphate	104.08	1.11
Urea	97.75	1.06
50% Ammonium sulphate + 50% Urea	102.33	1.08
Ammophos	102.78	1.06

Soil samples collected from the 24 plots were analysed for total and available sulphur content. The avergae values are given below.

Table–Ag. 29. *Sulphur content of soil*

Treatments	Available sulphur (ppm)	Total sulphur (ppm)
Ammonium sulphate	95.33	308
Urea	76.00	220
50% Ammonium sulphate + 50% Urea	89.83	264
Ammophos	90.50	264

For conducting the experiment thrice on the same site, planting, fertilizer application and recording of the growth measurements were repeated during the period under report. The height and diameter of the third year plants are given below.

Table–Ag. 30. *Growth measurements - Third season*

Treatments	Height (cm)	Diameter (cm)
Ammonium sulphate	64.97	0.77
Urea	57.98	0.66
50% Ammonium sulphate + 50% Urea	63.37	0.70
Ammophos	61.83	0.73
No Nitrogen	46.60	0.57

For growth measurements, the trend is the same as obtained during the first season. The plants treated with ammonium sulphate shows superiority over urea treated plants. The soil analysis data indicate that total and available sulphur is less in urea treated plots as compared to ammonium sulphate treated plots. The results so far obtained indicate that continuous use of urea may result in sulphur deficiency in rubber growing soils in the long run.

D. **Volatilization loss of urea**

The study is undertaken to explore the possibility of reducing volatilization loss from urea by neem cake coating and by physical mixing with neem cake under two levels of moisture. The volatilization loss of nitrogen was estimated after coating and mixing urea with neem cake at two different soil moisture levels, ie; field capacity and half field capacity. The estimations were made after 72 and 114 hours after application. The results are given below.

capacity and hall held capacity.

Table–Ag. 31 *Nitrogen loss*

Treatments	Moisture content	Period (hours)	Nitrogen loss (mg)
Neem cake coating	Field capacity	72	No loss
,,	,,	144	30.08
Neem cake mixing	,,	72	No loss
,,	,,	144	41.01
Neem cake coating	Half field capacity	72	No loss
,,	,,	144	,,
Neem cake mixing	,,	72	,,
,,	,,	144	,,

Volatilization loss of nitrogen was found to be high when the soil was kept at field capacity, 144 hours after its application. However, there was practically no loss of nitrogen when it was kept at half field capacity. The loss was higher in neem mixing than in neem coating.

8. PHYSICO – CHEMICAL AND MINEROLOGICAL CHARACTERISTICS OF RUBBER GROWING SOILS

The project is intended to estimate the macro and micro nutrient status of rubber growing soils to serve as a guideline for offering discriminatory fertilizer recommendation.

(a) Studies on phosphorus fractionation

Iron phosphorus was found to be the predominent fraction in all the soils studied. Total phosphorus content varied from 287 to 815 ppm, the highest being for the soils from Kolaba and the lowest for the soils from Kanyakumari. The surface soil samples registered higher amount of total P in Palghat, Calicut, Karnataka, Dapchari and Sawantwadi. Fractionation of inorganic P revealed that Saloid P, Aluminium P, Calcium P and Iron P ranged from trace to 1.21 ppm, 5.2 to 20.9 ppm, 19.2 to 122.0 ppm and 11.5 to 26.5 ppm, respectively. Correlation between different inorganic fractions against pH, available P and organic carbon were also worked out. Positive significant correlation was obtained between Aluminium P and available P, and organic carbon.

(b) Soil test crop response studies

i) Studies on the efficiency of different P extractants

An incubation study on the dissolution pattern of phosphorus applied at 0 to 60 kg ha^{-1} on soils collected from Kanyakumari, Calicut, Trichur and Kottayam were done over a period of 90 days with three different extractants viz; Bray II, Bray I and Olsen's reagent. The Olsen extractant was the most ideal for soils of Kanyakumari and Calicut regions followed by Bray II & Bray I, whereas, for Trichur and Kottayam, Bray II was the most suited extractant followed by Bray I and Olsen. However, detailed investigations are required to draw definite conclusion.

9. POST RECOMMENDATION EVALUATION OF DISCRIMINATORY FERTILIZER APPLICATION

The project is intended to evaluate the merits/demerits of following discriminatory fertilizer application (DFR). A few estates were selected for the study and in the selected estates, two adjacent blocks were set apart for this purpose. In one of the blocks discriminatory fertilizer application and in the adjacent block general fertilizer application (GFR) was followed. The yield data from the two blocks were collected from the estates and tabulated.

Table-Ag. 32. *Post recommendation evaluation of DFR*

Estate	Increase in yield (kg ha^{-1})	Savings in fertilizer (cost Rs ha^{-1})
Chemoni	33	68.00
Kumbazha	40	83.00
	60	154.00
Lahai	240	66.00
	-40*	70.00
Kundai	222	113.00
	40	160.00
	47	135.00

* In Lahai Estate, in the block of DFR there are 175 trees showing late dripping of latex, whereas in the adjacent GFR block there are only 125 trees showing such symptoms. That may be one of the reasons in yield depression of DFR block.

10. RESOURCE INFORMATION SYSTEM FOR RUBBER VIA REMOTE SENSING

This project aims at relating satellite imagery to ground truth data with a view to build up resource information systems for rubber plantations in different agro-ecological regions.

The ground truth data of Kaliyar and Malankara Estates were collected. The topo-sheet of Malankara Estate was reduced to 1: 50000 scale and forwarded to Space Application Centre, Ahmedbad for processing. The ground truth data and base informations were over laid on the map format. Steps were taken to procure the resurveyed map of Kaliyar Estate from the Resurvey Department. Action was initiated for procuring the maps of Cheruvally, Shaliacary, New Ambadi, Kinalur, Mooply and Poonoor Estates, representing different agro-eco regions to extend the study.

11. MULTIDISCIPLINARY PROJECTS ON BROWN BAST (*COLLABORATIVE STUDY*)

Leaf and latex samples and soil samples at two depths were collected from selected brown bast affected blocks (10) of Cheruvally and Malankara Estates. The rating of brown bast incidence worked out is as follows. From these areas 200 soil samples were analysed for available phosphorus and potassium. Twentyfive latex samples collected from the estates were analysed for nitrogen.

Table-Ag. 33. *Percentage of trees*

Clone	Normal	Dry	Partial dry	Partial dry + late dripping	Late dripping	Untapped
Malankara						
RRIM 600	33	52	4	1	1	10
GT 1	42	34	16	1	4	6
RRII 105 (77)	28	24	36	4	8	1
RRII 105 (78)	56	12	15	1	5	11
Koothattukulam						
RRII 105	67	13	4	1	6	10
GT 1	43	26	14	1	12	4
PB 86	47	30	17	2	3	1
Cheruvally						
PB 28/59	44	11	30	3	7	5
PB 235	54	17	17	2	9	1
RRIM 600	60	10	20	2	1	7

12. ADVISORY WORK

This Division has analysed 8424 soil and 994 leaf samples for offering discriminatory fertilizer recommendation to estates and small holdings.

Mycology and Plant Pathology Division

The main activity of the Mycology and Plant Pathology Division is crop protection. The Division is also undertaking investigations on improving soil fertility through microbes and pollution control with microbes. Regional meteorological stations, in traditional and non-traditional rubber growing belts, are under establishment. The relation between various meteorological factors with growth, yield and incidence of diseases are under study.

1. CONTROL OF ABNORMAL LEAF FALL DISEASE OF RUBBER IN INDIA

The most important leaf disease of rubber, causing significant yield loss, is the abnormal leaf fall disease caused by *Phytophthora* spp. The damage to health of plants due to shoot rot and die back is also considerable. Various studies to combat this disease economically are in progress.

(a) Survey on occurrence of diseases in rubber growing areas of north eastern regions of India

Diseases caused by *Phytophthora* was not noticed in the Regional Research Stations at Gawahati, Tura, Kolasib and Agartala. SALB also was not found in any of the germplasm materials imported from SALB endemic regions and planted at Gawahati.

(b) Defoliation experiments

Ethephon 0.25%, in spray oil or water, sprayed on trees with micron sprayer caused 40% and 60% defoliation, respectively starting from sixth day after application and ending by the 10th day. The same concentration by high volume spraying at 10 litres per tree caused 75% defoliation. Extensive die back of twigs was observed after three weeks and the trees refoliated after four weeks.

2. STUDIES ON HIGH VOLUME SPRAYING

High volume spraying is done in nearly 65000 ha, mostly small holdings, every year. The cost of spraying is almost double that of low volume spraying. An experiment laid out at Central Experiment Station, Chethackal to compare the efficacy of 1% and 0.5% Bordeaux mixture had to be abandoned as the experimental area was oversprayed while aerial spraying other areas.

3. SHOOT ROT DISEASE CONTROL

Shoot rot is a very important stem disease affecting young rubber plants in the nursery. It also affects young trees in field up to third year of growth. Due to the occurrence of this disease normal growth of plants is considerably affected.

A shoot rot control experiment by high volume spraying was conducted simultaneously at Thodupuzha (Malankara Estate) and Mundakayam (Manikal Estate) with nine treatments and control (unsprayed). The treatments were (1) Bordeaux mixture 1%, (2) Bordeaux mixture 0.5%, (3) Bordeaux mixture 1% + 0.5% Zinc sulphate, (4) Bordeaux mixture 0.5% + 0.5% Zinc sulphate, (5) Aliette 0.4%, (6) Copper oxychloride WP 0.5%, (7) Foltaf 0.2%, (8) Dithane M 45 0.2% and (9) Thiride 0.2%.

Since the disease incidence was very poor, correct evaluation of the treatments could not be made. However, in both the experimental areas Aliette 0.4% was found to give maximum control.

4. EVALUATION OF PANEL PROTECTANTS AND WOUND DRESSING COMPOUNDS

Bark rot disease, though not very common in India, can cause serious damage to the bark in some areas if left untreated. Moreover, the recommended organomercurial fungicide is likely to be banned in India due to health hazard reasons.

(a) Bark rot disease control experiment

The experiment was conducted at Lahai Estate in 36 tapping blocks containing 160 trees each in the GG 1, GG 2 area with six treatments replicated six times. Fungicide application was made on the same day of tapping on the lower cut at an interval of seven days from June to August 1987. A total number of 960 trees were given treatment under each, out of which 240 trees per treatment were chosen for detailed observations. At the end of the disease season results were assessed (Table Path-1) by computing the average disease incidence in each treatment.

Table–Path. 1. *Average disease incidence*

Sl No.	Treatment	Dose	Average disease intensity (%)
1.	Aliette	1. 6% (20 g/l)	51.25
2.	Aliette	0. 8% (10 g/l)	51.10
3.	Thiride	0.75% (10 g/l)	37.36
4.	Foltaf	0. 8% (10 g/l)	38.33
5.	Dithane M. 45	0.75% (10 g/l)	28.33
6.	Control (untreated)	—	64.17

S.E. 7.99 C.D. 16.46

Lowest disease incidence was obtained with Dithane M. 45 followed by Thiride and Foltaf.

(b) Evaluation of wound dressing compounds

Four samples of Rubber kote were subjected to preliminary screening and found to be non-phytotoxic. STP Rubber kote was subjected to large scale testing and found to be suitable for use in rubber plantations.

5. CROWN BUDDING OF SUSCEPTIBLE HIGH YIELDING CLONES WITH DISEASE RESISTANT / TOLERANT CLONES

Crown budding is a novel technique to combat the attack of a disease occurring on leaf and twigs by replacing a susceptible crown with a resistant one. Even though some difficulties are to be encountered, this technique has to be exploited for control of major diseases.

Yield recordings in the crown budding experiments in three locations were done once in a month for seven months by cup coagulation method.

Table–Path. 2. *Yield in crown budded trials*

Yield (g) of dry rubber /tree/tapping during 1987

Crown clones	Trunk clones		
	RRIM 600	RRIM 628	GT 1
F 4542	80	65	27
FX 516	70	89	43
RRII 33	68	77	41
Control	66	44	49

It was observed that yield increased in RRIM 600 and RRIM 628 crown budded plants and decreased in GT 1. Leaf retention was higher in crown budded plants than in sprayed control plants.

A new trial was started at Malankara Estate using RRII 33 and FX 516 as crown clones.

6. CHEMICAL FRUIT THINNING IN *HEVEA*

Chemical fruit thinning is a new approach for reducing the intensity of infection due to abnormal leaf fall disease, as pods are the single biggest source of inoculum.

A new experiment on fruit thinning was laid out at CES Chethackal on clone RRIM 600 with four different doses of Ethephon and one dose of Urea as treatments. Spraying was done with rocker sprayer at two stages, one at full bloom stage and the other at pod formation stage. Weekly yield recording by cup coagulation was carried out for studying the effect on yield. The results of the experiment is furnished below.

Table–Path. 3. *Average pod set and yield in fruit thinning trial*

Treatment	Average pod set (%)		Yield increase/decrease
	Stage 1	Stage 2	
1. Ethephon			
(i) 800 ppm	2.4	81.24	−50.33%
(ii) 1000 ppm	1.94	86.67	−153.31%
(iii) 1500 ppm	1.23	50.92	+ 71.19%
(iv) 2000 ppm	0.65	22.54	+256.62%
2. Urea 2%	4.59	100.00	+330.46%
3. Control waterspraying	6.83	94.87	—

(Note:– Stage 1 - Initial fruit set in relation to number of female flowers. Stage 2 - mature green fruits in relation to initial set.)

Phytotoxicity was noticed in plants sprayed with Ethephon at 1500 and 2000 ppm. No clear trend was seen with regard to yield.

7. PINK DISEASE AND ITS CONTROL

Pink disease is the most important stem disease of rubber during its growth period from third to twelfth year. It could be serious when the disease occurs at the forking region or trunk. The disease is widespread in high rainfall areas and in certain clones like RRII 105.

A pink disease control experiment was conducted at Manikal Estate to compare the efficacy of two carrier formulations, namely Rubber kote and Pidivyl China clay compound. Seven treatments were imposed in 25 disease affected trees each. Thiride 0.75% a.i. and Calixin 1% a.i. were used as fungicides. The control was treated with Bordeaux paste. Observations are being continued.

8. POWDERY MILDEW DISEASE AND ITS CONTROL

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

The following results were obtained in the 1987 season powdery mildew disease control experiment in mature areas using fungicidal tests.

Table–Path. 4. *Results of trial in mature area*

Name of the estate/ clone with year of planting	Treatment	Average disease intensity (%)
Vaikundam Estate	Calixin 1.5% dust	17.16
PB 86 (1968)	Sulphur dust 70%	25.75
Cheruvally Estate	Calixin 1.5% dust	41.50
PB 235 (1975)	Sulphur dust 70%	74.75
Kumbazha Estate	Calixin 1.5% dust	35.08
PB 235 (1981)	Sulphur dust 70%	40.41

In the spray trial experiments on young plants at Manikal Estate, out of the nine fungicides used,Saprol and Bavistin were found superior to all other treatments by numerical data. However, no statistical significance was found. The disease intensity was low in the experimental area.

9. DRY ROT DISEASE AND ITS CONTROL

Dry rot disease caused by *Ustulina deusta* is next in importance to pink disease among the stem diseases of rubber. The incidence of this disease is on the increase in recent years. It is more difficult to control this disease than pink, because by the time it is detected the penetration of pathogen is deep. Copper fungicides are ineffective and hence control measures are costly.

An experiment was conducted to compare the efficacy of two carriers of fungicide namely Pidivyl China clay compound and Sopkot. The results are furnished in the table below.

Table-Path. 5. *Percentage recovery of diseased trees*

Treatments	Concentration (% a.i.)	Pidivyl-China clay compound	Sopkot
Dithane M. 45	0.75	75.00	100
Topsin M. 70	0.35	73.68	90
Bavistin	0.50	78.95	90
Emisan	0.015	65.00	100
Tilt	0.20	84.21	100
Calixin	1.00	42.11	100

The results indicate that fungicides incorporated in petroleum compound is superior in checking the disease.

Based on the results for two years, three available fungicides (Emisan, Bavistin and Tnitide) were selected for a new experiment in which two methods of application were compared. In one method the fungicides were incorporated in Sopkot and applied to affected areas, after removing diseased tissues. In the other method after removing diseased tissues the affected area was washed with fungicide solution and after drying petroleum compound was applied. Observation is being continued.

10. HIGH PRESSURE INJECTION FOR DISEASE CONTROL

(a) Streptomycin against diseases of rubber

Analysis of the data for 1985 and 86 shows that none of the treatment is effective. The data for 1987 are to be analysed.

(b) Systemic fungicides against diseases of rubber

Statistical analysis of the data for 1985-86 indicate that none of the treatment is effective. The data for 1987 are to be analysed.

(c) Wood preservation by pressure injection

40% of copper sulphate was injected into a young rubber tree, at the rate of two litres per tree, and the parts cut from this tree had no fungal or insect attack for a period of nine months, whereas, in the untreated plant there was fungal and insect attack. But similar treatment in a 30 year old tree did not give desired effect as the fungicide did not penetrate and spread in all regions of the wood. This study will be repeated by using a bigger drill for deep penetration into the wood.

11. BIOLOGICAL TREATMENT OF EFFLUENT FROM RUBBER PROCESSING FACTORIES

Effluent from rubber processing factories cause very serious water pollution problems. Hence, the problem will have to be investigated in detail for evolving a suitable, simple, economic and efficient method for treating the effluent. The selection of a suitable micro-organism for the effluent treatment and the evaluation of the present treatment systems are also included in the study.

The washed water from different rollers of pale latex crepe factory (PLC) was analysed for different parameters and found that the water is less polluted and could be recycled. A detailed study was initiated in this regard.

A floating green plant *Wolffia arrhiza* has been isolated from the anaerobic pond of effluent treatment plants in a crumb factory at Kanyakumari district. Pollution load in the aerobic tank was considerably less compared to that of anaerobic tank. Rubber sheet serum fortified with 4% sucrose was found to be useful for yeast culture.

Sheet serum at 70% dilution increased the growth of algae *Chlorella vulgaris* and also pH, and decreased the bacterial growth and hydrogen sulphide production. This effect is represented graphically in fig. Path 1.

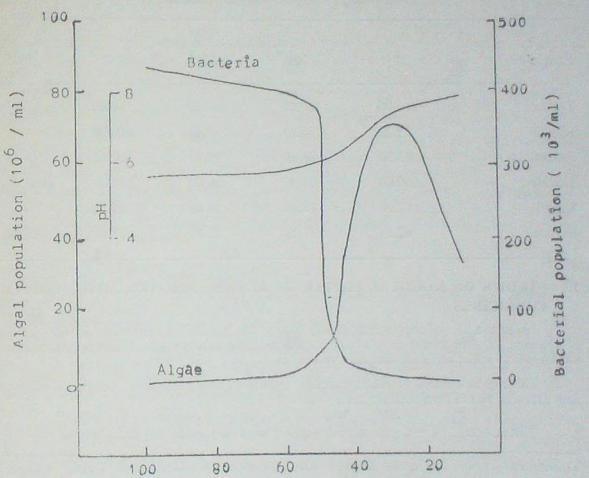

Figure Path. 1. Concentration of effluent (%)
Effect of dilution on algal and bacterial population in sheet aerum

12. MINOR LEAF SPOT DISEASES AND THEIR CONTROL

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

A field trial was conducted at Central Nursery, Karikattoor for the control of nursery leaf spot disease with 9 treatments viz. Kitazin 0.01 % a. i., Delan 0.2% a. i., Saprol 0.01 %

a. i., Topsin 0.03% a. i., Baycor 0.02% a. i., Bavistin 0.02% a. i., Thiride 0.2 a. i., S. 3308 0.01% a. i., and untreated control. Observations are being continued.

Fungicides Topsin, Kitazin, S. 3308, Thiride, Saprol and Baycor were tested against *Corynespora cassiicola* in the laboratory using poisoned food technique. The percentage of inhibition is furnished in table Path.6.

Table–Path. 6. *Percentage of inhibition*

Fungicide	Concentration in ppm 50	100	250	500	750
Topsin	100.00	100.00	100.00	100.00	—
Kitazin	32.20	56.10	89.44	100.00	—
S. 3308	83.30	88.89	99.10	100.00	—
Thiride	100.00	100.00	100.00	100.00	100.00
Saprol	61.10	77.78	86.60	89.10	—
Baycor	62.69	71.19	75.37	75.67	80.19

13. STUDIES ON RESIDUAL COPPER IN RUBBER SPRAYED WITH COPPER FUNGICIDES

Large quantity of copper fungicide is applied annually in rubber estates for the control of diseases. The problems due to copper residues have to be evaluated, as copper residues are known to affect soil structure and microflora.

The copper content of latex samples collected during selected months of 1984-85 and October 86 are furnished in table Path.7.

Table–Path. 7. *Copper residue (ppm of Cu in dry rubber) in latex samples*

Treatments	Jan 84	May 84	Oct 84	Nov 84	Dec 84	Jan 85	Oct 85	Oct 86
CoC 56% powder 8kg/ha	6.61	5.23	5.94	7.83	6.95	4.05	6.44	3.10
CoC 56% powder 16 kg/ha	8.82	6.40	7.14	8.34	8.28	5.77	7.03	3.45
CoC 40% paste 6.2 l/ha	4.89	4.25	6.54	6.40	7.26	4.75	4.94	3.50
CoC 40% paste 12.4 l/ha	7.99	6.16	7.08	7.80	9.27	6.46	6.82	3.75
Control	4.69	4.86	4.94	6.15	5.20	3.96	4.63	2.76

Copper content in the soil samples collected during 1985 and 1987 is furnished below.

Table-Path. 8. *Copper residue (ppm of Cu in dried soil) in soil sample*

Treatments	October 1985	October 1987
CoC 56% powder 8 kg/ha	68.34	79.63
CoC 56% powder 16 kg/ha	86.30	96.07
CoC 40% paste 6.2 l/ha	68.42	75.88
CoC 40% paste 12.4 l/ha	74.72	97.65
Control	50.61	62.07

14. ASSESSMENT OF YIELD LOSS DUE TO DISEASES

Crop loss studies are essential to evaluate cost benefit ratio of control operations. Systematic studies on crop loss due to diseases of rubber have not been conducted so far.

To study the extent of yield loss due to *Phytophthora* leaf fall in different clones, two tapping blocks each were selected under clones RRIM 600, RRII 105, GT 1 and RRII 118 in CES Chethackal and arrangements were made to record pretreatment yield in all these blocks. Study on yield loss due to powdery mildew disease at Vaikundam Estate, Kulasekharam is being continued.

15. OVER SUMMERING OF *PHYTOPHTHORA*

Studies on over summering of pathogens are necessary for the control of diseases in the weakest point of life cycle of the causative organisms. A knowledge on this aspect can also be used effectively to reduce the inoculum potential.

Spore traps to collect *Phytophthora* from the soil was kept in the different fields of RRII. During the month of June, *Phytophthora* spores were trapped on slides, even before the disease has started in the field. More sporangia were trapped in the lower heights of 15 and 30 cm as compared to higher heights of 60, 90 and 120 cm from ground.

Large number of oospores were found embedded in organic matter particles in the soil. Oospores were found in soil upto 20 cm depth.

16. STUDIES ON PHYSIOLOGICAL SPECIALISATION OF *PHYTOPHTHORA*

Physiological specialisation of pathogens can cause considerable problems in control, especially with resistant varieties. Information on this aspect is essential in breeding for resistance.

Phytophthora isolates No. 1 and 2 were rescreened by detached leaf petiole inoculation method. The tolerant clone RRII 33 was found to be susceptible to these isolates.

17. HOST PARASITE INTER-RELATIONS

Host parasite relationship is an important aspect of study in the biology of pathogens, which can reveal many clues to break this relationship for the control of pathogens.

When microtome sections of the artificially inoculated pink disease pathogen was examined it was found that the fungus is specifically entering through the lenticels. The

sections of the bark from maturing green stem having pink disease pathogen at pustular stage showed that the fungal hyphae was emerging through the lenticels from the cortex and disintegration of cortical cells was noticed.

18. EPIDEMIOLOGY OF DISEASES OF RUBBER

The initiation and spread of diseases are determined by various extraneous factors. Identification of these factors and information on the manner in which these factors help the spread of diseases can help in the forecast of diseases and timing the control measures to achieve best results.

Wetness of leaf was found to be an essential requirement for the epidemics of powdery mildew disease.

19. COLLECTION, CLASSIFICATION AND COMPARATIVE MORPHOLOGY OF REGIONAL ISOLATES

Cultures of various fungal pathogens of rubber numbering 119 are being maintained. Out of these 50 cultures were revived by passing through the host.

20. SELECTION, TESTING AND INTRODUCTION OF NEW LEGUMINOUS COVER CROPS FOR RUBBER

Establishment and maintenance of leguminous cover crop in rubber plantation is an important cultural operation. The leguminous plants used at present have some undesirable characters like drying in summer and palatability to cattle. Hence, action was taken to find out a most suitable cover crop.

Rubber plants growing with *Mucuna bracteata* and *Pueraria phaseoloides* as cover crops showed comparable growth. The biomass in *M. bracteata* area is above three times that of *P. phaseoloides*

Table–Path. 9. *Biomass and nitrogen contributed by M. bracteata and P. phaseoloides*

Cover crop	Girth of rubber (cm)	Biomass in tonnes per ha	Nitrogen in the biomass (kg) per ha
M. bracteata	42.13	15.63	465
P. phaseoloides	42.22	4.61	105

Thirteen leguminous plants including pulses and fodder crops are being tested as cover crops. *Mochai* and *Dolichos sp.* showed faster growth. An experiment was started to find out the effect of slashing of *M. bracteata* during summer and also the dual effect of *Rhizobium sp.* and *Beijerinckia sp.* in nodulation of *Pueraria*. Dual inoculation enhanced the biomass production.

Table–Path. 10. *Effect Rhizobium sp. and Beijerinckia sp. on nodulation and biomass production in Pueraria phaseoloides*

Treatment	No. of nodules per 10 plants	*Weight gm (Ten plants)*			
		Nodule	Shoot	Root	Total
Rhizobium sp	77	0.23	17.62	1.53	19.38
Beijerinckia sp.	79	0.25	18.17	1.45	19.78
Rhizobium sp. & Beijerinckia sp.	117	0.35	28.02	1.97	30.34
Control	59	0.17	13.17	1.22	14.56

21. ISOLATION AND TESTING OF ANTAGONISTIC MICROORGANISMS AGAINST PLANT PATHOGENS OF RUBBER

So far no report on the occurrence of antagonistic actinomycete in rhizosphere of rubber plants as well as their inhibitory activity against the pathogens of *Hevea* is available. Hence a study was carried out to isolate antagonistic actinomycetes in the rhizosphere soil of rubber and test them against major pathogens of rubber.

The antagonistic actinomycetes showing high antagonism to pink disease pathogen was field tested using carboxy methyl cellulose as the carrier and it was found to be effective. However, it was less effective in comparison with Bordeaux paste. The results are furnished below.

Table-Path. 11. *Results of pink disease treatment with Actinomycetes.*

Clone	Treatment	No. of trees treated	No. of trees recovered	Percentage of recovery
RRII 203	Actinomycete	28	20	71.0
(Artificial infection)	Bordeaux paste	11	11	100.0
RRIM 600	Actinomycete	24	17	70.8
(Artificial infection)	Bordeaux paste	8	7	87.5
Natural infection	Actinomycete	8	7	87.5

Carriers such as boiled maida, starch, CMC, gum arabic, Pidivyl, rubber latex, rubberkote and Chinaclay were tested for actinomycete and CMC was found to be suitable. The culture filtrate of the actinomycete also was found to prevent the growth of the pink disease pathogen. It was found to be heat sensitive.

Nine locally available antibiotics were tested against pink disease pathogen and among these only Aureofungin has some inhibitory effect.

22. STUDIES OF NON SYMBIOTIC NITROGEN FIXING MICRO-ORGANISMS OF RUBBER GROWING SOILS

Biological fixation of molecular nitrogen can be performed by a number of prokaryotic micro-organisms. The free living nitrogen fixing micro-organisms of rubber growing soils were studied giving special importance to *Azotobacter, Beijerenckia, Derxia* and *Azospirillum* and to find out their use in rubber plantation to maximise the yield at less cost without any pollution.

Commercial culture of *Azospirillum* inoculated at the rate of 10^9 bacteria per pot, increased the height of rubber seedlings and not the girth. *Beijerenckia* spp. was inoculated in Becking's broth with pH ranging from 3 to 9. After 15 days of incubation, the nitrogen fixed was estimated. The pH range of 5 to 7 was favourable for nitrogen fixation.

23. RHIZOSPHERE STUDIES OF RUBBER PLANTS

Mycorrhizal infection in PB 5/51, GT 1 and GG 1 mature plants were examined. All the three showed mycorrhizal infection to varying degree.

A pot culture experiment was started to study the effect of *Glomus fasiculatum, Gigaspora margarita* and a local isolate at different levels of phosphate on growth, nodulation and nitrogen fixation by *P.phaseoloides*.

24. WHITE GRUBS ATTACKING RUBBER

White grubs are serious pests of agricultural crops. The damaging stage survives in soil and hence control of the pest is difficult.

The attack of *Holotrichia serrata* was noticed in the regional nursery Manjeri. In other nurseries *Anomala* spp. occur in small number.

The results of the field trial on the control of root grubs is furnished below.

Table-Path. 12. *Comparative evaluation of different insecticidal formulations for the control of H. Serrata* F.

Treatment	Dose kg/ha	Mean percentage survival of plants/plot*	Grub population/30 cm^3
Carbofuran 3G	25	59.75 (56.65)b	0.15
Phorate 10G	25	90.50 (72.12)a	0.10
Carbaryl 5D	100	33.25 (35.19)d	0.25
HCH 10D	100	18.75 (25.62)e	0.40
Carbaryl 4G	25	60.25 (50.93)c	0.20
Phosalone 4D	100	36.00 (36.86)d	0.25
Carboryl + Lindane 4: 4G	25	89.75 (71.51)a	0.10
Control		7.25 (15.54)f	0.90
F test		Significant	
S. E. of X		1.08	

Note: *Mean of four replications. Figures in parenthesis are arc sin values. Mean values followed by the same letter do not differ significantly (P = 0.05) as per Duncan's multiple range test.

The results indicate that the plots broadcast with Phorate 10 G and Sevidol 4: 4G at 25 kg/ha gave significantly high percentage of survival of plants and low grub population. Carbofuran 3G at 25 kg/ha was the next effective treatment.

25. CONTROL OF BARK FEEDING CATERPILLAR OF RUBBER

Results of the field trial against bark feeding caterpillar *Atherastis circulata* indicate that Fenval 0.4% D is most effective for the control of this pest upto 98.99% at 15 kg/ ha. Quinalphos 1.5D and Carbaryl 5D applied at 15 kg per ha reduced the caterpillar population by 91.26% and 85.74% respectively.

26. CONTROL OF TERMITES INFESTING RUBBER

Observations on the intensity of termite infestation at the Central Experiment Station indicated that 18.1% of trees were affected.

27. STUDIES ON SLUGS AND SNAILS ATTACKING RUBBER

Application of Aldicarp at 0.1% as a slurry in maida along with Dithane M. 45 0.2% painted on bark upto 30 to 40 cm height from the base of plants gave effective control of slugs and snails. The fungicide also prevented the growth of black mould on the painted surface.

28. NEMATODES INFESTING RUBBER AND COVER CROP

Studies conducted in soils of 12 regional nurseries for the population density of plant parasitic nematodes indicated that the population densities varied from 265 to 10100 per 250 gm soil and frequency of occurrence varied from 40 to 100%. The population of plant parasitic nematodes revealed no correlation with the organic content of soil samples.

29. VERTEBRATE AND NON-INSECT PESTS OF RUBBER

Brodifacoum and Bromadiolone baits at 0.005% and Zinc phosphide baits at 0.2% concentration were comparatively evaluated against three rat spp. infesting rubber seedlings at the Central nursery, Karikattoor. The success in rubber nursery was 97.24%, 91.30% and 74.69% respectively on the basis of burrow count.

Aldicarb 10G (0.1%) and maida in a slurry applied at the base of rubber seedlings proved to be effective for the control of rabbits and hares.

30. BEEKEEPING IN RUBBER PLANTATIONS

Klienhovia sp. was identified as additional bee forage plant for off-seasonal bee management. Mites belonging to *Neocypholaelaps* spp. was found to be the main pollen feeder in the beehives.

Plant Physiology and Exploitation

Studies on water relations of mature *Hevea* on a soil plant-atmosphere-continuum (SPAC) basis, study of yield constraints in different agroclimates of the traditional area, identification of early prediction parameters associated with high yield and drought resistance, biochemical subcomponents of major yield components, trials on exploitation, field experiments on introduction of medicinal plants as intercrops in mature *Hevea* stands, etc., were the major activities of the division during the period of report.

1. STUDIES ON THE PHYSIOLOGICAL AND BIOCHEMICAL SUB-COMPONENTS OF *HEVEA*

A study has been taken up at the Central Experiment Station, Chethackal, from September 1987. Six trees each of clones RRII 105 and PB 235 (high yielders) and Ch4 and PilB 84 (low yielders) were selected for the study from a completely randomised planting in the germplasm garden. The trees were in the second year of tapping (BO-1 panel) and were selected based on their yield performance. The major yield components are being recorded every month. Biochemical parameters like lipids and mineral analysis of latex are being done in the four seasons. Monthly recordings of latex sugars and bursting index are being carried out. All the parameters have been done in whole latex. Monthly changes in dry rubber yield, plugging index, initial flow rate and dry rubber content are given in figure Phy. 1.

Although the differences in the yields of clones RRII 105 and PB 235 are not high the initial flow rate in RRII 105 is very high. Though the plugging index increased during wintering no increase was noticed in the bursting index. No definite pattern could be observed in the carbohydrate levels. Similarly there was no significant clonal variation in the bark HMG-CoA reductase activities.

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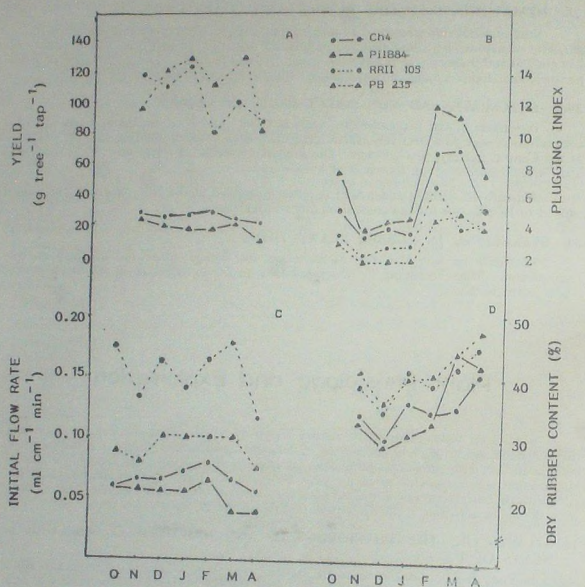

Figure 1. Phy. Monthly changes in yield, initial flow rate, plugging index and dry rubber content in four *Hevea* clones.

2. IDENTIFICATION OF PHYSIOLOGICAL AND BIOCHEMICAL PARAMETERS FOR EARLY PREDICTION OF YIELD POTENTIALS AND RESPONSES TO DROUGHT

Considering the importance of evolving methods for prediction of yield potentials and responses to environmental stresses in *Hevea* at very young stages of growth, various physiological and biochemical parameters were estimated in young plants of a number of clones comprising of high yielders (RRII 105 and RRIM 600), medium yielders (GT 1 and RRII 118), low yielders (RRII 13 and HP 20), drought tolerant ones (RRII 308, Gl 1 and RRII 105) and drought susceptible ones (Tjir 1, RRII 43 and RRIM 623).

(a) **Biochemical parameters in clones with contrasting yield potentials**

The various leaf parameters viz. glycolipids, triglycerides, phospholipids, sterols, total sugars, nonreducing sugars, starch, leaf hydrocarbon and leaf HMG-CoA reductase were estimated in dry and wet seasons. Six plants were sampled for each clone. Of all the parameters studied, amounts of glycolipids and sterols were found to be high in high yielders when compared to the levels in medium and low yielders. No definite pattern could be observed in other parameters.

(b) **Visual scoring of partial and complete coagulation during test tapping of clones with contrasting yield potentials**

Attempts to estimate bursting indices in latex samples obtained by test tapping were not successful because of complete and partial coagulation of latices soon after tapping. This phenomenon was found to be more prevalent in low yielding clones. Hence a visual scoring method was deviced for assessing partial and complete coagulation (precoagulation) in different clones. Twenty plants were sampled for each clone and observations were made during four test tappings. The percentage of plants showing precoagulation were worked out for six clones with contrasting yield potentials (Table Phy. 1). Clonal differences were highly significant. Percentage of plants showing precoagulation were low in high yielders an very high in low yielders. The values were intermediate for the medium yielders.

Table-Phy. 1. *Percentage of plants showing precoagulation in six Hevea clones during test tapping*

Clone	Precoagulation (%)
RRII 105	17.49
RRIM 600	17.01
GT 1	36.45
RRII 118	35.08
RRII 38	87.70
HP 20	70.49
CD 0.05	6.52

(c) **Clonal variation in thermostability of membranes of tissues**

In continuation of the studies conducted on thermostability of membranes of leaf tissue, two year old plants of eight clones were subjected to detailed study. Electrolyte leaching curves were prepared for sun leaves of each clone with five plants as replicates in a completely randomised design. The temperature required for 50% leaching of electrolytes were worked out for different clones. Clonal variation in such temperatures were found to be statistically significant (Table Phy. 2). Clones like RRII 308, RRII 118 and Gl 1 have better membrane stability when compared to other clones studied.

For massive screening programmes, development of temperature v/s electrolyte leaching curves will be tedious. Hence the mean value of I_{50} irrespective of clones was worked out and found to be 54.98°C or say 55°C. Therefore it is suggested that subjecting leaf discs to a temperature shock of 55°C for 15 minutes can be followed for screening *Hevea* clones.

When electrolyte leaching percentages caused by 55°C shock in different clones were compared, highly significant differences, in accordance to the I_{50} values, were evident (Table Phy. 2). The data shows that the later approach can be adopted for screening *Hevea* genotypes for susceptibility to thermal injuries.

Table-Phy. 2. *Thermal shock temperature required for 5 percent leaching of electrolytes (I_{50}) and percentage of electrolyte leaching at 55°C thermal shocks from leaf discs of Hevea clones.*

Clone	I_{50} (°C) Temperature of 50% leaching (°C)	% leaching at 55°C**
RRII 308	58.00	27.10
RRII 118	57.50	31.40
GI 1	55.37	46.14
RRII 105	54.75	53.05
Tjir 1	54.62	57.88
RRIM 600	54.00	58.26
RRII 43	53.12	60.19
RRIM 623	53.25	67.37
C.D 0.05	1.43	10.06

* Significant at 5% error
** ,, 1% ,,

(d) **Clonal variations in leaf epicuticular waxes and optical properties**

Since thickness of epicuticular wax is one of the characters associated with drought tolerance in plants, a study was undertaken to understand clonal variations. As epicuticular waxes not only minimise cuticular transpiration but also reduce stomatal transpiration by reflecting heat radiation, the optical properties of the leaves were also determined along with the estimations of epicuticular waxes in sun leaves. Initially the observations were made in three year old trees of six clones. For each clone six plants were selected at random from completely randomised planting. Six sun leaves were sampled and used for epicuticular wax estimation and for studying optical properties.

Data on leaf epicuticular waxes and optical properties are given in Table Phy. 3. Highly significant clonal variations were found in wax levels as well as in the diffuse reflectance. Though clonal variations in absorpttance and transmitance were also found statistically significant, the differences between clones were not as high as the reflectance values. Much of the reflectance is in the 750-1100 nm region (Figure Phy. 2 and 3). In the near infrared region nearly 50% of the light is reflected while it is only 8% in the visible range.

From the data it can be seen that drought resistant clones were having high amounts of waxes and have the reflection of heat radiation. The correlation between wax and reflectance was found to be highly significant ($r = 0.963$). This study indicates that quantification of optical properties can be included as one of the parameters for early predictions of *Hevea* genotypes for drought resistance. Since reflectance is highly correlated with the wax content, estimation of former parameter alone will be sufficient for screening, in which case the estimations can be made more efficiently.

Table–Phy. 3. *Leaf epicuticular wax content and optical properties in a few clones of Hevea brasiliensis*

Clone	Wax,** ug cm^{-2}	Optical properties			
		Absorptance*	Diffuse** Reflectance (R)	Diffuse* Transmittance (T)	R/T**
GI 1	120.36	0.830	0.106	0.063	1.480
RRII 308	93.12	0.855	0.095	0.056	1.269
RRII 105	87.81	0.867	0.087	0.044	1.256
RRIM 623	39.72	0.879	0.061	0.060	1.010
RRII 43	37.72	0.883	0.063	0.056	1.125
Tjir 1	35.79	0.088	0.055	0.054	1.020
C. D. 0.05	7.35	0.021	0.011	0.008	0.102

** Significant at 1% error
*Significant at 5% error

Absorptance = 1 – (R + T)
For optical properties the instrument calculates by taking 1 as 100 per cent.

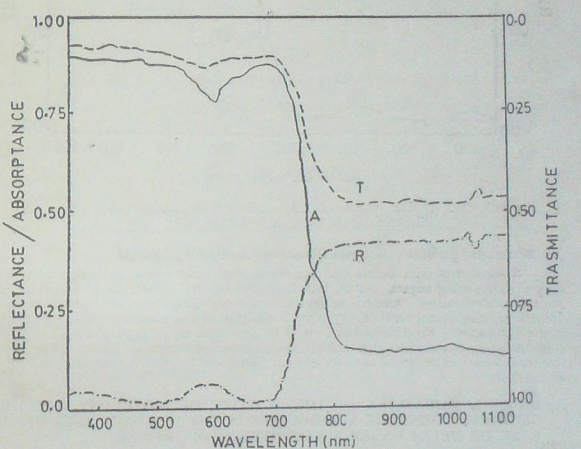

Figure 2. Phy. Optical properties of leaves of *Hevea brasiliensis*: Diffuse reflectance (R); Diffuse transmittance (T) and absorptance (A).

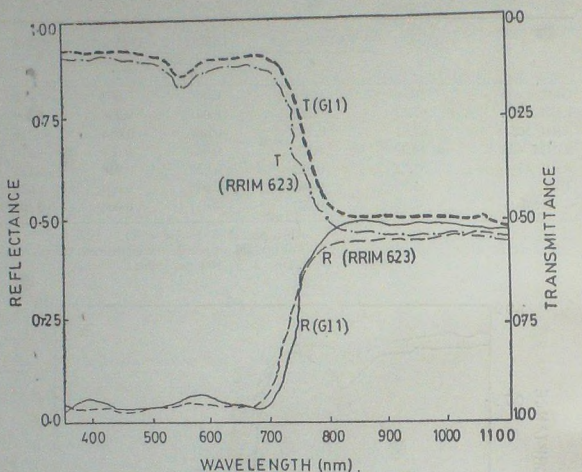

Figure 3. Phy. Diffuse reflectance (R) and diffuse transmittance (T) of the leaves of clones Gl 1 and RRIM 623.

(e) **Biochemical parameters in clones tolerant and susceptible to drought.**

A number of parameeters viz. glycolipids, triglycerides, phospholipids, sterols, total sugars, nonreducing sugars, starch, leaf hydrocarbon, leaf HMG-CoA reductase and proline were estimated. Analysis of proline in the wet season showed that the leaves of drought resistant clones have more proline. Analysis of this parameter could not be done in the dry season. No definite trend could be seen with all other parameters except that glycolipids were found to be high in RRII 308, an apparently drought resistant clone. Intensive studies have to be carried out with selected parameters for evolving biochemical methods of screening.

3. DIURNAL VARIATIONS IN THE ACTIVITY OF 3-HYDROXY 3-METHYL GLUTARYL COENZYME-A REDUCTASE IN THE DRAINAGE AREA OF THE BARK OF *HEVEA* UNDER ½ S D/2 SYSTEM OF TAPPING

Drastic diurnal changes during extreme drought periods in the activity of enzyme, 3-hydroxy 3-methyl glutaryl coenzyme-A reductase in the bark in the drainage area of trees-under 1/2 S d/2 system of tapping were reported last year. Similar studies were

conducted during subsequent wet season and the results are presented in Figure 4. Phy. It was found that the total activity was more in the wet season. The diurnal fluctuations in wet season were much less when compared to the patterns in dry season, indicating the influence of plant water potentials on the activity of the enzyme.

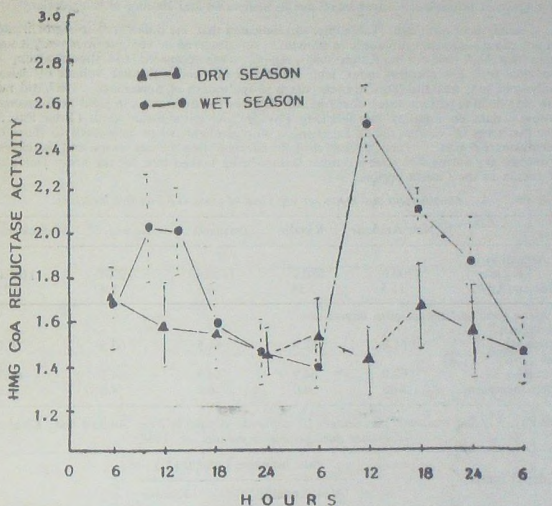

Figure 4. Phy. Diurnal variations in HMG–CoA reductase activity in the drainage area of the bark of *Hevea* under 1/2 S d/2 system of tapping (clone Gl 1) during dry and wet seasons (higher rate of HMG–CoA/Mevolanate indicate lower activity).

4. YIELD CONSTRAINT ANALYSIS OF *HEVEA* IN DIFFERENT AGROCLIMATIC ZONES OF THE TRADITIONAL AREA.

The study started during 1986-87 was continued. Estimations of soil moisture and latex nutrients were additional parameters. In the month of September 1987, soil, leaf and latex samples were collected and analysed to determine nutrient status.

Monthly rainfall and dry rubber yield per block in all the five locations are presented in Figure Phy. 5. The total annual yield during 87-88 and mean per tap yield (Table Phy, 4a) were highest at Kanyakumari and lowest at Calicut. In the other locations, the yields were medium and were not significantly different from each other. Consistently higher monthly yields were recorded at Kanyakumari except in the months of May, June and October 87. In May and June only six tappings each were possible and in October only two tappings were possible at Kanyakumari due to heavy rain and absence of rainguarding.

Analysis of girth data (Table Phy. 4b) indicated that the differences in agroclimates did not cause significant difference in growth. As observed in the previous year, it was found that high yields in the Kanyakumari region, when compared to Calicut region, is associated with low plugging index, high initial flow rate and high total volume of latex. Analysis of soil, leaf and latex nutrient status in the month of September 1987 did not show any definite pattern which could be correlated to the differences in yield performance. However, data on monthly rain fall (Fig. Phy. 5a) and soil moisture status (Table Phy. 5) show that trees in Calicut region experienced more drought when compared to those of Kanyakumari region. Persistance of drought effects during the wet season and the effects of overcast sky during flow time are other factors being looked into for the lower yields in wet season in the Calicut region.

Table Phy. 4. *Annual yield and mean per tap yield of clone GT 1 in five locations.*

	New Ambadi	Kinalur	Perinaad	Kundai	Malankara
a. Annual yield (Kg ha^{-1})	1200.0	880.0	1120.8	1090.0	1105.0
Yield/tap (Kg)	11.5	7.55	9.5	7.47	7.75
b. *Mean girth and annual girth increment*					
Initial girth (cm $tree^{-1}$)	61.0	62.4	61.5	60.5	59.0
Final girth (cm $tree^{-1}$)	62.0	64.9	64.5	64.1	61.3
% girth increment	1.60	4.0	6.0	4.0	4.0

Table Phy. 5. *Soil moisture percentage at different depths in New Ambadi and Kinalur estates during summer months of* 1988

Soil depth (cm)	Soil moisture content (%)	
	New Ambadi	Kinalur
January		
0–30	14.19	15.14
30–60	19.75	16.91
60–90	24.12	19.09
February		
0–30	13.22	11.32
30–60	18.0	14.02
60–90	22.1	13.22
March		
0–30	19.03	12.42
30–60	22.22	12.69
60–90	26.44	12.12

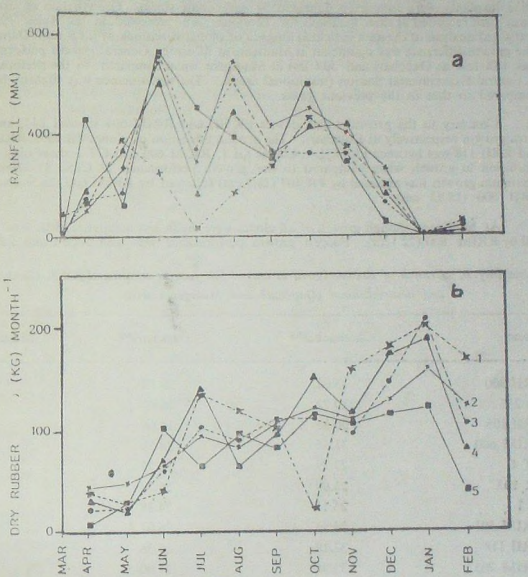

Figure 5. Phy. Monthly rainfall (March, 1987 to February, 1988) and dry rubber yield (April, 1987 to February, 1988) in different estates (1, New Ambadi; 2, Malankara; 3, Kundai; 4, Perinaad and 5, Kinalur) (clone GT 1)

5. PHYSIOLOGICAL EVALUATION OF *HEVEA* CLONES IN DIFFERENT AGRO-CLIMATIC ZONES

The investigations were continued. However, the trial at Agartala was abandoned, since the plants were completely damaged by severe hail storm. Growth data in terms of mean girth recorded at three locations for 12 clones are presented in the Table Phy. 6. Statistical analysis of the data indicated absence of clonal variations at CES and Dapchari. The growth difference was significant at Mudigere at 5% error. General growth performance was 14% less at Dapchari and 30% less at Mudigere when compared to the performance at Central Experimental Station (traditional area). The performance was slightly better, compared to that in the previous years.

Contrary to the general trend, clones PR 107 and RRIM 501 showed 24% and 7% extra growth respectively at Dapchari. The growth inhibition of clones PB 235, RRII 300 and RRII 118 was between 13–19%. Clones Gl 1, RRIM 600 and GT 1 show only 5–9% inhibition in growth when compared to the growth performance at CES. At Dapchari, maximum growth was attained by PR 107 (28.7 cm) followed by RRIM 600 (28.51 cm) and RRII 300 (28.13 cm).

At Mudigere, though growth of all clones were much less maximum girth was attained by RRIM 600 (22.1cm). Poorest growth performance was seen in Gl 1 and PR 107.

Table Phy. 6. *Growth of Rubber (girth in cm) at 5th year at traditional (CES, Chethackal) and nontraditional (Dapchari and Mudigere) areas.*

Clone	Chethackal^{NS}	Dapchari^{NS}	Mudigere*
RRII 300	33.02	28.13	21.75
PB 235	29.72	26.02	21.60
RRII 105	30.88	18.66	19.95
RRIM 600	31.55	28.51	23.12
GT 1	27.79	26.37	21.83
PR 107	23.09	28.70	17.34
Gl 1	26.13	24.38	16.67
RRIM 501	24.33	26.07	20.06
RRII 118	32.18	26.36	20.05
RRIM 703	32.90	21.00	24.41
Tjir 1	33.10	26.00	21.10
RRIM 612	32.17	25.32	21.85
Mean	29.73	25.46	20.85
S. E.	3.54	2.97	2.91
C.D $_{0.05}$	—	—	3.25

* Significant at 5% level
NS - Not Significant

6. PERFORMANCE OF RUBBER UNDER HIGH ELEVATION SITUATIONS

The trial is an ongoing one and is being continued. Girth attained in six years by various clones in the high and low elevation conditions is presented in Table Phy 7. In the high elevations maximum girth was recorded by clone RRIM 600 (33.46 cm), RRII 118 (33.23 cm) and RRIM 623 (32.71 cm). In clone RRIM 600 growth inhibition in high elevation was only 10% compared to its control in low elevation. Maximum inhibition in growth due to high elevation was observed in clones LCB 1320, RRII 105, PB 6/9, RRIM 501 and GT 1.

Table–Phy. 7. *Girth (cm) of different Hevea clones at Poonoor (Plains) and Wynad (High elevation)*

Clone	Poonoor**	Wynad*	% Inhibition
PB 28/59	40.93	30.77	24.82
RRII 203	46.80	32.16	31.28
PB 6/9	31.76	19.58	38.73
RRII 105	44.72	26.40	40.96
RRIM 612	43.91	32.12	26.85
RRIM 501	44.28	27.20	38.57
RRIM 605	39.74	26.68	32.86
GI 1	35.15	27.78	20.96
PB 5/51	40.36	27.44	32.01
PR 107	36.08	26.62	26.22
GT 1	44.97	28.28	37.11
RRIM 600	37.32	33.46	10.34
RRIM 623	44.01	32.71	27.32
Tjir 1	37.75	29.75	21.19
LCB 1320	45.73	27.03	59.10
RRII 118	50.63	33.23	34.46
Mean	39.02	28.82	26.20
SE	10.03	3.47	—
CD 0.05	5.74	6.62	—

* Significant at 5%
** Significant at 1%

7. IMPACT OF UNUSUAL DROUGHT ON *HEVEA* CLONES

The traditional rubber growing areas in the West Coast experienced unusual and severe drought during 1986–87 because of the failure of North-East monsoon and post monsoon rains. Data on soil moisture depletions in different estates and the afternoon leaf water potentials of different clones were reported earlier. Monthly yield data were collected for different clones in four locations wehre soil moisture depletions were studied. The mean monthly yields of different clones in the dry season (January-May 1987) and in two wet seasons (June-December 1986 and 1987) are presented in Table Phy. 8. The yield drop in different clones was in the range of 36% (GT 1) to 61% (Tjir 1) when compared to the favourable wet season yield of 1987. Though the absolute yield of clone RRII 105 was

high during the dry season, percent decline in yield was severe and was comparable to that of PB 235. In terms of percent decline, clone GT 1 was superior. RRIM 600 and Gl 1 were of intermediate nature. Clones Tjir 1 and RRII 118 were the most sensitive ones.

Table-Phy. 8. *Mean monthly yields (Kg/ha) of different Hevea clones in the dry season (January-May 1987) and two wet season (June-December 1986 and 1987)*

Clone	1986 Wet season	1987 Dry season	1988 Wet season
RRIM 600	119	72	135
GT 1	94	54	84
PB 235	109	56	125
Tjir 1	41	31	80
Gl 1	126	73	123
RRII 105	160	92	192
RRII 118	108	51	126

8. WHOLE TREE WATER RELATIONS IN RELATION TO LATEX PRODUCTION

In continuation of the studies on the components of soil–plant water relations in four *Hevea* clones, data on latex yield, yield components, soil moisture levels and diurnal changes in the components of plant–atmosphere water relations were collected for eight months at Central Experiment Station and for six months at Malankara Estate.

(a) Dry and wet season observations

Typical diurnal changes in plant and atmospheric factors with soil water potentials observed in *Hevea*, for clones RRII 105 and Tjir 1 are given in Figs. Phy. 6a, 6b, 7a and 7b, for dry season (April 1987) and wet season (December 1987/January 1988). Observations carried out during December 1987 - January 1988 are given as wet season observations as there were no soil moisture deficits due to prolonged N E monsoon activity. The soil moisture during the dry season was around –0.203 MPa in the 0–30 cm layer and during the wet season, it was –0.05 MPa. The present observations during the dry season were carried out in the first week of April at Malankara and third week at CES. Though there were rains of around 2.5 mm and 15. 0 mm on 21.3.87 and 22.3.1987 at Malankara, and 16mm and 32 mm on 4.4.1987 and 17 4.1987, respectively at CES, the soil moisture below the 30 cm depth was below the wilting point, indicating incomplete recharging of the soil water status due to the scanty rains received. Very low water potentials of the leaves observed during a drought survey, another study conducted earlier, were comparable to the dry season observations. However, the latex turgor pressures were improved in April compared to the values observed in March, before the rains (Fig. Phy. 8). Data on yield and yield components and components of water relations in dry and wet seasons are given in Tables Phy. 9 and Phy. 10, for CES and Malankara, respectively.

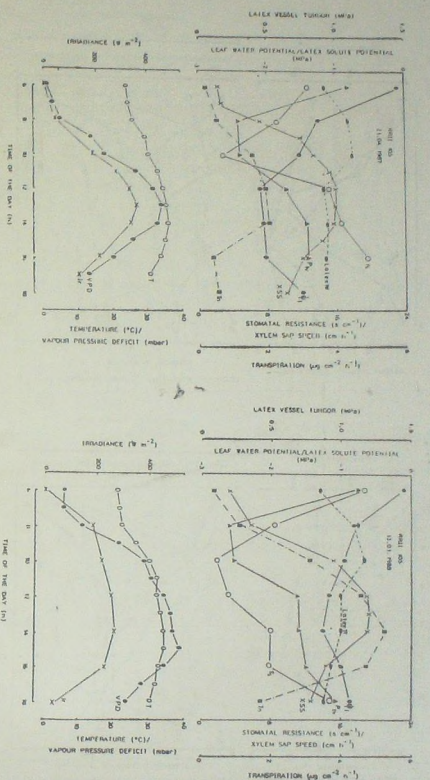

Figure 6a. Phy. Diurnal changes in components of water relations and atmospheric variables in RRII 105 during dry season (April 1987). Soil moisture was-0.203 MPa at 0–30 cm depth and 15–0 MPa below 30 cm depth.

Figure 6b. Phy. Diurnal changes in components of water relations and atmospheric variables in RRII 105 during wet season. Soil moisture was -0.05 MPa.

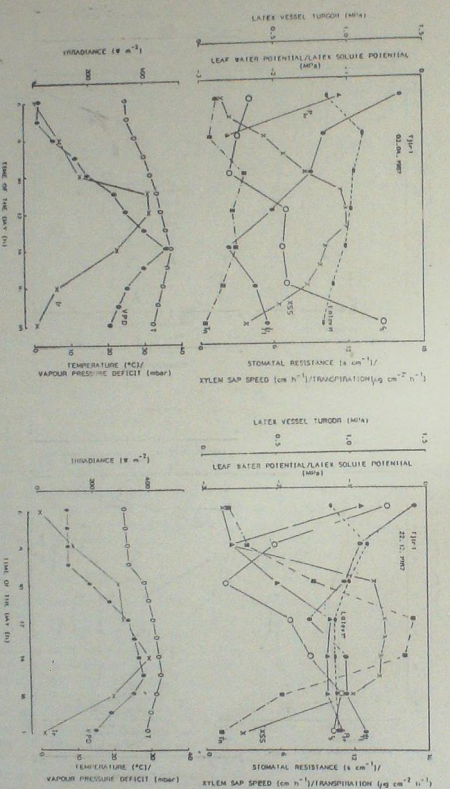

Figure 7a. Phy. Diurnal changes in components of water relations and atmospheric variables in Tjir 1 during dry season.

Figure 7b. Phy. Diurnal changes in components of water relations and atmospheric variables in Tjir 1 during wet season.

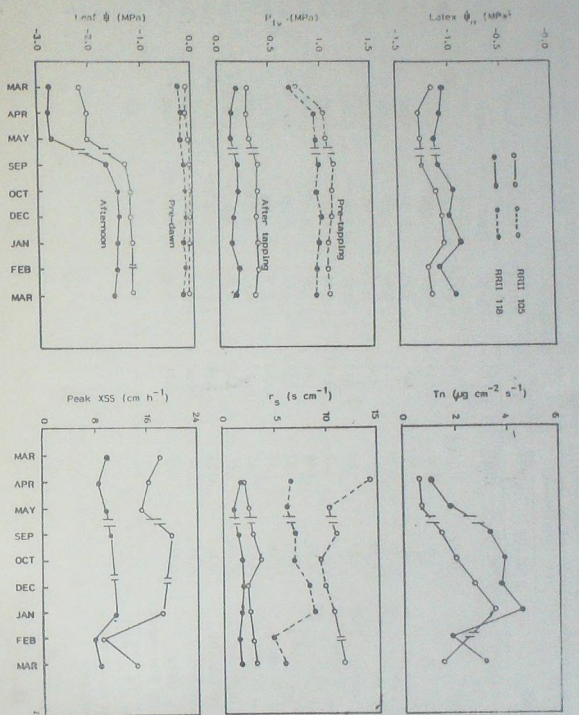

Figure 8. Phy. Changes in components of water relations viz. leaf water potential (Ψ_{leaf}); latex vessel turgor (Plv); latex solute potential(ψ_n); xylem sap speed (XSS); stomatal resistance (r_s) and transpiration (T_n) during the catch-up phenomenon in RRII 105 and RRII 118.

Table Phy. 9. *Yield, yield components and components of water relations in RRII 105 and RRII 118 during dry and wet seasons at CES*

Parameter	Dry Season		Wet Season		C.D.0.05		
	RRII 105	RRII 118	RRII 105	RRII 118	Seasons	Clones	S × C
Yield (g tree^{-1} tap^{-1})	46.26	18.62	119.50	50.70	9.41**	9.41**	13.31**
Initial flow rate (ml cm^{-1} min^{-1})	0.107	0.064	0.162	0.095	0.0065**	0.0065**	0.0092**
Rubber content (% w/v)	44.20	45.60	35.90	39.90	1.334**	1.334**	1.886*
Plugging index	3.95	6.59	2.02	3.20	0.148**	0.148**	0.209**
Pre-tapping P_{lw} (MPa)	1.10	0.88	1.11	0.89	NS	0.068**	NS
Minimum P_{lw} (MPa)	0.30	0.17	0.288	0.224	NS	0.024**	0.034*
Latex solute potential (–MPa)	1.29	1.06	1.15	0.92	0.061**	0.061**	NS
Pre-dawn Ψ_{leaf} (–MPa)	0.15	0.26	0.123	0.18	0.047**	0.047*	NS
Mean Ψ_{leaf} (–MPa)	1.59	1.98	1.11	1.39	0.150**	0.150**	NS
After-noon Ψ_{leaf} (–MPa)	1.88	2.42	1.28	1.66	0.167**	0.167**	NS
Minimum r_s (s cm^{-1})	2.18	1.82	2.10	1.76	NS	0.319*	NS
Mean r_s (s cm^{-1})	14.62	6.82	10.42	8.86	0.788**	0.663**	1.11*
Transpiration (mm day^{-1})	0.597	1.08	3.491	4.468	0.0628**	0.0628**	0.0889**
Transpiration co-efficient	0.111	0.242	0.898	1.039	0.0075**	0.0075**	0.010**
Xylem sap speed (cm/12 h)	135.97	72.34	158.26	106.84	3.54**	3.54**	5.01**
Pre-tapping P_{lw} (MPa) (March, 1987 & Wet season)	0.78	0.65	1.11	0.89	0.046**	0.046**	0.066**

**—Significant at 1% error;
* —Significant at 5% error;
NS—Non-Significant

Table–Phy. 10 *Yield, yield components and components of water relations in Gl 1 and Tjir 1 during dry and wet seasons at Malankara*

Parameter	Dry Season		Wet Season		C.D. 0.05		
	Gl 1	Tjir1	Gl 1	Tjir 1	Seasons	Clones	S × C
Yield (g tree^{-1} tap^{-1})	35.92	17.56	96.50	99.20	5.53**	5.53**	7.82**
Initial flow rate (ml cm–1min^{-1})	0.089	0.062	0.091	0.093	NS	NS	NS
Rubber content (%, w/v)	43.60	41.90	39.30	36.90	2.384*	NS	NS
Plugging index	5.49	8.08	1.89	1.81	1.09**	1.09*	1.546**
Pre-tapping P_{1v} (MPa)	0.95	0.89	1.02	1.08	0.0664**	NS	NS
Minimum P_{1v} (MPa)	0.194	0.196	0.246	0.274	0.019**	NS	NS
Latex solute potential (–MPa)	1.02	1.01	0.92	0.91	0.093*	NS	NS
Pre-dawn Ψ_{leaf} (MPa)	0.23	0.25	0.14	0.15	0.028	NS	NS
Mean Ψ_{leaf} (MPa)	1.90	1.94	1.32	1.27	0.161**	NS	NS
After-noon Ψ_{leaf} (–MPa)	2.32	2.64	1.66	1.58	0.212**	NS	0.299*
Minimum r_s (s cm^{-1})	1.42	1.66	1.08	1.50	NS	0.314*	NS
Mean r_s (s cm^{-1})	9.36	9.42	7.92	8.70	0.983*	NS	NS
Transpiration (mm da^{-1}y)	0.832	1.331	4.516	4.549	0.0976**	0.0976**	0.138**
Transpiration co-efficient	0.151	0.224	1.039	1.130	0.0237**	0.0237**	0.034**
Xylem sap speed (cm/12 h)	89.70	97.76	108.76	109.58	2.675**	2.675**	3.78**

**—Significant at 1% error; *—Significant at 5%error; NS — Non-Significant

Dry season: Results indicate significant variations during dry season in yield and yield components between RRII 105 and RRII 118 at CES. At Malankara, only total yield, initial flow rate and plugging index were found to be significantly different while rubber content did not show any variation between Gl 1 and Tjir 1. Of all the clones RRII 105 showed higher yield tree^{-1} tap^{-1}. Of all the physiological parameters, minimum resistance did not show any variation between the clones studied. At Malankara, all the components of water relations were found to be non-significant between Gl 1 and Tjir 1, other than maximum turgor, transpiration rates and cumulative xylem sap speed (Table Phy. 10).

Wet season: Yield and yield components were found to be significantly different between RRII 105 and RRII 118. Only plugging index was found to be significantly different between Gl 1 and Tjir 1 at Malankara. Of all the components of water relations, only minimum stomatal resistance did not show any significant variation in RRII 105 and RRII 118. But in Gl 1 and Tjir 1 no significant differences were noticed in any of the parameters studied.

(b) **Catch-up phenomenon:**

Observations on the above parameters were recorded in April, May, September October, December 1987, and January-March 1988 at CES and April-June and October, December 1987 at Malankara. Monthly observations were not taken up due to heavy rains during the said period. Data (Figs. Phy. 8 and Phy. 9) indicate that leaf water potentials and xylem sap speeds were in the maximum after the restoration of complete soil moisture status, ie., from the middle of June onwards. Transpiration rates were also found to be high during the wet seasons. The soil moisture levels were found to be at field capacity (–0.03 to –0.05 MPa). Further, drop in leaf water potential, xylem sap speed and transpiration and a rise in stomatal resistance were noticed in March 1988, with the onset of stress situation at CES in clones RRII 105 and RRII 118 (Figs. Phy. 8 and Phy. 9).

(c) **Effect of wintering:**

Changes in plant parameters like latex vessel turgor, latex solute potentials and xylem sap speed were observed during wintering in RRII 105 at CES, during February 1988. Results indicate that xylem sap speed was considerably reduced during wintering. Latex vessel turgor drops down to 0.2–0.25 MPa after tapping, and the rebuilt-up was noticed at around mid-day suggesting that absence of transpirational stress would speed up the recoupment of water for turgor maintenance (Fig. Phy. 10).

It is observed from the present studies that the turgor pressure in the latex vessels was in the range of 0.70 – 1.1 MPa. RRII 105 was found to maintain better turgor of around 0.3 MPa during the flow period. The turgor loss within the drainage area is mainly associated with the tapping process. The continued loss of turgor is associated with the continued removal of latex from the laticiferous system. However, clone RRII 105 was found to maintain better turgor inspite of higher latex yield. This could be due to higher water status of xylem tissue in the morning hours. This is even evident from the higher initial flow rate in RRII 105 which is associated with pre-dawn/pre-tapping turgor pressure of the latex vessels. In wet season, under adequate soil moisture, higher initial flow rate and lower plugging index might enhance the latex yield in all clones.

Present observations also indicate that transpiration rates were higher in clones RRII 118, Tjir 1, Gl 1 when compared to RRII 105, even though sap flow rate was higher in RRII 105. Inspite of a better plant water status, RRII 105 was found to maintain higher stomatal resistance, which might be an adaptive feature. Stomatal resistance did not show any significant variation at peak hours of stomatal opening, indicating the possibility that these clones do not behave differently at the time of maximal photosynthesis. Thus it is evident that clonal variation in stomatal behaviour plays a vital role in maintaining a favourable plant water status which results in higher yield. RRII 105 was found to have higher water uptake inspite of lower $\Delta \Psi$ values. This is another factor contributing to high plant

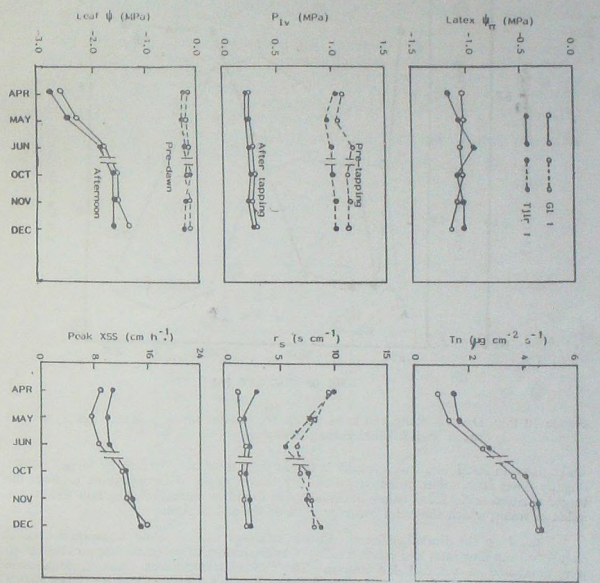

Figure 9. Phy. Changes in components of water relations during the catch-up phenomenon in Gl 1 and Tjir 1.

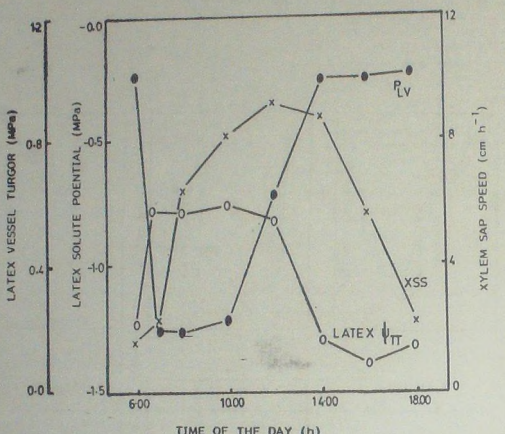

Figure 10 Phy. Diurnal changes in latex vessel turgor, latex solute potential and xylem sap speed in RRII 105 during wintering.

water status in RRII 105, which results in higher latex flow rate, caused by higher turgor. Slightly lower latex solute potentials in the dry season might also contribute towards the turgor maintenance. Latex solute potentials were found to increase during flow due to the influx of water, which showed a recovery towards the end of flow.

Based on the diurnal patterns of water relations studied, daily transpiration rates, cumulative sap flow rates and relative ratios of transpiration to potential evapotranspiration were computed in wet and dry seasons. The relative transpiration ratio (transpiration co-efficient) was found to be significantly different between RRII 105 and RRII 118 during both wet and dry seasons. But Gl 1 and Tjir 1 did not show any variation. This value has been found to change from 0.1 in dry season to 1.1 in wet season. RRII 105 was found to have low transpiration. This parameter can be used as a tool for studying water requirements of tree crops where use of lysimeters become tedious. It is also observed that transpiration rates were higher in the afternoon hours when the v. p. d. is high, even though maximum stomatal opening was seen in the morning.

These studies also indicate that in RRII 105 better water recoupments were noticed inspite of lower $\Delta \Psi$ values, indicating lower root resistance, resulting from either higher root intensity or root permeability to water. Though clonal variations in turgor pressure are significant, the seasonal variations are not high from April onwards. However, low

turgor values were observed at CES in March. Other qualitative changes induced by drought in the laticiferous system are also important in regulating latex flow. Further processing of data is in progress.

9. LIGHT AVAILABILITY ON GROUND SURFACE IN *HEVEA* PLANTATION DURING IMMATURE PHASE

Data on light requirements on many crop plants are now becoming increasingly available. Knowledge of light intensity on ground surfaces under immature *Hevea* during different phases of growth would be useful for selecting crop species for intercropping and in locating the area of planting of intercrops. A study has been initiated to quantify the availability of photosynthetically active radiation (PAR) in different one meter square quadrets of land below immature *Hevea* canopies.

The distribution of PAR on ground surface for three year old immature plantations are schematically presented in Fig. Phy. 11. Table Phy. 11 gives the extent of land surfaces with different light availabilities.

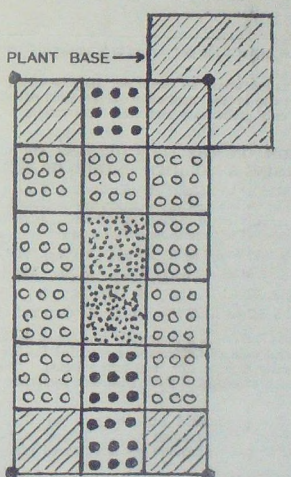

Figure 11. Phy. Light availability in three year old *Hevea* plantation (clone PB 260), planted with the spacing 6.25 m × 3.0 m 81-100%; 61-80%; 41-60%

Table-Phy. 11. *Availability of photosynthetically active radiation (PAR) on different parts of the ground surface under immature canopies of different ages.*

% of light available	Area in M²							
	1st year PB 217		2nd year PB 217		3rd year PB 260		4th year PB 310	
	5.14	3.6	4.2	3.0	6.25	3.0	6.7	3.0
81–100	9.6 (72.7)		6.6 (54.5)		5.5 (35.7)		2.2 (14.3)	
61–80	3.6 (27.3)		5.5 (45.5)		5.5 (64.3)		9.9 (64.3)	
41–60	—		—		—		3.3) (21.4)	

Figures in the parentheses indicate the per cent of area under different levels of light.

The above information would be useful not only in selection of intercrops and location of planting, but also in the prediction of the yield potentials of the intercrops. The data presented is only preliminary and more observations are being made.

10. REINVESTIGATION ON THE EFFECTIVENESS OF CALCIUM CARBIDE STIMULATION USING A MODIFIED METHOD OF APPLICATION

A new trial was taken up to evaluate the effectiveness of calcium carbide stimulation of conventionally tapped as well as puncture tapped trees of clone RRIM 600 in B1 1 panel stage. The method of application of calcium carbide was as reported by South China Academy of Tropical crops. The treatments included were

4 × 4 PI/40 d/2 6d/7. ET 5%. TA 2(2). 12/y (m)

4 × 4 PI/40 d/2 6d/7. CaC_2. Sa(20). 24/y (2w)

1/2 S d/2 6d/7. CaC_2. Sa (20). 24/y (2w)

1/2 S d/2 6d/7. ET 5%. Ba_3(2). 6/y/(2m) and 1/2 Sd/2 6d/7 (Control).

The experiment was laid out in a completely randomised design on single tree single plot basis. Pre-treatment yield of 178 trees were recorded for five tappings in December 1987. Trees with extremely high or low yield were rejected. The remaining trees were randomly assigned to each treatment. Each treatment comprised of ten trees as replicates.

A 30 cm long hollow, perforated bamboo pipe was fixed in the soil, 15-20 cm away from the tree, adjacent to the tapping panel. Twenty gm calcium carbide granules was sprinkled around the neck of the bamboo pipe and covered using a porcelain cup.

Four vertical bands of 40 cm length were made on the tree, 20 cm above the bud union and 4 punctures/band were made on each tapping in the case of treatments with puncture tapping. CaC_2 stimulation was repeated at 15 days interval, whereas, ethephon stimulation was carried out once in a month for puncture tapping, and at 60 days interval for bark application.

The first stimulation was carried out in December and tapping commenced on 2nd January 1988. Tree-wise yield were collected by cup coagulation method. The mean yield obtained for the initial five months of the trial are presented in Fig. Phy. 12. The yield differences were significant at 5% error. Half spiral alternate daily tapping system with CaC_2 stimulation gave the maximum dry rubber yield. The yield (g tree^{-1} tap^{-1}) in this treatment was 73 percent higher than that under 1/2 S d/2 control. This was 50 percent higher than the yield obtained with ethephon stimulation under the same tapping system. Similarly with puncture tapping system also higher yield was obtained with CaC_2 stimulation when compared to ethephon stimulation. However, puncture tapping was found to be less effective than conventional tapping system, and the difference between calcium carbide and ethephon effects was non-significant.

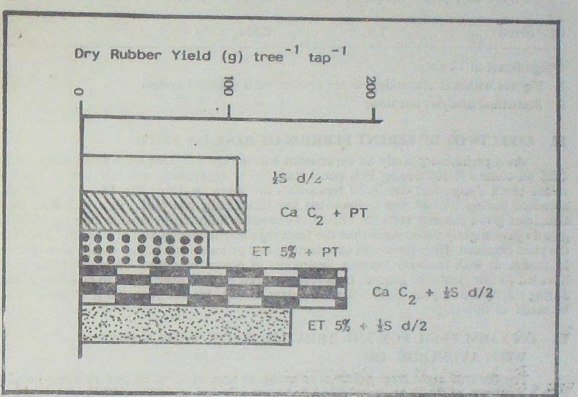

Figure 12. Phy. Mean dry rubber yield (g tree^{-1} tap^{-1}) under various treatments

11. EFFECTS OF DIFFERENT EXPLOITATION SYSTEMS ON THE YIELD OF MODERN *HEVEA* CLONES

The trial was continued and data on yield and associated parameters were collected. Maximum yield was obtained from trees under 1/2 S d/2 6d/7 system of tapping (Table Phy. 12). The difference in yield between 1/2 S d/2 6d/7 and 1/2 S d/3 6d/7 was reduced from 23.6% to 14.5% during the second year. In the 1/2 S double cut change over system the yield difference when compared to 1/2 S d/2 system was more in the second year. However, in the second year also, yield per tapping was higher for 1/2 S d/3 system (Table Phy. 12). Plugging indices were higher with low frequency of tapping. The girth increment was not statistically significant for the trees under different systems of tapping. Plugging index and d.r.c. were lower for more frequent tapping (Table Phy. 12). Though not statistically significant, brown bast incidences were numerically higher in plots under 1/2 S d/2 system.

Table-Phy. 12. *Annual yield, mean yield per tap, mean dry rubber content and plugging index of clone RRII 105 subjected to different tapping systems.*

Tapping system	Dry rubber yield** (kg/120 trees/year)	Dry rubber yield per tap** (kg/120 trees)	Mean I d. r. c. (%)	Plugging Index I	
				Wet season	Dry season
1/2 S d/2 6d/7	1160 (100)T	8.74	36.6	2.68	5.46
1/2 S d/3 6d/7	993 (85.6)	11.03	40.0	3.16	7.74
2×1/4 S d/2 6d/7 (t,t)	786 (67.8)	5.55	41.5	3.55	7.82
CD (0.05)	7.9	0.514	—	—	—

**Significant at 1% error

T Figures within brackets denote per cent of 1/2 S d/2 6d/7 system

1. Statistical analysis not done

12. EFFECTS OF DIFFERENT PERIODS OF REST ON YIELD

As a preliminary study an experiment was initiated in 1986 on a small scale trial at CES on clone PR 107 during BO_2 panel stage. The experiment was laid out on a randomised block design and details of treatments are given in Table Phy.13. The yield data collected during 1987-88 was summarised and statistically analysed. One year data shows that trees given summer rests for one or two months followed by regular tapping with rain guards gave slightly better yield than the trees regularly tapped in all the months. However, the yield obtained from trees with two months' rest periods during rainy season was inferior. In treatment with recovery tapping, symptoms of brown bast were observed which might have led to low yield. In general, trees receiving rest periods were found to give better yield during the period of peak yield. Since the data is only for one year, no generalisation can be made at this stage.

13. ON FARM TRIAL FOR THE TREATMENT OF BROWN BAST WITH AYURVEDIC OIL

For the trial eight large holdings covering an area of 57.68 ha and 19 small holdings with a coverage of 29.49 ha (total 87.17 ha) were selected in 1987. 292 litres of oil was supplied in December 1987 to the holdings selected. Further 40 litres of oil was supplied to two of the large holdings selected earlier, during this year also. While supplying the oil its application was explained and demonstrated.

14. ON FARM TRIAL FOR THE TREATMENT OF PINK DISEASE WITH AYURVEDIC OIL

Ten small holdings covering an area of 22.4 ha were selected for the trial and 40 litres of oil was supplied. The treatment was explained and demonstrated.

15. INTERCROPPING MEDICINAL HERBS IN RUBBER PLANTED AREAS

The trial started at CES Chethakal during last year was continued. So far nearly 1.5 ha was brought under intercropping with medicinal plants. An effective planting device that may cause least soil damage has been worked out and developed. The device developed is the trench planting system. Above the planted row, a contour biological bund with

Table–Phy. 13 *Yield of Dry Rubber from PR* 107 *under different treatments during* 1987-88 (*kg*/20 *trees*)**

Treat-ments	April '87	May	June	July	Aug	Sept.	Octo.	Nov.	Dec.	Jan.88	Feb.	Mar.	Total
T1	7.913	10.577	14.810	22.232	19.011	11.811	16.174	13.402	11.855	13.288	12.304	11.413	164.89
T2	R	9.575	14.319	24.069	18.647	12.164	20.387	15.081	15.705	15.422	14.547	15.678	175.59
T3	R	R	17.877	24.134	19.071	13.817	19.611	18.301	17.139	15.935	15.392	15.150	173.50
T4	8.830	11.773	2.945	R	R	8.343	10.086	17.103	24.818	22.519	17.340	21.137	144.19
T5	R	13.173	3.764	R	R	8.510	9.094	15.161	23.193	20.913	19.182	24.423	137.41
T6	R	11.918	3.817	R	R	7.062	7.779	11.893	17.741	18.185	15.497	17.011	110.90

** Significant at 1% error CD 0.05 8.26

T1– Continuous tapping with rain guard

T2– 1 month rest in summer with rain guard

T3– 2 months rest in summer with rain guard

T4– 2 months rest in monsoon without rain guard

T5– 2 months rest in monsoon + 1 month rest in summer without rain guard

T6– 2 months rest in monsoon + 1 month rest in summer without rain guard + additional tapping during peak period of yield (weekly one)

minimum 30–40 cm height was taken where suitable perennial shade loving plant is raised. *Strobilanthus haenianus*, again a medicinal herb, was identified for this purpose. This bund will be useful even otherwise in the normal course that may lead to natural terrace formation. The bund however will have to be raised every 3 or 4 years. Trenches for planting are to be taken in between bunds. In this system, only 3/4 depth of the trench is to be filled with top soil, to plant the selected species. It is estimated that by this method 12,000 nos of 'Koduveli', or 18,000 nos of 'Karimkurunji' or 36,000 nos of 'Sarpagandhi' plants can be planted per ha. At CES Chethackal the following nos of plants were established so far.

1.	*Adathoda bedommie* (Cheria adalodakam)	– 1250 Nos
2.	*Adathoda vasica* (Valia adalodakam)	– 250 ,,
3.	*Rawolfia serpentina* (Sarpagandhi)	– 500 ,,
4.	*Holostemma annulare* (Adapathiyan)	– 750 ,,
5.	*Plumbago rosea* (Koduveli)	– 250 ,
6.	*Kaemferria rotunda* (Chengazha kizhangu)	– 200 ,,
7.	*K. galanga* (Kacholam)	– 750 ,,
8.	*Alpinia galanga* (Aratha)	– 750 ,,
9.	*Sida rhombifolia* (Kurumthotty)	– 1000 ,,
10.	*Peuraria sp.* (Kattu payar)	– 10 ,,
11.	*Desmodium sp.* (Kattuzhunnu)	– 10 ,,
12.	*Strobilanthus haenianus* (Karimkurunji)	– 25000 ,,

The species cited are retained as nucleus plants for further multiplication and distribution to interested planters. With the available plants, an area of more than 15 ha can be intercropped next year.

1. DEVELOPMENT OF SOLAR DRIER FOR SHEET RUBBER

Solar driers are being used in drying agricultural products like paddy, ginger etc. and solar heaters are being used in many parts of the country for producing hot water. Sheet rubber is normally dried either in smoke houses or in hot air driers, the latter is not popular in India. The high cost of firewood has made smoke drying very expensive, and as a result, most of the small holders in India are drying sheet rubber in the open sun. This has resulted in the production of lower quality sheet rubber. In order to reduce the cost of drying and improve the quality of sheet rubber, a solar drier has been designed and fabricated and its performance is being evaluated.

The broad specifications of the drier are as follows.

1.	Capacity	— 800 kg (dry weight) per charge (1600 sheets of 600 × 375 × 3 (mm)
2.	Source of heat	— Solar energy along with a subsidiary heat source using firewood
3.	Type of loading	— Using trollies
4.	Dimensions of a trolley	— 1200 × 900 × 1750 (mm)
5.	Dimensions of drying chamber	— 5400 × 3000 × 1800 (mm)
6.	Blower capacity	— Capable of delivering 1 - 5 m per second
7.	Monitoring instruments	— 10 position temperature indicator
8.	Control	— An air vane control for alternate heating and tempering
9.	Area of solar panel	— 8 panels of 1800 × 1200 (mm)

The design of the drier was made in consultation with the Energy Society, New Delhi. The construction of the drier was made on RCC columns with an RCC roof having a slope of approximately 10° facing south. The walls were made of mud and brick. The bottom side of the RCC roof was given a thermocol lining. A 150 mm layer of cinder was provided below the concrete floor for insulation. The solar collectors were flat plate type with aluminium sheets coated with a selective coating acting as the absorber and toughened glass for glazing. The collectors were installed on the roof top in two rows and both rows were connected to the blower through insulated ducts. A photograph of the solar drier is given in Fig. Chem.1.

The following studies have been made using the drier.

1. Rate and extent of temperature attainment in the chamber and their relation to sun light intensity.
2. Rate and extent of drying sheet rubber and their relation to the temperature and air flow in the chamber.
3. Quality of the sheet rubber dried in the solar drier in comparison with smoke dried sheets.
4. Extent of fuel saving obtained in the solar drier.

Table-Chem. 1 gives the temperature realised inside the drier at various levels of solar intensity. It may be seen that even on a partially cloudy day, the temperature in the drier could be raised above 45°C. However, only when the sun is very bright and the solar meter reading above 100, a temperature above 50°C could be realised. The maximum temperature

Table Chem. 1. *Temperature attained at various levels of solar intensity*

Date	Total sunshine hours	Relative humidity(%) FN	AN	Solar intensity Time	mw/cm2	Temperature inside the chamber (°C)
27/4/1988	10	80	57	10 AM	84	40
				11 AM	100	42
				12 Noon	110	48
				2 PM	92	52
				3 PM	80	48
01/6/1988	5.8	95	81	10 AM	20	43
				12 Noon	10	43
				2 PM	60	45
				3 PM	20	53*
02/6/1988	6 Minutes	96	86	10 AM	20	50*
				12 Noon	16	43
				2 PM	12	43
				4 PM	10	53*

* With firewood backing

was attained around noon and this could be maintained upto about 3 O' clock, after which the temperature drops.

The drying curves for sheet rubber using solar energy alone and for solar energy backed up with firewood are given in Fig-Chem 1. The curves show that the initial drying of sheets is fairly rapid, but becomes very slow when the moisture content is reduced to about 8 - 10%. The final drying is diffusion controlled and therefore takes a longer time. A higher temperature is always essential at this stage of drying. The results also indicate that with solar drying alone, the sheets take a much longer period for drying. However, with firewood backing, sheets could be dried in five days in the solar drier. The quality of sheets dried in the solar drier is found comparable to that of conventionally smoke dried sheets, except that the colour is slightly lighter in the former.

In an efficiently designed smoke house, firewood consumption is reported to be about 1 kg per kg of dry rubber. However, using the newly designed solar-cum-fuel drier, firewood consumption was found to be only 0.25 kg per kg of dry rubber. This observation was made during the summer months. During cloudy days, the consumption of firewood would be more.

2. STUDIES ON EPOXIDATION OF NATURAL RUBBER

Epoxidation is a chemical reaction in which oxygen atoms are added to unsaturated centres of an existing molecule. Addition of cyclic oxygen atoms to the natural rubber backbone has been reported to improve its oil resistance and air permeability characteristics. The properties of epoxidised natural rubber depend not only on the extent of epoxidation but also on the extent of side reactions. Considering the great commercial prospects of epoxidised natural rubber in India, a project was taken up to standardise the method of preparation of epoxidised natural rubber different levels of epoxidation.

Although peracetic acid has been reported to be an ideal reagent for preparing epoxidised natural rubber, this chemical is very expensive and is not easily available in India. Therefore, the method being standardised is based on the reaction between performic acid and natural rubber in latex stage, the performic acid being produced *in situ*. The variables studied include concentration of formic acid, molar ratio between formic acid and hydrogen peroxide, dry rubber content of latex, time and temperature of reaction, stabilising system used for the latex and method of recovery of rubber from the reaction medium.

The effect of the different variables on the properties of the epoxidised rubber has been studied with a view to identifying the reaction conditions suitable for preparing epoxidised natural rubber of any desired level of epoxidation without having any undesirable (by-products. Characterisation of epoxidised natural rubber has been carried out using both proton and ^{13}C NMR. A set of reaction conditions suitable for the preparation of epoxidised natural rubber with 25 mole percent epoxidation has already been arrived at, after analysing several batches of epoxidised natural rubber prepared under laboratory conditions. However, consistency with respect to the properties has to be confirmed and the effect of scaling up is also to be investigated.

Further experiments are in progress, to prepare epoxidised natural rubber having higher mole percent epoxidation. Studies have also been initiated on the applications of epoxidised natural rubber.

3. STUDIES ON COMPRESSION SET OF NR VULCANIZATES

Unfilled and filled NR compounds were prepared using different cure systems, viz; conventional (CV), efficient vulcanization (EV) and peroxide (P). The fillers used were HAF black, china clay and precipitated silica. Compression set values were determined at different temperatures and for different periods of time. Results are given in Table Chem. 2.

Table Chem - 2. *Compression set values at different temperature and time*

Sample	Cure system	Compression set at °C/hrs											
		50/22	30/22	20/22	10/22	0/22	–5/22	–10/22	20/96	10/96	0/96	–5/96	–10/96
GUM	C	6.8	5.9	2.1	2.1	2.7	7.0	1.7	5.7	2.7	1.4	2.2	1.4
	EV	6.4	5.8	3.5	3.4	2.4	7.1	1.4	4.9	3.4	1.4	2.2	1.1
	P	4.2	2.1	3.6	3.8	2.3	14.9	2.8	6.8	3.8	3.2	2.8	3.6
HAF	C	7.2	7.3	3.0	3.0	2.9	7.8	2.9	7.4	3.0	2.3	2.3	3.6
	EV	6.1	7.1	6.3	7.3	2.9	9.2	3.6	7.5	7.3	4.2	2.6	4.5
	P	6.0	7.4	7.4	8.7	3.2	9.9	3.6	9.5	8.7	4.7	2.7	5.4
CLAY	C	3.7	8.4	2.3	4.8	1.4	5.2	6.2	6.5	4.8	2.1	2.4	1.4
	EV	3.0	8.1	3.3	6.9	1.7	7.2	6.5	8.9	6.9	2.3	2.7	1.9
	P	2.3	8.2	6.3	11.4	4.8	20.5	19.6	15.8	11.4	8.7	5.5	3.9
PRECIPITATED SILICA	C	4.2	9.7	6.2	7.8	3.0	6.5	9.4	10.1	7.8	3.1	3.0	2.7
	EV	4.0	7.7	6.2	11.9	4.0	7.0	5.4	12.8	11.9	4.7	5.5	3.8
	P	5.3	5.7	16.4	22.3	9.3	20.2	18.4	17.0	22.3	18.3	6.8	17.2

It was observed that at 30 and 50°C the compression set values were in the order CV EV > P. But the trend was reversed from 20°C downwards.

4. STUDIES ON NATURAL RUBBER – 1,2 – POLYBUTADIENE BLENDS

The effect of silica filler to improve the technological properties of NR-1, 2–polybutadiene blends, was investigated. The filler used was ultrasil VN3. The blend ratios are furnished in Table-Chem. 3. Quantitative evaluation of the ozone resistance of the blends, was also attempted.

Table–Chem. 3. *Blend Ratios*

Polymer	Ao^1	A^1	B^1	C^1	D^1	E^1	F^1	G^1	H^1
Natural rubber	100	90	80	70	60	50	40	20	..
1,2–Polybutadiene	..	10	20	30	40	50	60	80	100

Tables-Chem.4, 5 and 6 give formulation of the compounds, properties of the blends and ageing resistance of silica filled blends, respectively. Table-Chem. 7 gives the critical parameters for ozone attack of the unfilled blends.

Table–Chem. 4. *Compounding Recipe*

Ingredients	Unfilled Blend Ao^1, A^1, B^1, C^1	Silica filled Ao^1S, A^1S, B^1S
Polymer	100.0	100.0
Zinc oxide	5.0	5.0
Stearic acid	1.0	1.0
Phenyl β –naphthyl amine	1.0	1.0
Tetramethylthiuram disulphide	1.75	1.75
Diethylene glycol	..	2.0
Ultrasil VN_3	..	39.0
N-Cyclohexylbenzothiazyl sulphenamide	1.5	1.5
Sulphur	0.5	0.5

Table-Chem. 5. *Technological properties of the blends.*

Treatment	Tensile strength (MPa)	Elongation at break (%)	Modulus 300% (MPa)	Tear strength (KN/m)	Hardness (Shore A)	Compression set (%)
Ao^1S	26.2	574	9.65	90.4	66	37.9
A^1o	21.5	899	1.88	31.2	42	15.4
A^1S	25.2	533	9.85	92.4	70	40.8
A^1	20.4	818	2.34	34.0	45	19.2
B^1S	23.4	529	9.60	98.9	74	47.3
B^1	19.7	785	2.75	37.9	49	24.4
C^1S	21.2	516	9.60	88.5	76	53.2
C^1	17.1	762	3.27	42.9	54	30.7
D^1S	18.3	507	9.60	75.4	80	58.4
D^1	14.3	689	3.67	44.1	59	37.8
E^1S	17.9	507	9.80	79.0	83	62.6
E^1	8.1	487	4.37	47.9	64	45.9
F^1S	14.8	446	10.00	66.1	85	70.9
F^1	6.1	339	5.12	50.7	70	53.3
G^1S	13.5	365	11.50	73.4	87	78.4
G^1	9.4	367	6.80	56.6	79	63.1
H^1S	15.6	333	14.40	77.5	89	81.4
H^1	15.5	397	8.60	68.3	84	72.9

Table - Chem. 6. *Ageing resistance of silica filled blends**

Treatment	Modulus 300%	Tensile strength	Elongation at break	Tear strength
Ao^1S	118.3	81.4	77.2	87.8
A^1S	129.9	72.1	64.6	71.0
B^1S	134.5	72.4	71.9	83.1
C^1S	138.0	70.6	64.5	80.9
D^1S	141.1	76.7	60.5	76.1
E^1S	147.3	78.6	55.7	95.8
F^1S	143.2	82.4	62.6	97.4
G^1S	125.1	89.2	62.7	105.0
H^1S	116.2	84.4	66.4	109.1

*Percentage retained after ageing at 100°C for 96 hrs)

Table - Chem. 7. *Critical parameters of unfilled blends for ozone attack*

Treatment	Critical stress (MPa)	Critical strain (%)	Elastic stored energy density (KJ/m^3)	Elastic modulus (MPa)
Ao^1	0.07274	2.2020	79.47	0.05664
A^1	0.04603	0.8193	18.80	0.05664
B^1	0.08644	0.7377	31.79	0.11805
C^1	0.16392	0.7872	64.33	0.20986
D^1	0.27439	0.8281	112.72	0.33569
E^1	0.56297	8.0377	2205.73	0.07567
F^1	1.06974	13.1110	6740.67	0.09228

Testing of compounds G^1 and H^1 could not be done due to limitation on the length of the ozone test chamber.

5. EFFECT OF PROCESS AIDS ON ENGINEERING PROPERTIES OF NATURAL RUBBER COMPOUNDS

The aim of the project is to study the effect of process aids on the engineering properties of NR vulcanizates. Elastomers have replaced conventional materials in many engineering applications and natural rubber is extensively used in such areas. But the viscoelastic nature of NR imposes certain limitations.

Most of the products contain considerable amount of fillers and thus incorporation of process aids becomes essential. Six different process aids have been selected for the study. The formulation of the mixes are given in Table-Chem. 8.

Table-Chem. 8. *Formulation of mixes*

Ingredients	Treatment					
	1	2	3	4	5	6
Natural rubber (ISNR-5)	100	100	100	100	100	100
Stearic acid	2	2	2	2	2	2
Zinc oxide	5	5	5	5	5	5
SRF black	50	50	50	50	50	50
Naphthenic oil	5	..	..	..	..	..
Paraffinic oil	..	5	..	..	..	..
Aromatic oil	..	..	5	..	..	..
Pine tar	..	..	..	5	..	..
White factice	..	..	..	..	5	..
CI resin	..	..	..	..	..	5
CBS	1.5	1.5	1.5	1.5	1.5	1.5
TMTD	0.5	0.5	0.5	0.5	0.5	0.5
Sulphur	1	1	1	1	1	1

The vulcanizate properties of the above mixes are given in Table-Chem.9.

Table-Chem. 9. *Physical properties of mixes*

Property	Mix No.					
	1	2	3	4	5	6
300% Modulus, (MPa)	9.0	9.0	9.6	7.1	9.1	7.3
Tensile strength (MPa)	25.5	23.5	24.6	25.2	20.7	22.2
Elongation at break (%)	717	643	665	712	553	680
Retention in properties after ageing at 70°C for 10 days (%)						
300% Modulus	162	167	142	171	158	141
Tensile strength	78	88	73	82	78	71
Elongation at break	59	63	57	58	61	61
Tear resistance (KN/m)	84	87	80	71	67	79
Hardness (Shore A)	54	54	56	53	58	59
Compression set at 25% compression at 70°C, for 22 hrs. (%)	23.4	21.3	28.4	23.0	20.9	32
Compression set at 25%, compression at room temperature for 72 hrs (%)	6.5	6.2	9.6	7.6	6.8	17.1
Heat buildup $\triangle T$°C	17	17	19	20	19	26
Resilience (%)	68.5	69.4	64.8	64.2	68.1	62.9
Hysteresis (%)	42	49	42	48	47	50
Creep after 144 hrs, (%)	7	16	12.5	12	17	24

The stress relaxation characteristics of the mixes are given in Table -Chem. 10.

Table - Chem. 10. *Stress relaxation characteristics of mixes*

Time	Slope of the stress relaxation curves					
	1	2	3	4	5	6
30 Sec.	1.7	1.2	2.0	1.6	1.1	1.0
600 Sec.	2.5	1.6	2.5	2.2	2.5	2.0
5400 Sec.	3.0	2.5	2.3	2.6	3.3	3.3

From Table-Chem.9, it may be seen that the vulcanizate containing naphthenic oil gives the highest tensile strength and elongation at break and the one containing white factice shows the lowest strength followed by that containing CI resin.

Regarding the general engineering properties, the lowest set and creep characteristics are shown by naphthenic oil. Paraffinic oil shows the least stress relaxation charcteristics, but shows high creep values. This unusual behaviour of paraffinic oil may be attributed to its bleeding tendency caused by its relatively low compatibility with the polymer. CI resin showed the least desirable properties. Hence further trials were conducted to study the effect of concentration of naphthenic oil and CI resin on the engineering properties. Different concentrations of both the plasticisers at 1,2,4,8,10 phr were studied. The following conclusions have been made on the results obtained.

1. A rating of process aids can be made in the order naphthenic oil > Paraffinic oil > Pine tar > aromatic oil > White factice > CI resin, as far as engineering properties of the vulcanizates are concerned.

2. Creep and stress relaxation characteristics improve on addition of process aids other than CI resin

6. STUDIES ON OZONE RESISTANCE OF NR/ETHYLENE-PROPYLENE RUBBER

The effect of fillers on ozone resistance of NR/EPM rubber blends was studied. The fillers used were HAF black and china clay. The effect of blending of polymers in black masterbatch form has also been studied, as the method of addition of black is reported to influence the properties of the mixes.

The formulation and the properties of the mixes are given below.

Table - Chem. 11. *Formulation of mixes*

Ingredients	$A^1 - A_6$	$B1 - B_6$	$C_1 - C_6$
Polymer	100	100	100
HAF Black	50	50	..
China clay	..	..	50
Naphthenic oil	5	5	5
Dicumyl peroxide	6.25	6.25	6.25

Mixes $A_1 - A_6$	were 100:0, 95:5, 90:10, 80:20, 70:30 and 60:40 NR / EPM blends in which HAF black was added to the pre-blended polymers.
Mixes B_1-B_6	NR/EPM blends in the above proportion in which black was added to the individual polymers followed by blending the masterbatches.
Mixes $C_1 - C_6$	NR/EPM blends in the above proportions, in which chinaclay was added to the preblended polymers.

The ozone resistance of the mixes in terms of critical stress-strain parameters are given in Tables- Chem. 12, Chem. 13 and Chem. 14.

Table - Chem. 12. *Critical stress-strain properties of HAF-filled vulcanizates.*

MIX	A_1	A_2	A_3	A_4	A_5	A_6
Critical stress (MPa)	0.339	0.320	0.470	1.21	3.86	4.05
Critical strain (%)	7.49	9.35	13.87	44.79	295.4	348.1
Critical stored elastic energy density (MJ/M^3)	1.24	1.45	8.13	24.45	580.5	513.1
Elastic modulus E (MPa)	0.0487	0.0375	0.0386	0.0391	0.0497	0.0543

Table - Chem. 13. *Critical stress strain properties of china clay filled vulcanizates*

MIX	C_1	C_2	C_3	C_4	C_5	C_6
Critical stress (MPa)	0.1079	0.120	0.1275	0.1974	0.3086	0.4273
Critical strain (M)	8.062	9.77	15.02	18.88	52.21	93.88
Critical stored elastic energy density (MJ/M^3)	0.42	0.56	0.91	1.76	7.17	17.1
Elastic modulus (MPa)	0.0145	0.0135	0.0097	0.0124	0.0089	0.0088

Table - Chem. 14. *Critical stress-strain properties of HAF-filled vulcanizates (Masterbatch blending)*

MIX	B_1	B_2	B_3	B_4	B_5	B_6
Critical stress (MPa)	0.2765	0.276	0.3726	0.6036	4.12	4.55
Critical strain (%)	7.22	9.21	13.36	29.42	343.65	406.6
Critical stored elastic energy density (MJ/M^3)	0.97	1.23	2.39	8.22	610.9	807.8
Elastic modulus (MPa)	0.0411	0.0327	0.0316	0.0266	0.0531	0.0568

The data reveal that ozone resistance of NR/EPM blends (especially those having EPM above 10 phr) increases with the addition of HAF black. Blending of HAF black masterbatches of the two polymers is benficial only when the proportion of EPM is more than 30 phr and the addition of china clay reduces ozone resistance of NR and NR/EPM blends drastically.

7. DEVELOPMENT OF RUBBER COMPOUNDS FOR ENGINEERING APPLICATIONS

To improve the compatibility of natural rubber-nitrile rubber blends, acrylonitrile-NR graft was used as a compatibiliser. Properties of the blends were studied for filled and unfilled vulcanizates. As the results obtained were not encouraging a few other compatibilisers are being tried.

8. DEVELOPMENT OF CHEMICAL RESISTANT NR COMPOUNDS

To study the effect of ageing of NR vulcanizates in phosphoric acid, the following compounds were prepared.

Table–Chem. 15. *Composition of compounds*

Ingredients	Without antioxidant			With antioxidant		
	I	II	III	IA	IIA	IIIA
Natural rubber	100	100	100	100	100	10
Stearic acid	2	2	2	2	2	2
Zinc oxide	5	5	5	5	5	5
PBN ..	..	..	..	1	1	1
HAF black	40	..	..	40	..	..
China clay ..	..	100	..	..	100	..
Barytes	..	..	100	..	..	100
Naphthenic oil	3	3	3	3	3	3
CBS ..	0.6	0.6	0.6	0.6	0.6	0.6
Sulphur ..	3	3	3	3	3	3

The samples prepared were immersed in 40% solution of phosphoric acid at 70°C for 24 and 48 hrs. The properties of the samples were evaluated after ageing. The results are given in table - Chem. 16.

It was observed that upto 48 hrs., there was practically no deterioration in the properties.

9. STUDIES ON BLOOMING

The effect of filler, accelerator and process aids on blooming in NR vulcanizates was investigated. For this a masterbatch containing natural rubber (100 parts), stearic acid (1.5 part), zinc oxide (4. 0 parts) and antioxidant SP (1.0 part) was prepared. From the masterbatch, a gum compound and compounds with 100 phr clay and 50 phr precipitated silica were prepared incorporating process aids as follows:

1. CI Resin 1, 2, 3, 4 and 5 phr
2. PF Resin 3, 4 and 5 phr
3. White Factice 5 phr
4. Wood Rosin 3, 4 and 5 phr

Table - Chem. 16. *Properties of NR vulcanizates after ageing*

Sample	Before ageing					Aged in 40% H_3PO_3 at 70°C for 24 hrs.					Aged in 40% H_3PO_3 at 70°C for 48 hrs.				
	M_{100}	M_{200}	M_{300}	Tensile strength MPa	Elongation at break(%)	M_{100}	M_{200}	M_{300}	Tensile sterength MPa	Elongation at break (%)	M_{100}	M_{200}	M_{300}	Tensile strength MPa	Elongation at break (%)
I	1.94	4.33	7.83	26.78	697	2.50	5.50	10.20	28.8	634	2.70	6.20	11.00	28.3	632
IA	2.30	3.20	9.30	27.30	697	2.60	5.80	10.30	27.3	602	2.90	6.50	11.50	28.5	622
II	1.58	3.06	4.90	13.70	646	1.94	3.70	5.60	16.5	633	2.09	4.02	6.20	13.9	606
IIA	1.37	2.53	3.90	13.96	685	1.74	3.20	4.90	17.5	682	1.95	3.40	5.30	18.4	627
III	0.90	1.20	1.64	15.20	893	1.05	1.44	2.07	18.5	850	1.14	1.58	2.25	17.8	822
IIIA	0.53	1.30	1.80	14.30	850	1.14	1.58	2.25	17.8	822	1.15	1.67	2.40	18.5	809

The following cure systems were tried.

1. MBTS/TMTD/S 1.5/1.5/0.3 phr
2. MBTS/TMTM/S 1.5/1.5/0.3 phr

The moulded samples were kept exposed to air and light. It was observed that samples containing 5 phr CI Resin showed less severity in blooming.

Another trial was conducted by incorporating 0.5,1 and 1.5 phr calcium oxide and sodium carbonate in clay filled compounds to see whether the residual acidity of clay contributes to blooming. But addition of calcium oxide or sodium carbonate had no effect on blooming.

10. STUDIES ON POLYBAG COLLECTION OF LATEX

This project was started with a view to reduce the harvesting cost of rubber. Instead of collecting latex on all tapping days, latex was allowed to drip into polybag for 5, 10, 15 and 20 tapping days and then the lumps were processed into crepe and block rubber. A control sample was also prepared by coagulation of freshly collected latex from the same field using formic acid. The raw rubber properties of the samples are given in Tables-Chem 17 and Chem. 18. The technological properties were also determined. (Table-Chem. 19 and Table-Chem. 20).

Table-Chem. 17. *Raw rubber (Crepe) properties*

Property	Control	5 days	10 days	15 days	20 days
Dirt content (%)	0.010	0.020	0.019	0.013	0.012
Volatile matter (%)	0.42	0.71	0.66	0.57	0.59
Nitrogen (%)	0.42	0.45	0.43	0.44	0.42
Ash, (%)	0.14	0.44	0.34	0.32	0.40
Po ..	58	63	62	60	65
PRI ..	76	78	68	68	66
Acetone extract, (%)	2.26	2.14	2.19	2.17	2.22
Mooney viscosity, ML (1 + 4) at 100°C	91	105	105	98	97

Table-Chem. 18. *Raw rubber (crumb) properties*

Property	Control	5 days	10 days	Phosphoric acid treated 5 days	10 days
Dirt content (%)	0.010	0.010	0.013	0.019	0.012
Volatile matter (%)	0.203	0.52	0.38	0.45	0.32
Nitrogen (%)	0.44	0.31	0.35	0.25	0.25
Ash (%)	0.16	0.25	0.28	0.30	0.36
Po ..	43	57	63	52	56
PRI ..	67	77	59	77	77
Acetone extract (%)	2.61	2.46	2.48	2.28	2.21
Mooney viscosity ML (1 + 4) at 100°C	80	102	105	100	105

Table–Chem. 19. *Technological properties of the compounds*

Property	Control	5 days	10 days	15 days	20 days
Mooney scorch time at 120°C (Min)	12.25	7.00	7.00	8.50	7.75
Optimum cure time at 150°C (Min)	14.50	10.50	10.00	10.00	9.50
Modulus at 300% elongation (MPa)	1.71	1.88	1.73	1.65	1.75
Tensile strength (MPa)	15.1	17.2	17.00	16.9	17.3
Elongation at break (%)	672	807	871	886	903
Tear strength (KN/m)	26.7	28.4	27.9	28.3	27.7

Table–Chem. 20. *Percent changes in tensile properties after ageing at 70°C for 96 hr*

Property	Control	5 days	10 days	15 days	20 days
Modulus at 300% elongation	+32	+ 17	+31	+49	+42
Tensile strength	—26.5	— 33.5	—15.2	—17.8	—12.3
Elongation at break	— 4	—20	— 4	— 24	— 26

It was observed that the poly bag collected rubber cures faster than the control. The tensile strength of the polybag collected rubber vulcanizate was found to be slightly better than that of control. The other properties of the vulcanizate were not much influenced by the method of collection of latex.

11. PREPARATION AND PROPERTIES OF DEPOLYMERISED NATURAL RUBBER

For evaluating the use of liquid rubber as a plasticiser in nitrile rubber, seven compounds were prepared as per the recipe given in Table–Chem. 21. Properties of the vulcanizates were studied and the results are given in Table–Chem 21.

Table–Chem. 21. *Recipe (parts by weight) for compounding*

Ingredients	I	II	III	IV	V	VI	VII
Nitrile rubber	100	100	100	100	100	100	95
SBR ..	..	..	..	..	..	..	5
Zinc oxide	5	5	5	5	5	5	5
Stearic acid	1	1	1	1	1	1	1
SRF black	50	50	50	50	50	50	50
DBP ..	5	10	15	..	..	..	10
Liquid rubber	..	..	..	5	10	15	..
CBS ..	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Sulphur	0.5	0.5	0.5	0.5	0.5	0.5	0.5

Table-Chem. 22. *Properties of vulcanizates*

Properties	I	II	III	IV	V	VI	VII
Tensile strength (MPa)	11.85	13.13	11.07	13.03	12.45	11.27	12.45
r.a.a.at 70°C 96 hrs (%)*	107	104	108	99	101	104	103
Elongation (%)	683	662	683	631	603	609	557
r.a.a.at 70°C 96 hrs (%)	88	85	85	76	84	87	90
Modulus at 300 (%) elongation (MPa)	4.41	5.09	4.12	5.78	5.59	5.09	5.98
r.a.a. at 70°C 96 hrs (%)	123	126	130	138	125	119	119
Tear strength (KN/m)	48.1	49.6	44.3	52	48.6	43.5	50.5
Hardness (Shore A)	51	50	45.5	55	52	50	50
Compression set (%)	35	29.4	27.8	33	26.2	24.1	25
Green strength (MPa)	0.47	0.39	0.44	0.62	0.60	0.55	0.39
Volume swell (%)	1.6	0.7	..	3.1	5.3	7.0	2.0
Shrinkage (%)	0.8	1.9	3.1	0.3	..	..	2.3

* retention after ageing at 70°C for 96 hr.

It is found that green strength of the compounds containing liquid rubber is better than those containing the conventional plasticiser. Volume swell was high but shrinkage was low for compounds containing the liquid rubber compared to those containing conventional plasticiser.

12. GRAFT COPOLYMERISATION OF VINYL MONOMERS ON TO NATURAL RUBBER

Acrylonitrile graft natural rubber of 35% acrylonitrile (AN) content was prepared using gamma radiation. The oil and solvent resistance of this graft rubber was compared with that of nitrile rubber of low acrylonitrile content (AN-19%). Results are given below:

Table-Chem. 23. *Oil and solvent resistance of AN graft natural rubber*

	Nitrile rubber (AN – 19%)	Graft rubber (AN – 35%)
1. Swelling in hydraulic oil at room temp. for 70 hr (%)	1.8	9.9
2. Swelling in petrol at room temp. for 70 hr (%)	53	67

It is seen that graft rubber of even 35% acrylonitrile content is not having oil and solvent resistance comparable to that of nitrile rubber of 19% acrylonitrile content.

13. UTILIZATION OF WASTE MATERIALS FROM LATEX BASED RUBBER INDUSTRIES

Using the method developed earlier, reclaimed latex waste (RLW) was prepared and the technological properties were compared with those of whole tyre reclaim (WTR), in gum and blackfilled vulcanizates. The results are given below.

Table-Chem. 24. *Properties of reclaimed latex waste*

Properties	Reclaimed latex waste		
	Gum compound	Black filled compound	Whole tyre reclaim
Tensile strength (MPa)	0.88	5.23	4.08
Modulus at 100% (MPa)	0.61	2.04	1.94
Modulus at 200% (MPa)	..	4.05	3.80
Elongation (%)	165	264	223
Tear strength (KN/m)	8.0	20.5	18.6

It was observed that the properties of the black filled vulcanizates containing reclaimed latex waste were better than those of WTR. To assess the suitability of using reclaimed latex waste in the preparation of products like microcellular soling and V-strap, compounds were prepared by replacing 10 and 20 parts of NR by reclaimed latex waste and the properties were assessed. (Tables-Chem. 25 and Chem. 26)

Table-Chem. 25. *Properties of microcellular soling compounds*

Properties	Compound with 100% rubber	Compound with 10 parts RLW	Compound with 20 parts RLW
Sp. gravity	0.342	0.335	0.322
Hardness (Shore A)	28	24	23
Water absorption (%)	31	29	33
Heat shrinkage (%)	6.2	6.0	5.9
Split tear strength (Kg)	3.1	2.8	2.7
Expansion (%)	310	320	332
Din abrasion loss (mm^3)	576	593	630

Table-Chem. 26. *Properties of V-Strap compounds*

Properties	Compound with 100% NR	Compound with 10% RLW	Compound with 20% RLW
Tensile strength (MPa)	12.64	11.86	10.58
r.a.a. at 70°C for 96 hr (%)	99	98	98
Elongation (%)*	524	522	514
r.a.a. at 70°C for 96 hr (%)	98	96	94
Modulus at 300% elongation (MPa)	5.78	5.68	5.19
r.a.a. at 70°C for 96 hr (%)	107	109	111
Tear strength (KN/m)	42.9	40.8	39.6
De mattia flexing-crack initiation (Cycles)	1200	1030	1030
Crack failure (Cycles)	7500	5375	4375
Din abrasion loss (mm^3)	228	230	240

* retention after ageing at 70°C for 96 hr.

It was observed that the properties of microcellular soling and V-strap compounds were slightly inferior when the reclaim content was 20 phr. However, at 10% level, the properties were comparable with those of compounds containing cent percent natural rubber.

Agricultural Economics Division

1. EVALUATION OF PLANTING MATERIALS UNDER COMMERCIAL PLANTING

The study was initiated in 1974 for the continuous yield evaluation of important cultivars of rubber. The first and the second report of the study were published. The third report is under preparation. The data are being compiled for an econometric analysis.

2. STUDY OF PRODUCTION, CONSUMPTION AND UTILISATION OF RUBBER WOOD

Visits were made to all important centres of rubber wood consumption in Bombay, Bangalore, Madras and Mysore for the purpose. The estimated consumption in Bombay, Madras and Bangalore were placed at 1.13, 0.90 and 0.75 million m^3, respectively.

3. STUDY OF TECHNICAL FACILITIES AVAILABLE IN RUBBER WOOD CONSUMING UNITS.

A survey was undertaken covering 100 units. The study revealed that only 16 per cent of the units subjected the final products to some form of treatment. Only 2 per cent of the units stacked the logs in the North-South direction as an elementary measure to prevent cracking and end splitting.

4. STUDY ON FARM GATE PRICE

The study has been completed. The objectives of the study are to analyse the marketing system of natural rubber and to estimate the share of the producer in the consumer's rupee. The data for the study were collected from Kanjirappally and Changanacherry taluks. The study revealed that the growers realised a reasonable per cent of the terminal price.

5. STUDY OF THE EXTENT OF AREAS PLANTED WITH RRII 105

The study has been completed covering around 20,000 units planted in 1984. Around 90 per cent of the area of this 20,000 units has been planted with RRII 105.

6. STUDY OF INTERCROPS

The study initiated in the previous year has been completed. The study compared the economics of three important intercrops usually cultivated along with rubber viz. nendran banana, ginger and turmeric. The study revealed that banana was the most desirable intercrop from the point of view of stable income to the rubber growers.

7. CO-OPERATIVE SOCIETIES AS THE NODAL POINT FOR THE DISSEMINATION OF SCIENTIFIC INFORMATION ON RUBBER

The results of the study will enable us to quantify the extent of dissemination of scientific information through co-operatives and also the deficiencies and inadequacies in the dissemination. A questionnaire for the study has been prepared and mailed to 171 co-operative societies which associat with the Rubber Board in various schemes.

8. AN ECONOMETRIC ANALYSIS OF THE PRODUCTIVITY OF NATURAL RUBBER

The objective of the study is to quantify the contributing factors for the productivity differential. This study will give insight on the areas on which we have to concentrate for increassing productivity. Frame work of the study was finalised. Data on yield rates and other relevant variables pertaining to 50 estates are being processed. Data from an important planting company with a number of estates have been collected for the purpose.

9. MANAGEMENT OF RUBBER SMALL HOLDINGS AT DIFFERENT LEVELS OF INPUT

A detailed questionnaire has been prepared in Malayalam. It is proposed to undertake the study in Palai region taking up 300 small holdings.

10. SURVEY OF BROWN BAST AFFECTED TREES IN RUBBER SMALL HOLDINGS

For the study, hundred sample units each have been selected from the jurisdiction of the Regional offices of the Rubber Board at Palai, Changanacherry and Kanjirappally. Out of that 23 units have been visited and data were collected in a questionnaire.

11. STUDY OF PRODUCTION, CONSUMPTION AND UTILISATION OF RUBBER SEED OIL

During the period, visits were made to rubber seed oil producing units at Virudhunagar and Madurai for collecting data. For supplementing the data on the production of rubber seeds, visits were made to the Check Posts at Aryankavu, Amaravila, Walayar, Kumily, etc., A tentative estimate of rubber seed oil production has been worked out at 5000 tonnes for the year 1987-88.

12. STUDY OF COMMERCIAL PRODUCTION OF HONEY

A study of the potential production of rubber honey was made during the year. For the purpose, 42 co-operative societies and 13 purchasing centres engaged in honey production and marketing were visited. In addition, the offices of the Sarvodaya Sanghams in Cannanore, Calicut, Alleppey and Trivandrum were contacted. For supplementing the data, the offices of the Khadi & Village Industries Commission, Bombay, Khadi Board Office in Trivandrum and Central Bee Research Institute, Pune were visited. The study found that around 40 per cent of the honey produced in India originated from rubber plantations. On an average, 10 kgs of honey can be produced from one hive and 15 hives can be placed in a hectare of rubber plantation and 30 hives can be managed by one bee-keeper. The study noted that 3 lakh hectares of mature rubber plantation in India can produce about 45,000 tonnes of honey in a normal year. This area can give part time employment to 1,50,000 bee-keepers.

Central Experiment Station

The Central Experiment Station of the RRII was established at Chethackal, Ranni (Pathanamthitta District) about 50 km away from the Institute, in 1966 in an area of 254.8 ha. Field experiments have been laid out in the entire area by the Botany, Agronomy, Plant Physiology and Plant Pathology Divisions of the RRII and over sixty long term and short term experiments are now being conducted. Over 800 genotypes of wild Brazilian germplasm collections received from the Malaysian Centre are established and maintained in the Station.

A total rainfall of 3601.2 mm (Table–CES. 1) was received at the station during 1987-88 period.

Table–CES. 1. *Rainfall distribution at CES.*

Month		Rainfall (mm)
April	1987	187.0
May	,,	300.5
June	,,	589.6
July	,,	170.4
August	,,	545.1
September	,,	256.8
October	,,	787.1
November	,,	336.2
December	,,	73.3
January	1988	10.8
February	,,	91.6
March	,,	252.8
Total		3601.2

There are 206 permanent workers and 170 temporary casual workers attached to the station. The crop produced during the period under review was 258244.11 kg.

Research Complex for North-East Region

The Research Complex of the Rubber Research Institute of India, with its headquarters at Guwahati, concentrated on need based research investigations relevant to this region. The Complex has Regional Research Stations in Assam, Meghalaya, Mizoram and Tripura. In Guwahati (Assam), the Complex has established laboratories for Biotechnology and Plant Pathology and an Experiment Station (15 ha) at Sarutari Village about 25 km away, where trials on nutrition and evaluation of clones are in progress. In the Regional Research Station, Agartala (Tripura), laboratories have been established for investigations on Agronomy/Soils and Plant Physiology. The Experiment Station, having an area of 77 ha, at Taranagar is about 22 km away from Agartala where investigations on agronomy, physiological evaluation of clones, plant breeding etc. are being undertaken. The High Altitude Research Station at Tura (Meghalaya) has laboratory facilities for plant physiological investigations and two Experiment Stations, one (16 ha) at Ganolgre, 13 km from Tura at an altitude of approximately 600 m MSL and the other (20 ha) at Darachigre having an elevation of about 1100 m MSL about 10 km away from the Ganolgre farm. The thrust areas of research are study of growth and production physiology under high altitude situations and agro-management practices to suit socio-economic conditions of the tribal farmers. Laboratory facilities for investigations on Agronomy/Soils and an experiment station (50 ha) situated at Tuichuan, having an altitude of about 150 m MSL, about 16 km from Kolasib have been established in the Regional Research Station, Mizoram. Investigations on rubber based cropping systems to suit tribal social customs form the thrust area of research in this station.

Regional Research Station, Assam

The Station is undertaking long term and short term field experiments as well as on-farm research programme. Import, establishment and conservation of *Hevea* germplasm were also attended to. A seedling nursery and a budwood multiplication nursery were established mainly for generating planting materials for various trials. Attempts were made to develop techniques of micropropagation of *Hevea* to create variability and broaden the base for selection. The extent of damage caused by various diseases of rubber in different parts of the North-Eastern Region was assessed.

1. MULTIDISCIPLINARY EVALUATION OF CLONE

The trial, started in 1985, with a view to studying the relative performance of ten clones under the agro-climatic conditions prevailing in Assam, laid out in a single tree single plot completely randomized design with 50 replications, was maintained adopting optimum cultural practices. Thirty plants from each of the clones were selected at random for the purpose of recording periodic observations. Girth of trees were recorded four times a year (last week of February, May, August and November) to deleniate period with favourable growth factors and periods with stress conditions. Thus four distinct seasons, viz. rainy season (June-August - soil moisture not limiting, hours of bright sunshine limiting), autumn (Sept-Nov- soil moisture not limiting, hours of bright sunshine not limiting), winter (Dec-Feb - low temperature, soil moisture stress), and spring (March-May-soil moisture stress) have been identified.

The clone RRII 118 recorded maximum girth (19.97 cm) closely followed by RRII 203 (19.93 cm), PB 235 (19.74 cm) and RRIM 600 (19.11 cm). Performance of the clone Gl 1 is found to be very poor in this region. In terms of annual girth increment, RRII 203 registered maximum (10.42 cm) followed by RRII 118 (10.28 cm) and PB 235 (10.11 cm). In order to study the effect of stress conditions on different clones, percentage of growth recorded during different seasons to the annual growth was studied. It was observed that 70–80 percent of growth is attained during June-November. Clones RRII 118 and RRIM 600 were least affected by low temperature (December-February). In the clone RRII 118, 13.6 per cent of annual growth was attained during December to February while in RRIM 600 it was 10.7 per cent. PB 5/51 was found to be most affected by low temperature stress conditions. In clones PB 235 and RRII 105, the percentages of growth recorded during March-May were 20.8 and 17.5, respectively, which indicate that these two clones are least affected by conditions of soil moisture stress.

The second trial was started in June 1986 with another set of clones keeping RRII 105 and RRII 118 as common. The layout adopted is single tree single plot in completely randomized design with 40 replications. Uniform cultural practices were adopted in the experimental area. Periodic observations on height and girth of plants were recorded from 30 randomly selected plants under each. The growth measurements were done during the last week of February, May, August and November so that growth attained during different seasons can be worked out. The clone RRII 118 recorded maximum girth (9.96 cm) and height (305.8 cm). Among the clones tried, PCK 1 registered lowest values of both the growth parameters. The same trend was observed with respect to girth increment also. On an average 50 to 70 per cent of girth increment was recorded during the period from June-December. Appreciable difference was observed between clones with respect to the percentage of growth recorded during unfavourable seasons with low temperature (December-February) and low soil moisture (March-May). More than 20 percent of annual girth increment was attained during the period March-May (soil moisture stress) in the case of RRII 105 and PB 260. During the period December-February, when low temperature is being experienced, clones like RRII 105, RRIC 102, PB 310 and PB 311 accounted for 26 to 28 per cent of their annual girth increment. RRIC 105 was found to be very sensitive to stress situations. Effect of stress situations was less conspicuous on height of plants.

2. COMPARISON OF ROCK PHOSPHATE AND SUPER PHOSPHATE AS SOURCES OF P FOR YOUNG RUBBER

The trial started in 1986 was continued. Application of fertilizers, as per treatment combinations, was undertaken twice a year. The experimental area was maintained with optimum cultural operations. Observations of girth and height of plants were recorded at periodic intervals (May and December). Contrary to the earlier findings, it is observed that the girth recorded is more when phosphorus was withheld or when rock phosphate (water insoluble) is applied. However, this difference narrowed down as the trees grew up as could be seen from the percentage of girth increment under various treatments. Initial vigour of the plants in the control plot is still reflected on the cumulative girth and annual girth increase, even though the effect is becoming less conspicuous. A more or less similar trend was observed in the height of plants recorded in May and August 1987.

3. NUTRITIONAL TRIAL (IMMATURE PHASE) UNDER NATURAL GROUND COVER

This trial was started in 1986 as an on-farm investigation in the North-Eastern Rubber Plantations at Mendipathor in East Garo Hills District of Meghalaya State. The object of this experiment is to find out the optimum dose of nitrogen, phosphorus and potassium for young rubber grown in association with natural ground covers. Nitrogen and phosphorus

were tried as 0, 30 and 60 kg/ha and potassium at 0, 20 and 40 kg/ha. The area was maintained adopting optimum cultural practices except for maintenance of leguminous ground covers. The ground cover was kept under control by timely weeding.

4. NUTRITIONAL TRIAL-SEEDLING NURSERY

This trial was started in 1986, as a part of the multilocational trial, to evolve optimum fertilizer recommendation for seedling nursery with respect to major nutrients for the North Eastern Region. Factorial combinations of four levels of nitrogen (0, 166, 333 and 500 kg/ha), three levels each of phosphorus and potassium (0, 125 and 250 kg/ha) were tried in RBD.

The data on girth of plants were recorded at periodic intervals. The statistical analysis of the data on girth recorded during June 1987 revealed no significant response to any of the nutrients tried.

The experiment is being repeated in another location. Analysis of the soil samples collected from the experimental site (1986 trial) is in progress.

5. STUDIES ON THE INTERACTION BETWEEN POTASSIUM AND MAGNESIUM

This trial was started in 1987 to study the interaction of the two important cations, potassium and magnesium, and their influence on growth and yield of rubber. Planting using RRII 105 polybag plants (two whorl stage) was undertaken in August 1987. Pretreatment data on height and girth of plants were recorded. Treatment combinations are proposed to be incorporated during the ensuing manuring season.

6. EMBRYOGENESIS FROM EX-PLANTS OF *HEVEA*

Various phytohormone combinations are being tested to induce embryogenesis/organogenesis. Some of the combinations showed callus formation but organ formation and somatic embryogenesis have not been observed so far. The callus induced from immature leaves and petioles turned brown after two to three weeks of culturing. Antioxidants to reduce oxidation of phenolics released from tissues are being tested.

7. ANTHER CULTURE AND PLANTLET REGENERATION

156 phytohormone combinations are being tested. Some of the combinations of phytohormones in S-4 medium induced anthers to produce callus after 20–30 days in presence of light.

8. MICROPROPAGATION OF *HEVEA*

135 phytohormone combinations with media standardized earlier have been tested for the proliferation of shoot tips and axillary buds. None of the phytohormone combinations favoured growth of shoot tips and axillary buds collected from budwood nursery. Axillary buds of seedling origin sprouted at very low frequency (3%).

9. GENETIC TRANSFORMATION OF *HEVEA* CELLS BY *AGROBACTERIUM TUMEFACIENS*

Two strains, B_6S_3 and C_{58}, were tested to transform young *Hevea* stem cells *in vivo*. Both strains transformed cells and formed actively grown crown galls, characteristic of A. *tumefaciens* strains.

10. SURVEY OF DISEASES AND PESTS AFFECTING RUBBER IN NORTH-EASTERN REGION

The survey of diseases and pests affecting rubber was continued. 17 plantations, mainly in Assam, Tripura and Meghalaya, were visited for on-the-spot assessment of the intensity of incidence of various diseases. The percentage infection of individual disease was recorded and intensity of incidence was assessed by scoring as low, medium and high.

It was observed that rubber plants of all stages of growth are infected by Powdery mildew disease during winter months in all the 17 locations. However, the intensity was very low (10-20 per cent) in older plantations compared to nursery and immature gardens where the intensity of infection ranged from 40 to 60 per cent. The agrometeorological data collected from ten locations revealed that cool climate (minimum temperature 8–10°C), misty nights with heavy dew formation prevailing in the region favours the incidence of this disease.

Leaf diseases of rubber caused by *Drechslera heveae* (bird's eye spot), *Gleosporium alborubrum* and *Colletotrichum gleosporiodes* (secondary leaf fall) and *Corynespora cassiicola* were noted in all the 17 locations observed. However, the intensity of these diseases was very mild except in nursery and very young rubber plants. In Umling (Meghalaya) heavy defoliation and die back of shoots was observed. Leaf spot disease caused by *Alternaria* sp. was noted in germplasm nursery at Sorutari. Two new strains of *Drechslera heveae* and *Curvularia* sp. were also noted in Sorutari farm. Further studies are in progress.

Abnormal leaf fall and shoot rot were not found in any of the locations visited. Brown root rot disease caused by *Phellinus noxius* was also very rarely met with.

Problems due to attack of white ants have been observed from all parts of the region. Incidence of scale insect was reported from Borgaon, Ouguri and Sorutari (all in Assam) during December to April. Slug was found only in Borgaon during rainy season. An insect (unreported) was also noticed on rubber during March which naturally disappeared by the onset of summer season. These insects have been found to voraciously eat leaves leaving only the midrib and petioles.

11. ISOLATION AND CULTURING PATHOGENS

Drechslera heveae, Curvularia sp., *Corynospora cassiicola, Gleosporium alborubrum, Alternaria* sp., *Botryodiploidia* sp. and *Genignardia* sp. were isolated from the samples collected from the various regions.

Atleast some of these organisms are mild pathogens and hence further studies are required to confirm their pathogenicity.

12. MAINTENANCE OF *HEVEA* GERMPLASM

1600 genotypes have been imported so far from the *Hevea* germplasm source bush nursery in Malaysia. Due to reasons beyond control, budding success was very low. Around 500 genotypes from the collection have been established in the budwood nursery at Sorutari farm, Assam.

Regional Research Station, Tripura

Regional Research Station, Tripura, under the RRII was established in 1979 with a research farm extending over an area of 66.04 ha at Taranagar, Mohanpur with an office, a library and a laboratory attached to it at Agartala. The activities at this station were strengthened along with the implementation of the scheme on the accelerated development of rubber plantation in the North-Eastern Region.

1. NUTRITIONAL TRIAL

This trial was started as a 3^3 factorial experiment using clone RRIM 600 extending over an area of 4.8 ha with nitrogen and phosphorus at levels 0, 30, 60 kg/ha and potassium at 0, 20, 40 kg/ha. The treatment $N_1P_2K_2$ (30 kg nitrogen, 60 kg phosphorus and 40 kg potassium per ha) recorded the maximum girth and the percentage increase in girth for this treatment over the control was 39. 2. A positive response to the applied phosphorus was noticed throughout the experiment. The preliminary data are summarised in the following table.

Table–NET-1. *Girth at different levels of nutrients*

Treatment	Dose	Girth (cm)					
	(kg/ha)	1982	1983	1984	1985	1986	1987
Nitrogen	0	10.52	14.53	19.51	29.76	36.13	40.84
	30	10.94	15.74	21.13	31.13	38.15	43.01
	60	11.15	16.77	22.03	31.92	38.51	43.24
Phosphorus	0	11.03	15.43	14.30	28.22	32.97	34.16
	30	10.80	15.63	21.36	31.62	39.14	40.93
	60	10.77	15.50	21.38	31.76	40.65	42.49
Potassium	0	10.53	15.08	20.02	29.96	36.44	41.22
	20	11.05	15.68	21.07	30.84	37.13	42.60
	40	11.05	15.78	21.59	32.09	39.22	43.76

2. STUDIES ON PLANTING TECHNIQUES

This trial was laid out with five treatments: (T_1) conventional brown budded stumps from 1980 nursery budded during 1981; (T_2) brown budded stumps from 1979 nursery budded during 1980 and allowed to grow in the nursery and planted in the planting season of 1981; (T_3) brown budded stumps of 1979 nursery budded during 1981; (T_4) 2 months old green budded polybag plants and (T_5) 14 months old polybag plants. The girth recorded during 1987 October showed that the 14 months old green budded polybag plants are superior to any other treatment and the percentage increase in girth over conventional brown budded stumps for this treatment is 20.6. In terms of girth increment also during the six month period from April 1987 to October 1987, the 14 months old green budded stumps registered a higher rate of increment. Since this trial was affected by hail storm there had been a set back in the growth of the plants after April 1986. Soil in the trial area has been analysed for available nutrients and fertilizer application was followed based on the analytical values.

3. STUDIES ON INTERCROPPING

Since the earlier trial laid out in the Taranagar farm during 1982 was severely damaged by hail storm, the trial could not be continued and had to be stumped for regeneration.

A new intercropping experiment was laid out during this period as an on-farm trial at Takarjala about 55 km from Agartala in the plantation of TRPC, engaged in the rehabilitation of jum cultivators. Inspite of heavy odds like remoteness and management problems, the site was so chosen considering the demonstration potential. Rubber being a non-conventional crop for the tribals, growing crops of edible nature could sustain their interests in plantation and hence crops such as maize, arhar, banana and pineapple were chosen. The performance of banana and pineapple was extremely satisfactory. One crop each of arhar and maize was taken and fresh crop for a second season would be sown during the appropriate season. A study on the economics also is aimed at.

4. STUDIES ON HIGH DENSITY PLANTING

This trial, started in 1983, was damaged in 1986 due to hail storm and later replanted in 1987 using budded stumps following the same technical programme. Due to unfavourable weather that followed the planting, certain amount of casualty occured and arrangements have been made to fill up the vacancies with polybag plants. Routine recording of morphological parameters and other cultural operations were undertaken.

5. NUTRITIONAL TRIAL IN SEEDLING NURSERY

This trial was started in the year 1986 to evolve optimum fertilizer recommendation for seedling nursery with respect to major nutrients in the North Eastern Region, in particular Tripura. Factorial combinations of NPKMg were followed. Pre treatment observations on girth and height were taken before commencement of the trial and data of one season has already been collected and processed. The data indicated response to higher nutrient level. However, with one season's data from the seedling nursery, it is not possible to draw any conclusion and hence the trial has been repeated during 1987 following the same set of treatments at a different site, inside the farm. Percentage of buddable plants under each treatment was recorded at the end of the season.

6. DENSITY CUM NUTRITIONAL TRIAL IN SEEDLING NURSERY

This trial also was started in 1986 with a view to finding out the optimum density in seedling nursery and also the influence of three doses of nutrients on growth of seedling rubber. The data pertaining to 1986-87 has been collected. A preliminary analysis of the data indicated that a density of 188 plants per bed, ie. a spacing of 30×25 cm is the ideal one. However, for confirmatory purpose the trial was laid out again during August 1987.

7. COMPARISON OF DIFFERENT SOURCES OF PHOSPHATIC FERTILIZER IN SEEDLING NURSERY

This trial was taken up with the main objective of comparing two sources of rock phosphate mainly available in this region namely Purulia Rock Phosphate and Mussoorie Rock Phosphate and for comparison, one soluble source of phosphorus, Super Phosphate, also was considered. The trial was started during October 1987 in the seedling nursery. It is proposed to continue the experiment for two more seasons.

8. SOIL MOISTURE NUTRIENT INTERACTION IN *HEVEA*

This trial was taken up with a view to monitor the influence of four moisture regimes (1/3 bar, 1 bar, 3 bar and 15 bar), factorial combinations of three nutrients (3 levels of N, 2 levels of P and 3 levels of K) and their interaction on the growth of immature rubber. Due to the nonavailability of glazed pots, large size polythene bags (1000 gauge) were used

which could easily permit growth of plants for two years. Moisture levels are controlled by frequency of irrigation. A polythene shed had been provided to cut the possibility of rain water seeping in. Apart from the routine morphological parameters, parameters on soil plant atmospheric continum, nutrient dynamics etc., also are proposed to be monitored periodically. The trial was laid out in December 1987.

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9. FORMS OF PHOSPHORUS AT THE IMMATURE PHASE

This trial was laid out to compare the efficiency of different sources and combination of phosphatic fertilizer being used for rubber during its immature phase. Table given below shows the girth increment under each treatment during the period from April 1987 to January 1988.

Table–NET. 2. *Girth increment of plants under different sources of P*

Treatments	Girth increment (%)
T_1 (Water insoluble form of phosphorus during the entire immature phase).	42.18
T_2 (Water soluble form of phosphorus for the first two years and water insoluble forms of phosphorus for the remaining part of the immature phase).	47.58
T_3 (50% water soluble form and 50% water insoluble form for the first two years and the water insoluble form during remaining part of the immature phase).	55.36
T_4 (Water soluble form during the entire immature phase).	52.73
T_5 (Control)	51.20

Routine cultural operations were carried out and induction of branching was attempted since the plants had a tendency to grow lanky without branching at the proper crotch height.

10. TRIAL ON NUTRIENT REQUIREMENT DURING THE IMMATURE PHASE OF *HEVEA* PLANTED USING POLYBAG PLANTS

This on-farm trial is being carried out in Tulakona nursery cum demonstration plot of the NRETC. Periodic girth recording and routine cultural operations were carried out. The analysis of the soils collected from the area was also completed. The trial was set up aimed at assessing the nutrient requirement during the early stages of immaturity when the planting material used is polybag plants. Pre and post monsoon manuring and other cultural operations were carried out.

11. PHYSICO-CHEMICAL CHARACTERISTICS OF THE POTENTIAL RUBBER GROWING AREAS IN THE NORTH EASTERN REGION

This study was initiated with a view to characterising the soils in potential areas for rubber growing in the North Eastern Region on a physico-chemical basis. Profile samples were escavated and samples were collected from different states. The samples were subjected to analysis for available nutrients. During the period under report equipping the laboratory to undertake total mineral analysis with respect to macro and micro elements was completed only towards the end of the period. However, analysis of available nutrients had been carried out. Physical investigation of the entire soils also is envisaged as a part of the project. The soil samples collected from the various states of this region for the purpose of offering discriminatory fertilizer recommendation also was made use for a preliminary fertility survey. A summary of the data obtained is given below.

Table-NET-3. *Available nutrient status of potential rubber growing regions in three states of North Eastern Region*

	Organic carbon (%)	AVAILABLE NUTRIENTS (mg/100 g soil)				
		Phosphorus	Potassium	Calcium	Magnesium	pH
Tripura						
0–30 cm	0.71	0.29	4.82	13.77	5.97	4.38
30–60 cm	0.57	0.28	4.33	12.30	5.60	4.36
Assam						
0–30 cm	0.97	0.60	5.29	27.07	11.27	4.85
30–60 cm	0.78	0.34	4.36	19.50	9.65	4.70
Meghalaya						
0–30 cm	1.02	0.82	3.85	17.00	5.97	4.96
30–60 cm	0.73	0.54	3.14	12.76	5.29	4.90

The data indicate extremely low status of available phosphorus. The results obtained from the other field trials also suggest a good response to applied phosphorus. This points to the need for revising the fertilizer recommendation at least with respect to this nutrient. Detailed physico chemical and mineralogical analyses are to be taken up.

12. SOIL MOISTURE DEPLETION PATTERN UNDER DIFFERENT GROUND COVER MANAGEMENT

This trial, laid out in the year 1987, aims at a comparison of two popular leguminous ground cover, *Mucuna* and *Pueraria*, under rubber during its immature phase, with respect to soil parameters. It is envisaged to adopt various management practices like pruning the cover crops during the stress period and mulching. The trial was planted with budded stumps and the establishment of cover crops, plotwise as per treatment, is underway.

13. CLONE TRIAL

The girth of trees, in the clone trial (1979), at 150 cm from the bud union was recorded during May, September, November 1987 and February 1988 (i.e. in different seasons). RRIC 105 recorded the maximum girth whereas Gl 1 gave the minimum girth. The girth and percentage increase seasonwise is shown in Table NET-4. As the trees were affected severely by hail storm in April 1986, it has been decided to open the panel for tapping in this year only though most of the plants attained required girth for tapping.

14. MULTIDISCIPLINARY EVALUATION OF CLONES

This trial was laid out in 1987 with polybag plants. The clones which were used in 1982 physiological evaluation of clones also were incorporated in this trial, thus making total number of clones to 16. Periodic morphological parameters were recorded including plant height, number of flushes, girth and leaf area. The clone PB 235 recorded maximum girth and height. Physiological parameters were also used to be recorded such as leaf water potential, specific leaf weight and relative water content apart from stomatal characteristics and chlorophyll content. The 16 clones under trial are RRII 105, RRII 118, RRII 203, RRII 300, RRIM 501, RRIM 600, RRIM 605, RRIM 612, RRIM 703, PB 86, PB 235, PB 5/51, Tjir 1, PR 107, GT 1, and Gl 1. Routine cultural operations were carried out during the period under report and studies are in progress.

Table–NET-4. *Average girth (cm) and percentage of girth increment*

Clones	Feb 1987	May 1987	% of increase	Sept 1987	% of increase	Nov 1987	% of increase	Feb 1988	%of increase
RRII 5	45.00	46.39	3.08	48.57	4.60	49.52	1.95	50.70	2.38
RRII 105	48.19	49.74	3.21	52.09	4.72	52.90	1.72	53.60	1.15
RRII 118	54.04	55.93	3.46	58.56	4.70	59.94	2.35	60.65	1.18
RRII 203	48.58	50.60	3.58	52.93	5.19	54.28	2.55	54.70	0.77
RRIM 600	48.16	49.55	2.88	52.40	5.75	53.03	1.20	53.36	0.62
RRIM 605	50.69	52.25	3.08	54.40	4.11	55.48	1.98	55.98	0.90
RRIM 703	46.22	47.05	1.79	49.16	4.48	49.86	1.42	50.78	1.68
PB 86	43.86	45.54	3.83	48.27	5.99	49.89	3.35	50.33	0.94
PB 5/51	44.95	46.02	2.38	48.86	6.17	49.43	1.16	49.78	0.70
PB 235	52.18	43.60	2.72	56.04	4.55	57.39	2.40	57.88	0.85
GI 1	40.24	41.21	2.41	73.72	6.09	44.15	0.98	44.62	1.06
GT 1	48.26	49.90	3.41	51.80	3.79	53.14	3.16	53.49	0.09
RRIC 52	50.20	52.75	5.08	54.52	3.36	56.57	3.76	57.48	1.60
RRIC 105	56.47	58.38	3.38	60.71	3.99	62.42	2.81	62.92	0.80
Her 1	42.45	43.67	2.87	45.26	3.64	46.15	1.36	46.60	0.98

15. INDUCTION OF MUTATION

This trial was replanted during 1987 with slight modification. Bud patches of RRII 105 were treated with non-buffered 0.5% and 1% acqueous solution of ethyl methane sulfonate and methyl methane sulfonate with different doses. After treatment the budgrafts were planted in polythene bags. Morphological features of plants were recorded from time to time. Field planting was carried out during August 1987. Recorded the plant height, number of flushes of leaves and girth of the plants during November 1987.

Table–NET. 5. *Average plant height, number of flushes and girth*

Treatments		Plant height (cm)	No. of flushes	Girth (mm)
EMS 0.5%	30 m	34.60	1.98	5.74
	45 m	45.66	2.46	6.00
	60 m	46.19	2.30	6.57
EMS 1%	30 m	49.73	2.48	6.62
	45 m	49.12	2.30	6.26
Control		37.13	2.22	5.92
MMS 0.5%	30 m	52.39	2.52	6.68
	45 m	42.19	2.28	5.78
	60 m	46.39	2.40	6.32
MMS 1%	30 m	40.07	2.33	6.02
	45 m	45.83	2.20	6.49

16. OPTIMUM SEASON FOR BUDDING IN TRIPURA

Green and brown buddings were carried out every week. The initial and final successes were recorded and it is seen (Table NET-6) that success was very high during February and March for green budding, whereas, brown budding showed maximum success during July

Table–NET. 6. *Month wise success (%) of green and brown budding*

Months	Percentage success	
	Green budding	Brown budding
April 1987	95.8	55.83
May	95.8	59.16
June	90.8	69.16
July	67.5	81.66
August	50.8	65.83
September	40.0	41.60
October	10.0	36.66
November	3.3	13.33
December	00.0	0.58
January 1988	45.0	—
February	97.0	—
March	98.0	—

17. SELECTION FROM POLYCLONAL POPULATION

Field planting was carried out during August and plant height, number of flushes of leaves and girth of plants were recorded. The average plant height was 41.88 cm, girth 3.68 mm and number of flushes of leaves 1.96.

18. MOTHER TREE SELECTION

Plus trees selected from three locations were monitored for their yield.

19. EVALUATION FOR STRESS TOLERANT CLONES

Planting for this trial was carried out using polybag plants during September 1987. Morphological and physiological parameters were recorded periodically and routine cultural operations were carried out.

20. EFFECT OF VIGOUR OF STOCK PLANT ON GROWTH OF SCION

The results inidcated that the most vigorous two year old stock plants were superior, in comparison to two year old stocks of medium and low vigour and one year old stock of high, medium and low vigour. To separate the effect of girth and the inherent growth vigour of the stock seedlings on the subsequent growth of scion, hormone analysis will be carried out.

21. RELATIONSHIP BETWEEN GIRTH AND BIOMASS

Field planting for this trial was carried out in June 1987 with two clones, RRII 118 and RRIM 600. Plant height and girth were recorded and destructive harvesting was done. Average build up of biomass per unit girth shows that RRII 118 is having a slight superiority during the initial stage. Routine cultural operations for the trial were carried out.

22. EFFECT OF AGROMETEOROLOGICAL FACTORS ON PHYSIOLOGICAL PARAMETERS RELATED TO GROWTH OF *HEVEA BRASILIENSIS*

The study aims at finding out various interactions between agrometeorological parameters and growth of *Hevea*. Planting of clones RRII 105,RRII 118, RRIM 600, GT 1 and PB 235, with polybag plants was carried out in August 1987 and twice plants were subjected to destruction in total. The data showed that the leaf area was the highest in clone RRII 105, whereas, highest leaf area ratio was recorded for clone RRII 118. Highest leaf area index was denoted for clone RRIM 600. Other parameters like CGR, RGR, MGR etc were also worked out. This trial to study the effect of environmental parameters on photosynthesis and water relations in young plants also was planted using the same clones in August 1987. Morphological and physiological parameters including diurnals of stomatal behaviour were recorded.

Another experiment was carried out with a view to monitoring the influence of irrigation on factors influencing photosynthesis and water relation during the stress period (winter and summer). After field planting with polybags in 1987, irrigation was imposed using a drip irrigation system ensuring uniform supply of water so that the soil moisture is maintained at the same level. Physiological and morphological parameters were recorded periodically.

Effect of artificial shading on interaction between physiological parameters and environmental parameters on young plants was taken up. Field planting was carried out during August 1987. Three levels of shade were provided and physiological parameters recorded regularly.

Diurnals of stomatal behaviour and leaf water potential of growth of sun and shade leaves to assess the differential response of sun and shade leaves of mature plants to environmental variations were recorded.

23. STUDIES ON FLOWERING AND FRUIT DEVELOPMENT IN *HEVEA*

This project aims at studying in detail, the pattern of flowering that occurs in different *Hevea* clones, including aspects such as the time of flowering, duration, time taken from flowering upto fruit maturity, time of 50% flowering, etc. in 15 *Hevea* clones of the existing 1979 clone trial. The information collected will be of much value in future breeding programmes and will also aid in the selection of parents for establishment of polyclonal gardens.

The work was initiated during the month of April 1987. Data on flowering were collected at weekly intervals.

Off season flowering was noticed in three clones namely PB 5/51, PB 86 and RRII 105 in August. From the data collected during 1988, it was seen that PB 86 flowers earlier than others. The observations were recorded at 7–10 days interval and will be continued upto June. The same will be repeated during 1989 also for drawing conclusions.

24. PROGENY ANALYSIS IN *HEVEA*

Seed collection was carried out from the mature trees of 1979 clone trial. Seeds were collected after bagging and were put in the nursery. Due to poor germination and late start of experiment sufficient number of seedlings could not be obtained. However, the seedlings retained were recorded for morphological parameters.

Regional Research Station, Meghalaya

The Regional Research Station, Tura (Meghalaya) was established in 1985. Under this research station there are two experimental farms, one at Ganolgre (600 m) and the other at Darechikgre (1100 m). Both the farms are situated about 13 km away from Tura town. The sites are located within the longitude of 90°E-91°E and latitude 25°N-26°N and climate of this region is sub-tropical. Temperature goes below 10°C during winter season and wintering period is prolonged from November to mid-March.

1. MULTIDISCIPLINARY EVALUATION OF CLONES

Girth of trees in the 1985 trial was recorded during different seasons and summary is given in Table NEM-1. Maximum girth was noted during the period June to August in all clones, except PB 235. RRII 118 and RRII 203 showed comparatively better girth. Girth increment was also higher in RRII 118. The percentage of plants showing leaf shedding during the winter season is shown in Table NEM-2. Maximum number of plants showing wintering was Gl 1 while minimum was in PB 235.

Girth, height, number of flushes of leaves, number of leaves and leaf area were recorded in different seasons in ten clones in the 1986 trial. Average girth and girth increment are shown in Table NEM-3. Maximum girth increase was recorded between June to August in all clones and RRII 118 and RRII 208 showed comparatively better girth.

2. NUTRITIONAL TRIAL IN SEEDLING NURSERY

Under this trial there are 108 plots, under two conditions, viz. sun and shade condition. Fertilizers were applied as per the layout and girth and height of plants were recorded at monthly intervals.

3. ASSESSMENT OF POTENTIAL INTERCROPS

Under this trial 1043 numbers of polybagged plants of RRIM 600 was planted during July 1987. There are eight intercrop treatments with four replicates. The intercrops are paddy, maize, cotton, ginger, pineapple, banana and a mixed crop of paddy with maize. Maize was harvested during the month of August while cotton and ginger in the month of December 1987. The studies are being continued.

Table–NEM 1: *Mean girth and girth increment during different seasons in ten clones of Hevea brasiliensis (at 600 m MSL)*

Sl. No.	Clone	Average girth (mm)				Girth increment (mm) during different seasons			
		Feb 1987	May 1987	Aug 1987	Nov 1987	Mar to May 1987	Jun to Aug 1987	Sep to Nov 1987	Total
1.	RRII 105	70.8	78.1	97.1	111.5	7.3	18.9	14.4	40.7
2.	RRII 118	79.5	88.9	115.2	133.3	9.4	26.2	18.1	53.8
3.	RRII 203	77.9	86.5	114.2	127.7	8.8	27.7	13.5	50.1
4.	RRIM 600	72.5	80.8	105.5	118.5	8.3	24.7	13.0	46.0
5.	RRIM 605	72.7	80.5	106.3	119.2	7 8	25 8	12 9	46.5
6	PB 86	70.8	77.1	95.7	106.8	6.3	18.6	11.2	36.1
7.	PB 235	71.0	83.4	102.1	122.0	12.4	18.7	19.9	51.0
8.	PB 5/51	58.1	65.0	83.7	95.4	6.9	18.7	11.7	37.3
9.	Gl 1	65.6	73.0	93.3	103.0	7.4	20.3	9.7	37.4
10.	GT 1	72.3	80.6	107.2	122.0	8.3	26.6	14.8	49.7

Table-NEM. 2. *Percentage of plants which showed wintering in different clones.*

Sl.No.	Clone	Percentage of plants wintered
1	RRII 105	33.33
2	RRII 118	30.30
3	RRII 203	61.36
4	RRIM 600	68.75
5	RRIM 605	15.78
6	PB 86	71.11
7	PB 235	4.54
8	PB 5/51	60.60
9	GI 1	74.41
10	GT 1	67.44

4. NITROGEN REQUIREMENT UNDER DIFFERENT GROUND COVERS

During the month of July 1987, 1213 numbers of RRIM 600 budded stumps were planted in the field, in which only 721 numbers sprouted and 499 stumps were dried. *Pueraria* and *Mucuna* have been planted as cover crop as per the layout and all the post planting operations were done in time.

5. RUBBER BASED CROPPING SYSTEM

Under this trial, four perennial crops (coffee, orange, tea and rubber) are included. All perennial crops are growing well and operations were done in time.

In another trial, three perennial crops (coffee, tea and orange) were included. These crops were planted in separate block between rows of rubber, besides a treatment with cover crop in patches. The intercrops were planted during the month of July and August 1987. RRII 118 was selected for this trial and planted in polybags, but sprouting was very poor and could not be planted in field.

6. SELECTION FROM POLYCLONAL POPULATION

A total of 1430 numbers of polyclonal seedling stumps were planted in the field during the month of July 1987 and 225 numbers in polybags for gap filling. 71.05 per cent plants in the field and 87.11 per cent in polybags have sprouted. Due to winter and adverse environmental condition 4. 66 per cent plants died in the field and 84. 62 per cent in polybags.

7. EVALUATION OF CLONES FOR STRESS TOLERANCE

Under this trial nine clones are included. 570 numbers of budded stumps were planted in the field and 180 numbers in polybags for subsequent gap filling. 60.36 per cent sprouting was recorded in the field and 65.55 per cent in polybags. However, during winter 8.72 per cent plants were died in the field and 82.9 per cent in polybags.

8. PHYSIOLOGICAL STUDIES

The diurnal pattern of air temperature, relative humidity and photosynthetically active radiation were recorded (November, 1987). The air temperature increased and the relative humidity decreased following the increased photosynthetically active radiation with maximum value at 11.30 hours, when the relative humidity attained the minimum value. Leaf temperature, stomatal conductance and transpiration rate are shown in Table NEM-4.

Table–NEM. 3. *Mean of girth recorded for the period from Nov* 1986 *to Nov* 1987.

Sl. No.	Clone	Mean girth (mm)				Girth increment (mm) during different seasons				
		Nov 86	Feb 87	May 87	Aug 87	Nov 87	Nov 86 – Feb 87	Mar to May 87	Jun to Aug 87	Sept to Nov 87	Total
1.	RRII 5	17.1	17.4	22.3	40.0	43.5	0.2	5.0	17.6	3.5	26.4
2.	RRII 105	18.3	18.8	24.4	45.5	51.5	0.5	5.6	21.1	6.0	33.2
3.	RRII 118	19.6	19.8	27.8	51.1	58.6	0.2	8.0	23.3	7.5	39.0
4.	RRII 208	21.2	22.3	33.5	53.6	59.5	1.0	11.2	20.1	5.9	38.3
5.	RRIC 102	16.1	16.1	23.9	44.6	45.6	0.0	7.8	20.7	1.0	29.5
6.	RRIC 105	15.8	16.3	21.0	42.8	45.2	0.5	4.8	21.8	2.4	29.4
7.	PB 260	18.2	21.8	25.6	44.8	50.1	3.6	3.8	19.1	5.3	31.9
8.	PB 310	14.8	14.8	19.8	40.7	47.4	0.0	5.1	20.9	6.7	32.6
9.	PB 311	15.9	16.7	22.3	40.2	45.8	0.7	5.6	17.9	5.6	29.9
10.	PCK 1	16.4	18.2	23.5	43.0	47.5	1.7	5.3	19.5	4.3	30.9

Table-NEM. 4. *Mean diurnal values of leaf temperature, stomatal conductance and transpiration of different clones during the month of November 1987.*

Clone		SOLAR TIME								
		7.30	8.30	9.30	10.30	11.30	12.30	13.30	14.30	15.30
Gl 1	A	25.10	26.10	27.20	29.60	30.95	29.80	29.00	28.10	26.80
	B	17.85	183.50	119.40	94.90	145.00	202.50	169.50	77.70	62.15
	C	2.15	2.50	1.54	1.80	3.48	4.16	3.62	1.56	1.30
GT 1	A	25.20	25.90	28.35	29.50	30.85	29.80	29.00	28.20	26.50
	B	143.00	187.50	61.40	71.70	100.80	150.00	137.00	66.50	40.60
	C	1.90	2.89	1.16	1.36	2.50	3.54	2.91	1.26	0.67
RRII 203	A	24.60	26.60	26.80	30.20	30.60	29.90	29.00	28.20	27.70
	B	146.00	110.00	82.70	72.70	97.40	123.00	118.50	104.60	112.60
	C	2.64	2.43	1.48	1.94	2.79	2.80	2.66	2.17	2.46
RRIM 600	A	25.50	25.35	28.20	29.20	30.70	29.60	28.90	28.20	26.20
	B	200.70	194.05	53.20	74.40	74.30	118.00	122.20	48.80	42.20
	C	1.89	2.22	0.97	1.08	1.66	2.39	2.14	1.08	0.78
RRII 105	A	25.30	25.60	28.00	29.20	30.10	29.60	29.10	28.20	26.30
	B	150.50	208.50	65.60	80.50	129.00	147.00	161.70	60.40	44.20
	C	1.98	3.08	1.33	1.39	2.13	3.12	2.68	0.98	0.74
PB 235	A	24.50	26.60	26.90	30.20	30.60	29.90	29.10	28.20	27.60
	B	143.50	141.50	129.15	52.70	121.40	88.80	105.45	75.15	61.40
	C	1.67	2.14	1.86	1.25	3.42	2.10	2.30	1.15	1.37

PB 5/51	A	25.30	25.95	27.90	29.50	30.60	29.60	28.90	28.10	26.60
	B	175.50	182.00	103.25	41.30	81.25	156.50	131.50	143.00	66.85
	C	2.50	2.60	1.48	2.38	2.74	3.41	3.03	2.87	1.25
PB 86	A	25.20	25.50	27.90	15.09	30.75	297.70	29.00	28.10	26.45
	B	179.50	203.50	75.85	75.55	114.00	163.00	125.00	59.95	57.90
	C	2.50	2.81	1.32	1.32	2.64	3.64	2.84	1.14	0.86
RRII 118	A	24.90	26.50	26.90	30.10	30.70	30.00	29.10	28.10	27.40
	B	152.00	170.00	101.00	47.25	58.05	118.00	101.05	76.40	77.70
	C	1.90	1.90	1.64	1.25	1.81	2.81	2.39	1.55	1.68
RRIM 605	A	24.90	26.20	27.10	29.70	30.80	30.60	28.90	28.10	27.10
	B	157.00	187.50	95.40	63.70	106.00	143.50	121.50	58.15	92.60
	C	1.85	2.56	1.54	1.68	2.68	3.38	2.77	1.20	0.59

A Leaf Temperature (°C). B = Stomatal conductance. C = Transpiration.

It has been observed that leaf temperature increased with increasing solar time and recorded maximum at noon hours in all clones. The maximum transpiration was recorded at around 12.30 hours in all clones. In all clones maximum stomatal conductance were recorded in the morning hours and minimum around noon hours. RRII 105, RRIM 600 and PB 86 showed more stomatal conductance than other clones. (These values were not recorded at high altitude due to cloudy weather during the month).

The rate of leaf area expansion was recorded in two clones at two altitudes (Table NEM-5). It has been observed that the rate of expansion was higher at the lower altitudes than at the higher altitude in both clones and also that it was higher in RRII 105 than in RRIM 600 at both the altitudes.

Table–NEM. 5. *Rate of leaf area (cm^2) expansion of two clones at two altitudes.*

Clone	Feb-Mar	Aug-Sep	Nov–Dec
RRIM 600			
600 m MSL	2.487	3.063	0.417
1100 m MSL	1.988	0.245	0.160
RRII 105			
600 m MSL	3.355	2.770	0.658
1100 m MSL	2.370	0.422	0.088

Regional Research Station, Mizoram

The Regional Research Station, Mizoram was established at Kolasib in the year 1985 with a research farm attached to it at Tuichuan situated about 13 km from Kolasib town on the Kolasib-Rhaira road, with an area of 50 ha.

1. MULTIDISCIPLINARY EVALUATION OF CLONES

The available girth data show high variability because of highly undulating terrain and as such average values may not be meaningful at this stage.

2. STUDIES ON INTERCROPPING

The trial was laid out in 1987 with banana, paddy, pineapple and maize as inter-crops. The growth of banana and pineapple had been extremely satisfactory.

3. RUBBER BASED CROPPING SYSTEM

This trial was initiated in 1987 to evolve an optimum cropping pattern with rubber and other perennial crops such as orange and coffee under Mizoram conditions. The trial had been laid out and entire planting operations were completed.

4. INFLUENCE OF PHYSIOGRAPHIC FEATURES ON THE GROWTH OF *HEVEA*.

The terrain of Mizoram being highly undulating with steep slopes, the aspect effect is likely to influence the growth of *Hevea*. The trial was laid out to cover all aspects. Other physiographic features and their influence are also being studied.

Apart from the above trials, layout of a polyclonal seed garden with high yielding clones also has been completed during the period under report.

Other Regional Research Stations

In addition to the stations in the North Eastern States, the Institute has established two Regional Research Stations, one in Maharashtra and the other in Orissa. A *Hevea* breeding station has also been established with one substation each in Tamil Nadu and Karnataka. With a view to undertaking location specific research investigations the Institute contemplates to establish more Regional Research Stations and preliminary activities were taken to establish one such station in West Bengal.

Regional Research Station, Maharashtra

The Regional Research Station, Dapchari, is located about 145 km away from Bombay in Maharashtra State and has an experiment farm of 50 ha. In addition to field experiments, budwood and seedling nurseries have been established.

1. DRY-FARMING METHODS IN *HEVEA* CULTIVATION

North Konkan region experiences over seven months dry period during November to middle of June with temperatures ranging from 13°C to 40°C which makes the region marginal for *Hevea* cultivation. In order to impart partial amelioration of moisture stress during immature period, various dry-farming techniques like deep irrigation, pit irrigation, dew catching method, pitcher irrigation and China clay spray on canopy of plants were evolved. Twelve treatments of dry-farming methods were imposed on three year old plants of clone RRII 118 raised with life saving irrigations at the rate of 15 l/plant/week. The plants were divided into three groups according to girth and treatments were laid randomly with single tree single plot design. The treatments were commenced in September 1986. Though statistically not analysed, the data show that among the twelve treatments, effect of deep irrigation is discernable over control plants without irrigation (Table–Dap. 1). During first

Table–Dap. 1. *Growth of Hevea under dry-farming treatments*

Sl. No.	Treatments	Girth (cm) 1986	1987	1988	Girth increment (cm) (1986-87)	1987-88
1.	Deep irrigation I (200 l/15 d)	14.1	20.3	28.5	6.2	8.2
2.	Deep irrigation II (200 l/20 d)	13.9	19.9	27.7	6.0	7.8
3.	Deep irrigation III (200 l/25 d)	14.0	20.1	27.9	6.1	7.8
4.	Pit irrigation I (50 l/10 d)	13.8	20.6	27.5	6.8	6.9
5.	Pit irrigation II (50 l/15 d)	14.0	19.8	27.2	5.8	7.4
6.	Pit irrigation III (50 l/20 d)	13.6	19.1	26.4	5.5	7.3
7.	Dew catching	14.1	19.5	25.8	5.4	6.3
8.	Dew catching - Granite chips	13.4	19.8	26.5	6.4	6.7
9.	Pitcher drips (5 l/d) with polythene mulch	14.0	19.2	26.1	5.2	6.9
10.	Pitcher drips (5 l/d) with organic mulch	13.8	19.4	26.5	5.6	6.9
11.	Organic mulch with China clay spray	14.1	19.2	26.1	5.1	6.9
12.	Control with mulching without irrigation)	14.1	18.9	25.3	4.8	6.4

year, deep irrigation (200 l/15 d) had showed approximately 1.5 cm girth increment over the control, while other treatments like pit irrigation, dew catching methods, pitcher irrigation and China clay spray have showed only marginal extra growth. During second year deep irrigation (200 l/15 d) had maintained the same trend in girth increments, whereas all other treatments did not show much increase in growth when compared to the control. Two years of restricted deep irrigation at the rate of 200 l/plant/15 days resulted in 3.2 cm extra girth over the unirrigated controls.

2. CONTACT SHADING AS A SUBSTITUTE FOR CONVENTIONAL SHADING

Reports had shown that contact shading with reflectants can replace conventional shading in black pepper, (*Piper nigrum* L), a shade loving plant. In non-traditional areas like North Konkan, on account of high ambient temperatures during summer conventional shading with shade baskets made of coconut leaves is essential for one season even when *Hevea* plants are field planted after raising in poly bags.

An experiment was laid out in 1987-88 to evaluate the effectiveness of contact shading of rubber plants in replacing the conventional shading. Budgrafted plants of clone RRIM 600 raised in polybags were planted in the field in June 1987. The treatments included were conventional shading with coconut leaf basket and contact shading with China clay (5, 10 and 15% solutions w/v in water). In contact shaded plants the stems were painted with 20 per cent China clay solution containing gum arabic (4% w/v) as adhesive. The upper surfaces of the leaves were given a coating of China clay by spraying the solution. The design of experiment was RBD with five replicates and nine plants in each replicate. All treatments received irrigation during summer months. Visual recordings were made for number of casualities and greenness of leaves. Girth at 125 cm height was recorded in November 1988.

Table-Dap. 2. *Effect of contact shading on casualties and growth of young Hevea*

Sl. No.	Treatments	No. of casualties	Girth (cm)
1.	Conventional shade	2	9.2
2.	Contact shade - 5% China clay	1	9.6
3.	Contact shade - 10% China clay	1	10.0
4.	Contact shade - 15% China clay	1	10.3

The data show that contact shading is effective. Though not statistically analysed it was found that contact shaded plants showed better growth. There was no symptom of sun scorch in the contact shaded plants. The leaves of plants contact shaded with 15% China clay were comparatively more green over other treatments. Ten per cent China clay spray can be considered sufficient.

Regional Research Station, Orissa

The Regional Research Station, Orissa, is under establishment at Annapurna Village, Dhenkanal District, about 11 km from Kamakhyanagar, over an area of 40 ha. An area of 8 ha was brought under experimental planting, but due to reasons beyond control around 60% of the plants were lost. About 15000 assorted seedlings and 5000 seedlings from polyclonal seeds were maintained in the nursery. Two ponds were opened for irrigation purposes and action has been initiated for opening a tube well. The area could not be properly fenced as the land lease agreement is yet to be executed.

Hevea Breeding Station

The Hevea Breeding Station of the Rubber Research Institute of India has two sub-stations, one in Karnataka and the other in Tamil Nadu. The substation in Karnataka is located at Nettana, about 100 km away from Mangalore and has an area of 50 ha. One field experiment on yield cum exploitation methods was laid out. A small area has been planted with polyclonal seed materials, with a view to having selections from them. A source bush nursery of promising clones as well as a seedling nursery for raising stock plants were also established. The experimental areas were properly maintained and cultural operations were carried out timely. Preliminary work for the establishment of a meteorological observatory was in progress. Action has been initiated to provide an electric fencing system for the experimental farm. Action was in progress for the 1988 planting programme, to lay out a field experiment on ortets, selected mostly from small holdings, as well as for further planting on clone cum exploitation methods. Planting materials required for this purpose have been raised.

The substation in Tamil Nadu is located at Paraliar, approximately 40 km away from Nagercoil and has an area of 23. 1 ha. Planting has been undertaken for establishing a breeding orchard with 25 selected clones. A seedling nursery and a source bush nursery were also established. A few plants from the seedling nursery, which apparently tolerated flood situation, were selected for further multiplication and observations. Cultural operations were carried out timely and the area has been provided with barbed wire fencing.

Agrometeorology Unit

1. WEATHER CONDITIONS AT EXPERIMENT STATIONS

The general weather conditions during 1987 at RRII and its Regional Research Stations are summarised and presented in figure Agromet. 1.

Contribution of the North-East monsoon during October and November was more at Chethackal than at Kottayam. However, the evaporative demand of the atmosphere (1589 mm) was same at both the locations. In July only 182 mm of rainfall was received at Kottayam and Chethackal which is the lowest recorded during the past 30 years. At Dapchari (Konkan region of Maharashtra) there was nine months continuous rainless period, resulting in a water deficit of 1074 mm, whereas the water deficit at Chethackal and Kottayam were 307 mm and 358 mm respectively. At Agarthala (North-East region) there was only marginal drought conditions due to uniform rainfall distribution.

2. AGROCLIMATIC ASPECTS OF RUBBER CULTIVATION

The available meteorological data from traditional and non traditional regions are being collected from the Archives of India Meteorological Department, Agricultural Universities, State and Central Agencies, etc.

The climatic water balance diagrams at some locations of Orissa State are illustrated in figure Agromet. 2. At most parts of Orissa drought intensity was more than that in

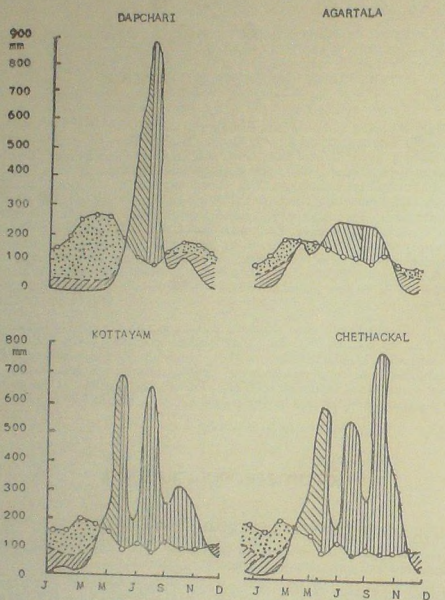

FIG. AGROMET 1. WATER BALANCE CONDITIONS DURING 1987 IN DIFFERENT EXPERIMENT STATIONS

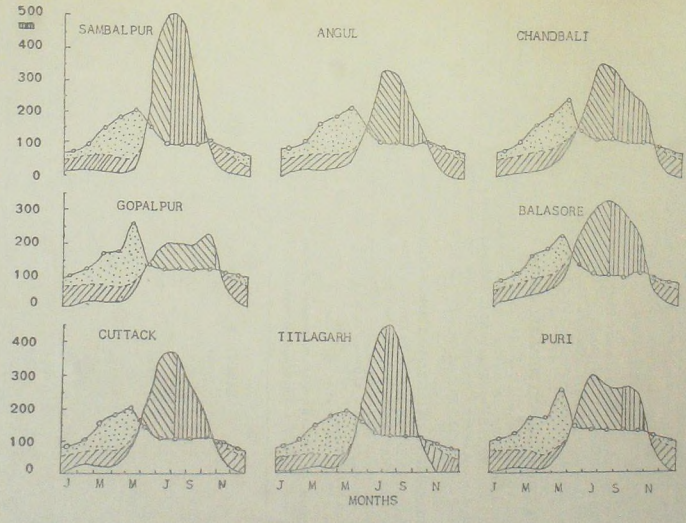

FIG. AGROMET 2. THORNTHWAITE'S CLIMATIC WATER BALANCE DIAGRAMS OF ORISSA
(Legend as fig. Agromet - 1)

traditional areas and at some places it was comparable to that of Palghat. The index of moisture adequacy shows that the soil moisture availability in rainfed conditions are below 80% in an year. High temperatures of the order of 46 to 48°C and mean wind speeds of 25 km were recorded. However, with adequate agronomic practices rubber cultivation could be successfully undertaken in Orissa.

The components of climatic water balance model (1961–87) of traditional rubber growing belt are furnished in table Agromet.1. The characterisation of daily rainfall receipt at Kottayam (Table-Agromet. 2) indicates that the possibility of getting more than 50 mm per rainy day was highest in the monsoon, followed by post monsoon season.

3. STUDIES OF CROP WEATHER RELATIONS

Simple correlations with 12 weather parameters on seasonal basis with yield of RRII farm indicated that some of them have significant impact on yield. Studies of monthly rainfall and crop yield at different lag periods are summarised in table Agromet. 3. Heavy rains during monsoon season was responsible for the low yield during this period. Rainfall in general had positive effect on yield only after one to two months.

4. ESTABLISHMENT OF AGROMETEOROLOGICAL OBSERVATORIES

Arrangements are being made to establish Regional Meteorological Observatories at Keeriparai (Kanyakumari District) and Neettana (South Canara District). Action is in the final stage for procuring an area at Mundakayam region. Two observatories in Meghalaya were established. Action is in progress for the establishment of observatories at Assam and Mizoram.

Table–Agromet. 1. *District wise components of water balance of rubber under different agroclimatic conditions of Kerala.*

District	Rainfall (mm)	Water requirement (mm)	Water deficit (mm)	Water surplus (mm)	Index of moisture adequacy (%)
Trivandrum	1696	1412	81	334	94.3
Quilon	2535	1336	52	1251	96.1
Alleppey	2629	1349	75	1355	94.4
Kottayam	2566	1557	126	1135	91.9
Iddukki	2586	1336	100	1350	92.5
Ernakulam	3021	1335	101	1788	92.4
Trichur	2904	1440	217	1681	84.9
Palghat	2333	1546	257	1044	83.4
Malapuram	2843	1478	231	1596	84.4
Kozhikode	3343	1412	197	2128	86.0
Cannanore	3354	1414	267	2371	81.1

Table–Agromet. 2. *Percentage distribution of daily rainfall at Kottayam* (1956-87)

Month	Rainfall (mm)				
	Less than 2.5	2.6-10.0	10.1-20.0	20.1-50.0	50.1 and above
January	96.57	1.61	1.11	0.71	0.00
February	92.98	3.57	1.00	1.56	0.89
March	88.14	5.31	3.33	2.91	0.31
April	70.42	10.94	9.17	7.71	1·77
May	60.69	13.71	8.57	12.30	4.74
June	24.27	20.83	18.13	25.31	11.46
July	26.41	19.66	19.25	24.19	10.40
August	37 20	22.48	17.24	17.04	6.05
September	52.50	20.73	10.21	12.29	4.27
October	53.33	17.84	13 21	11.59	4.03
November	64.27	13.13	10.00	9.48	3.13
December	89.51	4.84	3.12	2.02	0.50

Table–Agromet. 3. *Simple correlation coefficients showing the influence of rainfall on the heterogeneous crop yield of Hevea at Kottayam.*

Month	Same month	Next month	Second month
January	–0.2386	0.2286	–0.0599
February	0.0536	0.1499	0.5361*
March	0.1562	0.5348*	0.4253
April	0.3450	0.2979	–0.2427
May	0.0551	–0.0789	–0.7367**
June	–0.2910	0.6704**	0.3780
July	–0.3707	–0.0578	–0.0686
August	–0.5521*	–0.2599	–0.5112*
September	–0.5852*	–0.4013	–0.1724
October	0.0417	0.3424	0.5440*
November	0.0783	0.2730	–0.3009
December	0.4378	0.1493	–0.4817

*Significant at 5% error
** Significant at 1% error

Library and Documentation Centre

The Library maintained a good collection of documents on rubber and related areas. The collection was reclassified, catalogued and organised with a view to having computerised information retrieval. The total collection of books exceeded 19,900 and the bound periodicals 13,100. The library subscribed to about 600 periodicals.

Various services were provided based on the information intake. The Library and Documentation Centre also organised translation of articles, compilation of weekly price consolidates, publication of Rubber Alert, Rubber Digest, Recent Additions to RRII Library, etc. with a view to disseminating the right information to the right user at the right time. As part of information dissemination, about one lakh copies of different information materials were made by the Reprographic Section, against demand. The facilities and services of the library were also extended to planters, manufacturers and others connected with the rubber industry. Research scholars and students from universities and colleges also utilised the services of the Library. Scientists from other national reserach institutions also visited the Library for consultation and reference.

1987-88

Budget

Sl. No.	Head of Account	Approved Budget (Rs. in lakhs)	Acutual Expenditure (Rs. in lakhs)
	Non Plan		
1.	Pay and allowances	68.59	68.59
2.	Contingencies	20.40	20.40
3.	Other charges (Including RRII Estate & Nursery)	40.66	40.66
4.	Non Plan Schemes	11.35	11.35
5.	Non Plan Projects (CES Chethackal)	37.00	37.01
	TOTAL NON PLAN	178.00	178.01
	Plan		
6.	Plan schemes	25.00	25.69
7.	NERDS Research Component	65.00	45.35
	TOTAL PLAN	90.00	71.04

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S. Visalakshy Ammal, B.Sc.	: Senior Scientific Assistant
C. K. Soman	: Assistant Superintendent (Farm)

RUBBER CHEMISTRY, PHYSICS AND TECHNOLOGY DIVISION

N. M. Mathew, M.Sc, L. P. R. I, Ph.D.	: Deputy Director
Baby Kuriakose, M.Sc, L. P. R. I, Ph.D.	: Rubber Technologist
N. M. Claramma, M.Sc, L. P. R. I.	: Rubber Chemist

P. Viswanathan Pillai, M.Sc.	: Research Assistant
K. T. Thomas, M.Sc, L. P. R. I, M.Tech.	: Research Assistant
K. Mariamma George, M.Sc.	: Research Assistant
N. Radhakrishnan Nair, M.Sc.	: Research Assistant
Jacob K. Varkey, M.Sc.	: Research Assistant
Leelamma Varghese, M.Sc.	: Research Assistant
Benny George, M.Sc.	: Research Assistant
C. K. Premalatha, B.Sc, L. P. R. I.	: Senior Scientific Assistant

ACCOUNT SECTION

S. Rajasekharan Pillai, B.Sc, S. A. S.	: Budget & Accounts Officer
Joy Cyriac, B.Sc, A. C. A.	: Accountant
T. Thanka	: Superintendent

ADMINISTRATION SECTION

C. M. Abraham, B. A.	: Assistant Secretary
B. Lakshmanan	: Administrative Officer
M. C. Santhamma	: Assistant Superintendent

ART/PHOTOGRAPHY SECTION

K. P. Sreerenganathan	: Senior Artist/Photographer

INSTRUMENTATION SECTION

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

DOCUMENTATION/ LIBRARY

V. K. G. Nair, B.Sc, D. Lib. Sc, A. D. I. Sc.	: Documentation Officer
G. Ajithkumar, B.Sc, B. Lib. Sc, A. D. I. Sc.	: Documentation Officer
P. J. Lukose, B.A, B. Lib. Sc.	: Senior Librarian
Mercy Jose, B.Sc, B. Lib. Sc.	: Librarian (Documentation)

STATISTICS SECTION

G. Subbarayalu, M.Sc.	: Statistician
A. Malathy, M.Sc.	: Statistical Officer

EXPERIMENT STATION AT RRII

E. A. Raghavan	: Assistant Superintendent (Farm)

ESTATE WING

T. K. Somanatha Pillai	: Assistant Estate Officer

SECURITY WING

C. K. Abraham, B. A, B.Ed.	: Assistant Security Officer

CENTRAL EXPERIMENT STATION

M. J. George, M.Sc.	: Deputy Director (Experiment station)
Jacob Abraham, B.Sc, M. B. B. S.	: Medical Officer
P. P. John	: Assistant Superintendent
K. Soman	: Assistant Superintendent (Farm)

HEVEA BREEDING SUBSTATION, KARNATAKA

M. D. Issac	: Assistant Superintendent	(Farm)

REGIONAL RESEARCH STATION, MAHARASHTRA

T. Mohankrishna, M.Sc, Ph.D.	: Plant Physiologist	
T. R. Chandrasekar, M.Sc.	: Assistant Botanist	
S. George	: Assistant Superintendent	(Farm)

REGIONAL RESEARCH STATION, ORISSA

N. Reghunathan Nair, B.Sc (Ag.)	: Senior Superintendent	
R. Raveendran	: Assistant Superintendent	(Farm)
K. Bhaskaran Nair	: Assistant Superintendent	

REGIONAL RESEARCH STATION, ASSAM

Radha Raman Sinha, M.Sc (Ag.) Ph.D.	: Deputy Director
Gopal Chandra Mondal, M.Sc, Ph.D.	: Plant Pathologist
Ramphool Singh, M.Sc. (Ag.)	: Research Assistant
Dilip Kummar Daimari, M.Com.	: Junior Accountant

REGIONAL RESEARCH STATION, MEGHALAYA

Anasuya Prasad Thapaliyal, M.Sc, Ph.D.	: Plant Physiologist
T. A. Soman, M.Sc.	: Research Assistant
H. K. Deka, M.Sc, Ph.D.	: Research Assistant

HIGH ALTITUDE RESEARCH STATION, MEGHALAYA

D. Bhuvanendran Nair, M.Sc, Ph.D.	: Research Assistant

REGIONAL RESEARCH STATION, MIZORAM

Varghese Philip, M.Sc (Ag.)	: Research Assistant

REGIONAL RESEARCH STATION, TRIPURA

A. K. Krishnakumar, M.Sc (Ag.)	: Deputy Director
N. Ghosh Hajra, M.Sc, Ph.D.	: Plant Breeder
Dhurjati Chaudhuri, M.Sc (Ag.)	: Plant Physiologist
Sudeshna Ghosh Hajra, M.Sc.	: Research Assistant
Rajeswari Meenattoor, M.Sc (Ag.)	: Research Assistant
Jiban Chakrabarti, B.Com.	: Junior Accountant