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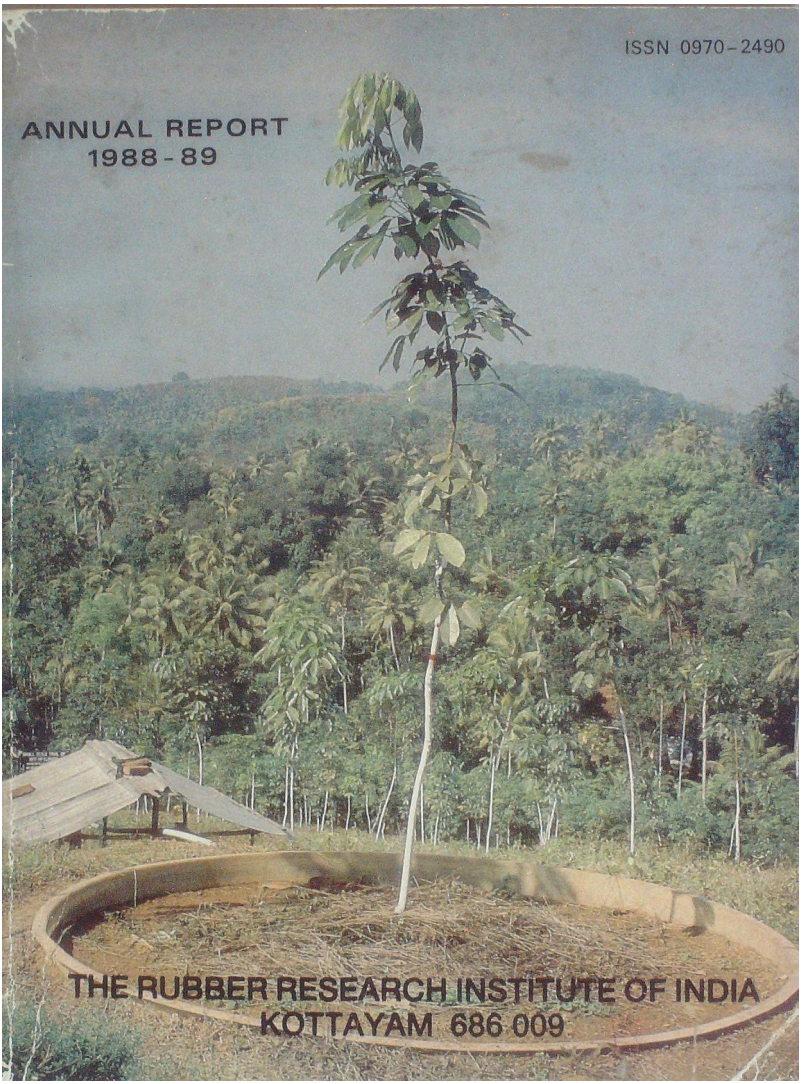

THE RUBBER RESEARCH INSTITUTE OF INDIA
KOTTAYAM 686 009

ANNUAL REPORT
1988-'89

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

Published by

M. R. SETHURAJ,
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KERALA, INDIA.

Cover

Lysimeter (a device to study
water requirement of crop plants)
installed at the Rubber Research Institute of India

Photograph for Cover

K. P. SREERENGANATHAN

JULY 1990

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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 and Training.

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Secretary

Finance & Accounts

K. S. Varma,
Financial Advisor

Research

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Director

Rubber Processing

C. M. George,
Project Officer

Training

Dr. E. V. Thomas,
Joint Director

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12. Dr. B. Sripathi Rao, 116, Cunningham Road, Bangalore – 560 052.

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13. Prof. S. K. De, Dean, Postgraduate Studies, IIT, Kharagpur – 721 302.

14. Dr. D. Joseph Francis, Professor & Head, Dept. of Polymer Science & Rubber Technology , Cochin University, Cochin – 682 022.

VII. Agrometeorology

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

DIRECTOR'S REVIEW

The thrust areas of research continued to be (a) providing adequate research support for developing appropriate agro-technology as well as evolving and evaluating suitable clones for the non-traditional areas, (b) refining the package of practices for the traditional areas aimed at monitary savings in inputs as well as more effective application methods and (c) technological research for product improvement with the ultimate objective of conserving natural rubber.

The Botany Division attempted 12,000 hand pollinations during 1989 season. A test incision method for one year old plants was found to be promising in connection with attempts for early selection of hybrid seedlings. Once perfected, the approach can be useful in reducing the period of breeding cycle. A breeding orchard was set up in the *Hevea* Breeding Station to facilitate hand pollination programmes. Ortet selections continued to receive adequate attention. Cytoplasmic control of male sterility has been observed in hybridization involving male sterile female parents. Anatomical studies revealed the relationship between intraxylary phloem and girth increments.

The tissue culture plants derived out of shoot tip micropropagation method, planted in half hectare of land at the Experiment Station have shown good vigour. The plants, established with ease, indicate the success of the hardening process. In another line of investigation, anther culture, regular appearance of embrioids have been encountered.

Agronomy Division concentrated on further refinement of discriminatory fertilizer recommendation system. More field trials were laid out aimed at regionalisation of fertilizer recommendations. The Division also initiated studies to perfect methods for rapid tissue analysis which when completed, would be highly useful for the mobile soil and leaf testing laboratory. The irrigation experiment, while indicated positive effect on growth during early years with a possibility of reducing immaturity period, did not indicate economic benefit in mature plantations in traditional areas. However, in locations with prolonged drought even mature plantations seem to respond well to irrigation.

Investigations in mycology, pathology, microbiology and entomology were continued by the Pathology Division. A new copper fungicide formulation – Instant Bordeaux – and Bordeaux mixture plus zinc sulphate was found effective against shoot rot. Studies with different cover crops indicated that *Mucuna bracteata* is highly resistant to nematodes.

The Physiology Division carried out detailed investigation of water requirement of *Hevea* of different ages under different agro-climatic situations. The results indicate very heavy water demand and the normal level of irrigation followed in non-traditional areas is proved to be inadequate. The widespread complaint of high incidence of tapping panel dryness in RRII 105 led to compare closely d/2 and d/3 systems. The first 45 months' data indicate that both yield and the incidence of tapping panel dryness were higher under d/2 system. The Institute's present recommendation of d/3 system should hold good unless otherwise

proved after five years of experimentation. Biochemical investigations showed that estimation of leaf lipids will indicate the latex lipid levels and this could be utilised in early evaluation studies. In constraint analysis for yield, moisture stress appeared to be the most important agroclimatic factor in reducing productivity in the traditional areas. Studies conducted at the Regional Research Station, Dapchari indicated that clones with higher tolerance against thermal injury performed better under the stress situations prevalent there. This indicates the importance of thermal injury under high temperature which seems to be more important than soil moisture stress *per se*. The light requirements of various medicinal plants were studied with the objective of introducing them in mature plantations and a few economically valuable species were identified which could be successfully cultivated under mature canopy.

The evaluation of the solar-cum-smoke drier was continued. The efficiency of the solar collectors was found to be 53.6% and the overall efficiency of the drier 13.3%. Based on the reaction conditions already identified for the preparation of epoxidised natural rubber of different mole per cent epoxidation, bench scale batches have been prepared and characterised. Samples of these batches were compounded and their vulcanizate properties studied. The suitability of 1, 2–polybutadiene as a substitute for SBR high styrene resin in microcellular solings was studied. It was found that incorporation of 1, 2–PB contributes to higher output, light weight, higher flex life and lower blooming with slightly inferior technical properties. The use of liquid natural rubber as a reactive plasticiser in nitrile rubber was also studied. The various factors affecting the transparency of latex vulcanizates have been identified. Work under the UNIDO project on truck tyre retreading was started.

Studies on rubber wood, ancillary products, evaluation of planting materials under commercial planting, management aspects, etc. were continued by the Agricultural Economics Division. There is an awareness of the vast potential of rubber wood and the rubber wood industry is worth around Rs. 400 million. Rubber seed oil contributed about Rs. 70 million annually and rubber honey continued to enjoy 40% of the honey production in the country.

The thrust areas of activities of the regional research stations are breeding and identifying clones suitable for the specific agro-climatic conditions, evolving agro-management techniques appropriate to the local conditions, selection of suitable intercrops, watch on diseases and pests and evolving techniques for their control, survey of soil fertility status and other related aspects. Many new field experiments were laid out with these objectives in view and the projects already taken up were continued. Appropriate irrigation in non-traditional areas like Dapchari could narrow down the difference in growth compared with traditional areas.

The Institute started publishing the Indian Journal of Natural Rubber Research.

BOTANY DIVISION

The major areas of investigations in the Botany Division have been tree improvement through conventional hybridisation method as well as ortet selection, clone evaluation, bark and wood anatomy, cytogenetics, floral biology, introduction/collection of germplasm and their conservation and evaluation. The five sections of the Division — Plant Breeding, Germplasm, Propagation, Anatomy and Cytogenetics — continued to concentrate on the respective thrust areas of activity.

1. HYBRIDISATION AND SELECTION

The 1989 hybridisation programme was completed and a total number of 11999 hand pollinations, belonging to 31 cross combinations, were carried out. The final fruit set obtained for the 1988 hybridisation programme was 3.52 per cent and the resultant progenies (532 seedlings) were established in a nursery. The 1986 HP seedlings were test tapped at an age of 24 months for 15 days on alternate daily half spiral system. Girth was also recorded just before test tapping. Simple correlations were computed for the girth (X_1) and the yield by incision test method (X_2) at the age of one year, the girth (X_3) and the test tap yield (X_4) at the age of two years, for 14 families planted in a separate layout. The results (Table-Bot. 1) revealed highly significant positive correlation ($r = 0.51^{**}$), between juvenile yields at an age of one year (incision test method) and that at an age of two years (test tap method). Similarly the girth at one year was significantly correlated with the yield at one year ($r = 0.58^{**}$), the yield at two years ($r = 0.76^{**}$) and with the girth at two years ($r = 0.81^{**}$).

Table–Bot. 1. *Correlations of nursery characters at the age of one year and two years.*

Characters	X_2	X_3	X_4
Girth at one year (X_1)	0.58**	0.81**	0.76**
Yield at one year (X_2)	—	0.50**	0.51**
Girth at two years (X_3)	—	—	0.74**
Yield at two years (X_4)	—	—	—

** $P < 0.01$.

A family wise evaluation based on test tap yield revealed that the cross combinations PB 5/51 × RRII 208, PB 242 × RRII 105 and PB 242 × PB 86 were among the higher yielders. These families showed comparatively higher girth also (Table–Bot. 2).

Out of a total of 449 seedlings evaluated for juvenile growth and yield, 29 per cent was selected and multiplied and a small scale trial is being laid out (Table–Bot. 3).

These seedlings recorded a test tap yield above the population mean i.e., 7 g per plant per 15 tappings. All the selected seedling genotypes also recorded high juvenile yield at the age of one year.

Table-Bot. 2. *Mean girth and juvenile yield at an age of two years.*

Family	Characters at two years	
	Girth (cm) $\bar{x} \pm$ SE	Test tap yield (g/15 tappings) $\bar{x} \pm$ SE
RRII 105 x RRII 118	16.40 ± 0.63	6.50 ± 0.70
RRII 105 x RRII 208	14.59 ± 0.60	7.03 ± 0.77
RRII 105 x PB 86	14.64 ± 0.66	5.33 ± 0.83
RRII 105 x PR 107	14.07 ± 0.76	6.83 ± 0.78
RRII 105 x PB 217	15.21 ± 0.69	5.96 ± 0.84
RRII 105 x PB 5/51	14.59 ± 0.76	6.95 ± 1.34
RRIM 600 x RRII 33	13.21 ± 0.48	4.23 ± 0.60
RRIM 600 x RRII 203	14.46 ± 0.64	6.50 ± 1.25
RRIM 600 x PB 235	12.96 ± 0.67	6.02 ± 0.90
RRIM 600 x G1 1	15.11 ± 0.47	6.50 ± 0.57
PB 5/51 x RRII 208	16.40 ± 0.97	11.13 ± 1.65
PB 242 x RRII 105	17.70 ± 0.96	10.44 ± 1.39
PB 242 x PB 86	16.50 ± 0.92	9.82 ± 1.39
IAN 45/873 x RRII 105	14.23 ± 0.79	5.47 ± 0.63
Population Mean	15.01 ± 0.71	7.05 ± 0.97
RRII 105 (control)	13.48 ± 0.69	8.20 ± 1.24
	C. V. 19.52	C. V. 42.11

Table–Bot. 3. *Details of selections based on juvenile yield.*

Family	No. of selections with test tap yield > 7 g.
RRII 105 x RRII 118	13 (9.92)
RRII 105 x RRII 208	12 (9.16)
RRII 105 x PB 86	6 (4.58)
RRII 105 x PR 107	7 (5.34)
RRII 105 x PB 217	9 (6.87)
RRII 105 x PB 5/51	7 (5.34)
RRIM 600 x RRII 33	2 (1.53)
RRIM 600 x RRII 203	7 (5.34)
RRIM 600 x PB 235	5 (3.82)
RRIM 600 x Gl 1	7 (5.34)
PB 5/51 x RRII 208	16 (12.21)
PB 242 x RRII 105	15 (11.45)
PB 242 x PB 86	19 (14.50)
IAN 45/873 x RRII 105	6 (4.58)
Total	131 (100)

(Figures in parenthesis indicate the percentage over the total progeny selected)

Field planting of 174 progenies of the 1983 hybridisation programme, along with their parents, controls and a few ortets, was taken up in an area of 8.1 ha at the Kerala Agricultural University Campus, Vellanikkara. Among the 1982 HP progenies, planted in 1985 for testing, during third year of growth the family RRII 105 × RRIC 100 recorded maximum girth (Table–Bot. 4) during 1988–89.

Table–Bot. 4. *Mean girth of HP progenies.*

Combination	Mean girth (cm)
RRII 105 × RRIC 100	27.74 ± 0.39
RRII 105 × PR 107	24.58 ± 1.50
RRII 105 × PB 5/51	22.57 ± 1.21
GT 1 × RRIC 100	25.69 ± 0.54
GT 1 × RRII 105	23.33 ± 0.68

A breeding garden, consisting of 25 clones, was laid out and established at the *Hevea* Breeding Sub-station in Paraliar (Tamil Nadu).

2. ORTET SELECTION

Under ortet selection programme, three small scale trials involving 63 ortets were laid out at Cheruvally estate. Ortet selection programme at Boyce estate yielded 43 new clones which recorded promising yield. These clones were vegetatively multiplied. Action is being taken to lay down two small scale trials, one comprising 36 clones in a simple lattice design with four replications and the other with 13 clones in an RBD with three replications (with clones RRII 105, RRIM 600 and GT 1 as controls). Four rounds of yield recording of 199 selected mother trees were carried out in Koney estate. Based on yield data of different seasons, 50 trees were finally selected for further multiplication. As a result of preliminary screening of 657 ha at Kodumon estate, 75 apparently promising genotypes were chosen for further observations and recording of yield.

3. SPECIAL TECHNIQUES IN BREEDING

Observations on colchinie treated plants belonging to 15 clones were continued. The VM 6 generation of a few continued to show morphological variations. The trees in the 1982 trial on polyploids were opened. The progenies of the genetic variant showing dwarf nature were budded with RRII 105 and the budgrafted plants were raised in polybags for further observations. The four types of progenies were also multiplied and the budgrafted plants were planted at the RRII experiment station as an observational trial.

4. EVALUATION OF CLONES

Regular recording of characters from the various large scale as well as block trials was continued. Table-Bot. 5 indicates the performance of clones in the 1968 large scale trial of RRII clones comprising five primary clones, four secondary clones and Tjir 1 (control). RRII 112 recorded the highest yield during the first five years. RRII 119 and RRII 108 recorded the highest yield during sixth to tenth year, while yield over 10 years revealed RRII 108, RRII 112 and RRII 119 as the highest yielders. RRII 2 recorded the highest girth increment on tapping.

Yield and secondary characters of nine RRII 100 series clones in a trial were tabulated and processed. Data on yield during the first five years of tapping, vigour before and after tapping, thickness of virgin and renewed bark, yield depression during wintering and incidence of diseases and wind damage revealed wide variations with respect to the different characters studied (Table-Bot. 6). Among the clones RRII 105 out-yielded all others. RRII 105 recorded the highest annual yield among the eleven clones under testing at Manikkal estate (Table-Bot. 7), during the fourth year of tapping.

Table–Bot. 5. *Performance of clones in trial.*

Clone	Parentage	Mean yield in g/tree/tap			Yield depression due to wintering as percentage of mean yield	Mean girth in cm.		
		Yield for the first 5 years	Yield for 6th to 10th years	Yield over 10 years		Girth at opening	Girth at 10th year of tapping	Mean annual girth increment
RRII 1	Primary clone	41.05	42.53	41.81	8.75	54.99	89.56	3.46
RRII 2	Primary clone	36.28	41.21	38.75	21.05	40.40	84.46	4.41
RRII 19	Primary clone	39.19	55.76	47.48	20.31	33.02	85.79	3.28
RRII 20	Primary clone	43.81	43.92	43.87	20.33	48.26	84.03	3.58
RRII 21	Primary clone	40.78	48.62	44.71	15.59	44.75	81.81	3.71
RRII 108	Tjir 1 x Mil 3/2	40.78	56.80	48.79	40.25	50.06	84.18	3.41
RRII 112	Mil 3/2 x Hil 28	44.20	52.97	48.59	17.62	52.51	89.55	3.70
RRII 115	Mil 3/2 x Hil 28	35.37	51.61	43.49	21.18	50.22	84.49	3.43
RRII 119	Mil 3/2 x Hil 28	39.61	56.96	48.29	16.82	47.74	82.19	3.45
Tjir 1 (control)	Primary clone	37.78	49.50	43.64	25.76	46.36	88.71	4.24
	General mean	39.89	49.99	44.94	20.82	48.83	85.48	3.67
	S. E.	3.84	4.32	3.65	—	3.82	2.87	0.40

Table–Bot. 6. *Performance of clones in trial.*

Clones	Mean yield over 5 years (g/tree/tap)	Mean yield depression during wintering as percentage of mean yield	Mean girth at opening (cm/tree)	Mean annual girth increment after opening (cm/tree)	Mean thickness of virgin bark (mm/tree)	Mean thickness of 5 years renewed bark (mm/tree)
RRII 101	40.58	43.67 (41.35)	44.22	5.93	11.21	8.04
RRII 103	42.53	32.33 (34.45)	45.08	3.95	11.45	8.66
RRII 105	62.17	33.33 (35.24)	51.08	3.47	11.78	8.71
RRII 106	32.50	26.00 (30.52)	47.17	4.68	10.93	8.16
RRII 107	33.97	42.67 (40.77)	48.02	4.18	10.49	7.50
RRII 114	33.60	31.67 (34.22)	50.88	5.47	11.02	7.95
RRII 116	42.95	23.67 (29.03)	52.65	5.18	10.54	7.24
RRII 151	30.51	51.67 (45.95)	44.20	4.74	11.18	7.80
RRII 153	37.37	47.33 (43.47)	44.51	4.28	10.68	8.09
Tjir 1	35.32	62.33 (52.14)	47.89	4.30	10.61	7.69
S. E.	2.71	1.88	1.97	0.39	0.38	0.35
C. D.	8.05	5.58	5.85	1.16	—	—

Figures in parenthesis indicate the corresponding transformed figures (angles). S. E. and C. D. are for these figures only.

Table–Bot. 7. *Performance of clones during the fourth year of tapping.*

Clone	Parentage	Yield (kg/ha/yr)
RRII 1	Primary	1080
RRII 5	Primary	1131
RRII 102	Tjir 1 x Gl 1	1446
RRII 105	Tjir 1 x Gl 1	1627
RRII 118	Mil 3/2 x Hil 28	1080
RRII 203	PB 86 x Mil 3/2	1591
RRII 206	Mil 3/2 x AV 255	1113
RRII 208	Mil 3/2 x AV 255	1591
RRIC 102	RRIC 52 x RRIC 7	1462
GT 1	Primary	1075
RRIM 600	Tjir 1 x PB 86	912

Of the two clones RRII 105 and RRIM 600 planted at Myladi, RRII 105 recorded an average yield of 1747 kg/ha/yr in comparison to RRIM 600 which recorded 1335 kg/ha/yr over a period of 9 years. At Chittadi estate, Mundakkayam, Ch 153 recorded 1069 kg/ha/yr whereas GT 1 recorded 915 kg/ha/yr during the sixth year of tapping. Ch 153 was also more vigorous (65.05 cm) compared to GT 1 (62.36 cm) as shown by the mean girth during the 13th year.

Among the twelve clones in the trial at Chithalvetty estate, RRIC 52 recorded maximum girth (Table-Bot. 8) four years after planting.

Table–Bot. 8. *Twelve clone trial at Chithalvetty.*

Clone	Girth in cm	Clone	Girth in cm
RRII 1	24.08	019	22.98
RRII 43	24.27	RRIC 52	38.38
RRII 44	29.21	PB 235	33.19
RRII 105	29.12	PB 260	34.46
RRII 300	31.50	PB 310	25.98
018	32.04	PB 311	31.81

In an observational trial at Iymkompu RRII 43 showed comparatively better girthing (Table–Bot. 9) four years after planting.

Table–Bot. 9. *Observational trial at Iymkompu.*

Clone	Girth in cm
RRII 43	29.77
RRII 44	25.71
PB 311	27.95
RRII 300	21.65
RRII 105	21.29

At Chittadi, polybag planting of seven modern clones was taken up for laying out a block trial during the ensuing season. Three new block trials were laid out with selected modern clones at Malankara (8 clones), Koney (8 clones) and Venchempu (9 clones). Field planting of six selected clones was done for an observational trial at Coonoor. Budded stumps of four selected clones were planted in polybags for an observational trial at UAS regional station at Brahmavar. One hundred and fifty budded stumps each of 27 selected modern clones were planted in polybags and a polybag nursery was established for experimental planting at RRII during 1989 season.

5. ESTIMATION OF GENETIC PARAMETERS

Among the three families of progenies raised from seeds resulting from open pollination and planted during 1986, progenies belonging to Tjir 1 recorded highest mean girth (15.55 cm). The progenies belonging to GT 1 and RRIM 600 origin recorded a mean girth of 14.57 cm and 13.97 cm respectively. Progenies belonging to ten families were maintained in the field and casualties were supplied. Open pollinated progenies belonging to fourteen families were raised in a ground nursery to lay down a field trial in Karnataka.

6. INTRODUCTION, COLLECTION AND CONSERVATION OF GERMPLASM

Introduction of Brazilian germplasm was continued. 1500 genotypes were introduced and multiplied during the period. The materials belong to different diversity centres of the Amazonia (Table–Bot. 10).

Table–Bot. 10. *Introduction of Brazilian genotypes*

Place of origin	No. of genotypes introduced	No. of genotypes survived
Acre	677	638
Rondonia	744	709
Mato–Grosso	67	64
Mixed seedlings	12	12
Total	1500	1423

Efforts are being made to introduce the remaining genotypes and the lost materials from RRIM germplasm centre. The introductions of 1987, raised in polybags, are being maintained carefully in the nursery. Descriptors for evaluation at the source bush nursery stage are being finalised.

7. EVALUATION OF GERMPLASM

The three germplasm gardens established in 1976, 1979 and 1981 have been maintained and observations were recorded. The old popular clones of the gardens were utilised for breeding experiments in 1988. Garden III was opened for tapping.

Yield data from Garden I, for the year 1988 showed that out of the 51 clones 23 gave an yield above the field average (41.59 g), but none of them reached the level of the control (Table–Bot. 11) during the third year of tapping.

Table–Bot. 11. *Yield (g/t/t) of clones in germplasm garden during third year of tapping.*

Clone	Yield g/tree/tap	Clone	Yield g/tree/tap
PB 215	56.83	PB 6/50	46.55
PB 252	63.04	Gl 1	42.93
PB 28/186	66.24	Ch 32	46.13
PB 253	57.41	LCB 1320	51.26
PB 230	50.41	GT 1	45.96
PB 206	46.02	Ch 153	43.27
PB 242	48.82	AVT 73	44.02
PB 235	69.21	Dj 7	49.59
PB 5/63	51.65	Ch 26	47.04
PB 217	62.41	Tjir 1	49.93
PB 5/76	49.35	Ch 2	45.04
PB 5/60	47.08	RRII 105	74.58

8. CYTOGENETICAL INVESTIGATIONS

Detailed meiotic studies were carried out in the hybrids of two cross combinations involving GT 1 as the female parent and RRIC 100 and RRII 105 as the male parents. All the male flowers produced on clones established from F_1 progenies were totally devoid of fertile pollen indicating cytoplasmic male sterility. The cytoplasmic control of male sterility is the first report in *Hevea brasiliensis*.

Pollen morphology of three species of *Hevea*, namely *H. brasiliensis*, *H. benthamiana* and *H. spruceana* was studied after acetolysis. A total of fifty pollen grains, five each from ten slides, were selected for measurement of pollen characteristics and the data were statistically analysed (Table–Bot. 12). There is significant differences in pollen morphology

among the three species. The pollen size of *H. brasiliensis* ranged from 33–38 μm x 26-33 μm, that of *H. spruceana* 32–36 μm x 25–29 μm and that of *H. benthamiana* 25–31 μm x 20–26 μm.

Table–Bot. 12. *Morphological characters of pollen.*

Species	Polar diameter (μm)	Equatorial diameter (μm)	Exine thickness (μm)	Pore diameter (μm)
	SE: 0.56	SE: 0.27	SE: 0.10	SE: 0.11
	CD: 1.63	CD: 0.78	CD: 0.29	CD: 0.32
H. brasiliensis	36.20	28.64	4.21	6.24
H. spruceana	34.03	26.60	4.43	5.03
H. benthamiana	28.55	22.28	2.63	3.38
G. Mean	32.93	25.84	3.75	4.88

9. FLORAL BIOLOGY AND FRUIT SET IN *HEVEA BRASILIENSIS*

The experiment to improve fruit set following hand pollination was repeated during the period under report, employing treatments that gave promising results during the 1986 and 1987 flowering seasons. A large number of hand pollinations were carried out under each of the treatments. Fruit counts were recorded two weeks, four weeks, eight weeks and four months after hand pollination (Table–Bot. 13).

Figure 1 presents a comparison of final fruit set under the five treatments employed during the three years of study.

Statistical analysis of pooled data on final fruit set (Table–Bot. 14) revealed that the method of enclosing panicles in a butter paper cover following hand pollination was significantly superior to the conventional method of hand pollination and protecting pollinated flowers with cotton and latex. However, none of the treatments tried could raise final fruit set to more than 5%.

The second experiment aimed at improving fruit set under open pollination was also repeated with six of the more promising treatments. A randomised block design with three replications was employed for imposing foliar spray of nutrients at different concentrations on trees of clone Gl 1 of uniform age.

Table–Bot. 13. *Fruit set under various treatments* — 1988

Treatment	No. of flowers pollinated	Fruit set after pollination							
		2 weeks		4 weeks		8 weeks		4 months	
		No.	%	No.	%	No.	%	No.	%
Conventional method of hand pollination — Control	573	132	23.04	59	10.30	26	4.54	21	3.67
Boric acid : Sucrose	612	60	9.80	46	7.52	35	5.72	23	3.76
Butter paper cover	513	195	38.01*	88	17.15*	49	9.55*	26	5.07
GA3 — 20 ppm	517	94	18.18	81	15.67*	31	6.00	24	4.64
Gandhimati & Yeang (1984)	520	171	32.88*	54	10.38	23	4.42	23	4.42

* Chi-square value for comparison with control significant at 0.05 level.

Table–Bot 14. *Pooled data for 3 years on fruits retained till maturity.*

Treatment	No. of flowers pollinated	Fruits retained till maturity	
		No.	%
Conventional method — Control	1045	30	2.87
Boric acid : Sucrose	977	42	4.30
GA 3 — 20 ppm	901	37	4.11
Butter paper cover	823	41	4.98*
Gandhimati & Yeang (1984)	880	34	3.86

* Chi-square value for comparison with control significant at 0.05 level.

Observations on the mean number of flowering twigs per branch, female flowers per panicle and fruits per branch were recorded from four branches selected at random on each tree. Table-Bot. 15 gives the mean number of fruits per branch, recorded at three intervals after cessation of flowering.

Table-Bot. 15. *Number of fruits per branch at three intervals after flowering.*

Treatment	Mean number of fruits per branch		
	1 month	2 months	4 months
Unsprayed — control	14.67	18.50	9.50
Borax — 100 ppm	28.33	28.17	19.08
Urea — 5%	5.25	9.42	8.00
Urea — 10%	10.17	16.17	11.67
Orthophosphoric acid — 1%	22.75	27.58	18.83
Orthophosphoric acid — 2%	13.17	11.81	8.75
Urea — 10% + Orthophosphoric acid — 10% + Borax — 100 ppm	18.17	23.25	13.33

Spraying trees with Borax at 100 ppm concentration appears to be promising, showing a mean final count of 19.08 fruits per branch.

10. ANATOMICAL (GENERAL) INVESTIGATIONS

Studies on the intraxylary phloem and its association with certain growth characters were continued. Analysis of data collected earlier revealed marked differences of anatomical and growth characters among clones. The number of intraxylary phloem points had significant association with the number of primary xylem points, twig diameter and the rate of girth increment on tapping (Table-Bot. 16). The number of primary xylem points also was correlated with the twig diameter. This trait also showed a positive relationship with the rate of girth increment on tapping though not significant.

Table-Bot. 16. *Correlation among anatomical characters, diameter of one year old twig and the rate of girth increment on tapping.*

Characters	No. of xylem points	No. of intraxylary phloem points	Xylem thickness	Phloem thickness	Diameter of one year old twigs	Rate of girth increment on tapping
Number of primary xylem points	—	0.8158**	-0.1182	0.1370	0.5258**	0.3122
Number of intraxylary phloem groups	—	—	—	—	0.5067**	0.4231*

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

Paraffin blocks of leaf samples and twig samples (each from 60 trees involving ten clones) were prepared and microtomy has been commenced. For early evaluation studies sample collection was made. Epidermis was separated by conventional method. Stained preparations were observed using light microscope. Size and density of stomata of six clones, three of which are drought tolerant and the other three drought susceptible, were recorded. Surface study of *Hevea* was made using scanning electron microscope giving emphasis to the phenology of epicuticular wax and organographic variability of wax pattern and stomatal structure.

Observations were also made on the ontogeny of stomata in *Hevea*. Stomatal development was found to start before completing the leaf expansion.

11. BARK ANATOMICAL INVESTIGATIONS

Under characterisation and screening work, 100 numbers of Brazilian germplasm in the nursery (Table-Bot. 17) and 195 genotypes comprising 19 cross combinations obtained from 1983 hand pollinations (after two years growth) were observed for the number of latex vessel rows and bark thickness.

Table-Bot. 17. *Range of characters (at two years) among the genotypes from different sources.*

Source	No. of latex vessel rows	Bark thickness (mm)
RO/J/05	1.89 — 5.22	1.83 — 3.67
RO/JP/3	1.11 — 4.89	1.67 — 3.89
MT/IT/14	1.67 — 5.11	1.67 — 4.44
General	1.11 — 5.22	1.67 — 4.44

Bark study for identification of anatomical parameters of yield and other secondary characters were continued. Microscopical observations and data collection, with respect to ten clones, at the age of eleven years are being carried out. The data with respect to bark at the age of ten years are being summarised.

Periodic collection of bark samples and recording of bark thickness for investigating the process and extent of bark renewal have been completed and samples are being processed.

12. WOOD ANATOMY OF *HEVEA*

Dimensional studies of wood fibres at different height levels of the tree trunk were completed in the clone PB 86. The average length and width of normal wood and tension wood fibres (gelatinous fibres) were considered separately with special emphasis to positional effect and tree to tree variations. Table-Bot. 18 depicts the mean length and width of normal fibres and gelatinous fibres of wood discs at different height levels.

At all the three height levels increase in length associated with a decrease in width was noticed in normal fibres as compared to those of gelatinous fibres indicating that the tension wood fibres were short and broad. The average fibre length showed significant difference among various height levels of the tree trunk.

Table–Bot. 18. *Mean length and width of normal fibre and gelatinous fibre of wood discs at different heights (disc average).*

Height	TREE – 1								TREE – 2							
	Normal Fibre length (μm)		Gelatinous Fibre length (μm)		Normal Fibre width (μm)		Gelatinous Fibre width (μm)		Normal Fibre length (μm)		Gelatinous Fibre length (μm)		Normal Fibre width (μm)		Gelatinous Fibre width (μm)	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
60 cm	1275.62	10.91	1138.04	11.37	20.56	0.27	26.19	0.29	1287.98	11.61	1235.07	11.13	18.94	0.26	26.63	0.23
210 cm	1207.04	11.37	1060.33	10.26	20.51	0.34	27.43	0.34	1306.80	13.43	1178.35	12.44	17.25	0.21	24.76	0.27
360 cm	1243.20	12.59	1174.29	11.29	19.63	0.26	24.72	0.26	1342.34	11.55	1275.44	11.60	18.05	0.24	26.30	0.25

Table–Bot. 19 illustrates the frequency of occurrence of very short (length upto 1000 micrometer), short (above 1000 upto 1500 micrometer), and long (above 1500 upto 2000 micrometer) fibres in wood discs at 60 cm, 210 cm and 360 cm height positions. The frequency of short fibres was the highest and that of long fibres was the least in all wood discs irrespective of the nature of fibres.

Studies on the average number of pores and area occupied by them in a unit sectional area of wood discs at different height levels along the tree trunk were studied in a tree of PB 86 and this observation is being extended to more number of trees. Preparation of wood samples was done for the study of the anatomical variation between seedling trees and the corresponding budded trees. A comparative study on the incidence of tension wood in seedling trees and budded trees is under progress.

Table–Bot. 19. *Frequency of occurrence (%) of fibre types.*

Height	Tree No.	NORMAL FIBRE			GELATINOUS FIBRE		
		Very short	Short	Long	Very short	Short	Long
60 cm	Tree 1	7.60	82.80	9.60	21.20	77.20	1.60
	Tree 2	10.80	83.20	6.00	8.40	84.00	7.60
210 cm	Tree 1	14.80	82.00	3.20	33.34	66.66	—
	Tree 2	10.40	68.40	21.20	13.50	84.50	2.00
360 cm	Tree 1	11.60	78.40	10.00	15.11	80.45	4.44
	Tree 2	2.00	75.20	22.80	5.33	83.55	11.12

13. PROPAGATION TECHNIQUES

The trial at RRS, Tripura was continued during the period. Both green budding and brown budding were done every week.

Girth of the plants in the trial on depth of planting was recorded and a summary is given in Table–Bot. 20. It is seen that the control (bag plants) had the maximum girth at about three years of growth.

Table–Bot. 20. *Mean plant height.*

Treatments	Mean girth (cm)
Normal budding, 60 cm tap root	13.57
Budding, 50 cm above collar	13.30
Budding, 30 cm above collar	13.91
Budding, 45 cm above collar	13.50
Normal budding, 45 cm tap root	12.95
Bag plants	16.92

The trial on benchgrafting was repeated during this year also. Benchgrafting was done with five clones. Benchgrafted plants and normally budded plants were planted in bags and maintained properly. Growth characters of the benchgrafted and control plants raised in bags during the last year were recorded. The casualties in the field trial were filled.

14. GENETIC BASIS OF STOCK RELATIONSHIP

Carried out annual girth recording in the trial on genetic basis of stock scion relationship of 14 different treatments with different stock scion combinations. The girth data at the fourth year of growth (Table-Bot. 21) indicates that RRII 203 on assorted stock as well as own stock continued to be the most vigorous stock scion combinations among the different treatments.

Open pollinated seeds of four clones were established in a seedling nursery for diallel budding and field planting in the ensuing season.

Table-Bot. 21. *Girth of different stock scion combinations.*

Stock	Scion	Mean girth (in cm)
RRII 105	RRII 105	22.94
RRII 118	RRII 118	16.95
RRII 203	RRII 203	29.85
RRII 208	RRII 208	21.02
GT 1	GT 1	22.43
Gl 1	Gl 1	20.24
RRIM 600	RRIM 600	21.68
Assorted	RRII 105	21 65
Assorted	RRII 118	16.87
Assorted	RRII 203	30.53
Assorted	RRII 208	21.69
Assorted	GT 1	19.52
Assorted	Gl 1	15.28
Assorted	RRIM 600	20.21

15. HORTICULTURAL MANIPULATIONS

Studies on crown budding of polybagged plants were continued. Crown budding of polybag plants were completed. They were cut back to develop the crown shoot and those which had developed the crown shoot to the appropriate stage were transplanted to the field. The trial was laid out at the RRII experiment station and following numbers of plants were planted in the field.

Table–Bot. 22. *Planting of crown budded plants.*

Treatment	Number planted
Normal budding & cutting back	27
Budded below 2nd flush & cut back	27
Budded below 3rd flush & cut back	27
Normal budding with one flush of crown leaves	12
Normal budding with two flushes of crown leaves	23
Normal budding having 15 cm brown crown shoot	21
Nursery plants crown budded and cut back in situ	36

(No. of plants cut back under each treatment was 36)

16. STUDIES ON EARLY EVALUATION IN *HEVEA*

Data on girth and juvenile yield of 13 clones at an age of two years from the trial on early evaluation for yield revealed that the vigorous clones RRII 6 and RRII 118 recorded higher girth and yield in comparison to the other clones (Table–Bot. 23)

Table–Bot. 23. *Girth and juvenile yield.*

Clone	Girth	Juvenile yield (g) (Mean of 10 tappings)
	Mean ± SE	Mean ± SE
RRII 105	14.26± 0.32	4.69± 0.44
RRII 300	13.77± 0.33	4.24± 0.45
GT 1	13.74± 0.33	3.41± 0.46
Tjir 1	13.46± 0.33	4.23± 0.46
RRII 6	15.20± 0.33	5.24± 0.46
RRII 38	13.56± 0.32	1.53± 0.44
RRII 118	16.55± 0.30	5.18± 0.41
RRII 208	14.04± 0.33	3.19± 0.46
RRIM 501	13.48± 0.33	2.81± 0.45
RRIM 600	14.76± 0.31	4.62± 0.42
RRIM 612	14.52± 0.34	3.46± 0.47
PB 311	14.72± 0.32	4.38± 0.44
HP 20	13.69± 0.33	2.05± 0.45

Similar trend was revealed for the girth and yield data (Table–Bot. 24) at an age of three years also.

Table–Bot. 24. *Girth, panel length and yield at the age of three years.*

Clone	Girth	Panel length	Juvenile yield (g) (Mean of 15 tappings)
	Mean ± SE	Mean ± SE	Mean ± SE
RRII 105	20.24 ± 0.82	12.43 ± 0.42	46.41 ± 4.18
RRII 300	19.82 ± 0.80	12.92 ± 0.41	37.20 ± 4.11
GT 1	21.66 ± 0.82	13.10 ± 0.42	38.24 ± 4.18
Tjir 1	18.82 ± 0.88	12.34 ± 0.45	36.84 ± 4.51
RRII 6	24.31 ± 0.82	15.36 ± 0.42	58.58 ± 3.92
RRII 38	20.37 ± 0.80	13.20 ± 0.43	13.28 ± 4.18
RRII 118	24.80 ± 0.76	14.76 ± 0.40	53.48 ± 4.05
RRII 208	20.25 ± 0.86	12.64 ± 0.48	35.89 ± 4.34
RRIM 501	17.22 ± 0.80	11.78 ± 0.47	26.70 ± 4.34
RRIM 600	20.52 ± 0.76	13.41 ± 0.42	42.64 ± 4.26
RRIM 612	21.37 ± 0.79	13.90 ± 0.42	27.31 ± 4.18
PB 311	20.56 ± 0.78	13.11 ± 0.40	37.26 ± 3.86
HP 20	18.16 ± 0.82	12.02 ± 0.44	19.92 ± 4.42

17. STUDIES ON INBREEDING

During the 1988 flowering season, a total number of 14412 selfing in 3 treatments were attempted in clones RRII 105, RRIM 600, RRII 118 and Tjir 1, along with the observation of fruit set under natural condition. Even though some pollinations were attempted in PB 86, due to the severe attack of diseases, no fruit set was obtained both in self and open pollination. In general it was found that selfing led to reduced seed yield and that the per cent of fruit set varied with the different treatments and clones (Table–Bot. 25). The studies are being repeated.

Table–Bot. 25. *No. of pollinations and per cent fruit set after self and open pollination.*

Clones	SELFING			Open pollination
	Conventional hand pollination	Bagging inflorescence after pollination	Bagging unemasculated panicles	
RRII 105	2484 (1.81)	2087 (0.43)	2707 (0.26)	1110 (0.36)
RRIM 600	1201 (2.50)	600 (0.67)	711 (0.28)	1088 (1.47)
RRII 118	769 (0.13)	Nil	760 (0.13)	932 (0.43)
Tjir 1	1266 (0.24)	763 (0.26)	1064 (0.09)	700 (0.71)

(Values in parenthesis indicate per cent fruit set)

Out of a total of 105 fruits obtained from 1988 selfing programme, 236 seedlings were planted in the RRII Nursery with suitable statistical design.

18. GENETIC DIVERGENCE, PREPOTENCY AND INBREEDING DEPRESSION

This project was initiated during the year under report. The first part is a study on genetic divergence among 42 clones maintained in the germplasm garden at the Central Experiment Station, Chethackal. The trees planted in a randomised block design are now in the fourth year of tapping. Observations on yield and yield components, wintering behaviour, flowering attributes and other secondary characters are being recorded for estimation of genetic divergence. The second part envisages a detailed study of open pollinated seedling progeny of selected clones for identification of prepotent parents. The seedlings have been planted in a suitable statistical layout for observation. The third part envisages observations on selfed seedling progeny of selected clones and estimation of inbreeding depression.

BIOTECHNOLOGY DIVISION

The Biotechnology Division mainly concentrated in perfecting the biotechnological techniques for the generation of elite materials. Cellular manipulations for crop improvement were also in progress.

1. TISSUE CULTURE

Tissue culture derived plants were planted in the field during 1988 planting season in about 0.5 ha. The plants are growing very well and the growth rate is good. All commercial cultivars recommended for planting by the Rubber Board are being tried to suit this *in vitro* propagation system. The *in vitro* requirements of these cultivars varies from one another. At present more tissue culture derived plants are being generated in the Division for subsequent field planting. Simultaneously this tissue culture propagation system is being refined to be converted into a commercial propagation system.

2. ANTHER/POLLEN CULTURE

The use of anther and pollen cultures to produce haploid plants is a technique utilized here for rubber crop improvement. Last year a few plants were regenerated by this technique. During the current year, the same effort was continued. Many embryoid-like structures are already visible in the cultures.

3. SOMATIC EMBRYOGENESIS

Somatic cells in culture may undergo embryogenesis to produce embryos which may grow similar to natural zygotic embryos and produce whole plants. Various explant sources are being tried to induce somatic embryogenesis. This system can be utilized not only as an alternative propagation system but also for *in vitro* manipulations for crop improvement in rubber.

AGRONOMY / SOILS DIVISION

The thrust areas of research in the Agronomy and Soils Division are investigations on nutritional requirements of different high yielding clones of rubber at various stages of growth in different agroclimatic regions, agromanagement practices of rubber, ljke irrigation and soil moisture management, intercropping and crop combinations, weed management and soil conservation. The Division also undertakes follow-up study on discriminatory fertilizer recommendation which has gained wide acceptability among rubber growers. Three regional laboratories and the central laboratory at RRII along with the four mobile soil and tissue testing laboratories cater to the needs of rubber growers in different regions.

1. NUTRITIONAL STUDIES (IMMATURE PHASE)

1.1 The project aims at finding out the nutritional requirement of high yielding clones of rubber during immature phase in different agro-climatic regions. Three field experiments are in progress under this project involving two clones. Six locations were selected for starting new field experiments with the clone RRII 105 during 1989 and planting materials were distributed for this purpose. The experiment at Kanyakumari (Kanthimathy) started in 1986 and the experiments at Punalur (Shaliacary) and Mundakayam (TR & T) started in 1985 were continued. The girth data (two and a half years after planting) do not indicate a clear response to application of any of the nutrients. However, the highest level of potassium (40 kg ha^{-1}) is found to depress growth slightly.

As in the case of girth, much response was not there to the application of P and K, while application of N showed a positive response in girth increment.

The girth observed at four years after planting at Mundakayam indicated that there is response to N upto 60 kg ha^{-1} and to K_2O upto 20 kg ha^{-1} levels, whereas in the case of P there was a negative response. A similar trend was also noticed for girth increment (1987–89).

The mean girth recorded four years after planting at Punalur showed that application of nitrogen and phosphorus has increased girth upto the highest level, whereas, potassium increased the girth only upto 20 kg ha^{-1}. A similar trend was also noticed in the case of girth increment of plants for 1987–88.

1.2 *Evaluation of the effects of two sources of organic manure on soil physical properties and growth of immature rubber.*

The experiment was laid out at TR & T Estate, Mundakayam, to compare the effects of farm yard manure and 'Cake-O-Meal' of early growth of rubber. No significant difference in growth of plants was noticed between the treatments.

2. NUTRITIONAL STUDIES (MATURE PHASE)

The objective of this project is to find out the nutritional requirement of modern high yielding clones during mature phase in different agroclimatic zones.

2.1 Nutritional requirement of different clones in different agroclimatic zones

Eight field experiments were in progress involving three high yielding clones. Among these, the experiment at Trichur (Pudukad estate) started in 1981, was concluded during this period.

2.1.1 Experiment at Calicut (Kinalur estate, clones GT 1 and RRII 105)

Table–Ag. 1 shows that the main effect of any of the nutrient did not appear to follow any definite pattern of influence in yield, during the period under report, in the clone GT 1.

Table–Ag. 1. *Mean yield*, 1988.

	Level of nutrient (kg ha^{-1}) and yield (g $tree^{-1}$ tap^{-1})				
N	Yield	P_2O_5	Yield	K_2O	Yield
0	32.36	0	32.45	0	32.11
20	32.46	20	31.53	30	31.63
40	32.16	40	33.01	60	33.24

Similarly, there was no response in girth (1989) and girth increment (1985–89) as a result of application of fertilizers except that N at 20 kg ha^{-1} resulted in better girth and girth increment (Table–Ag. 2).

Table–Ag. 2. *Mean girth* (1989) *and girth increment* (1985–89).

Level of N (kg ha^{-1})	Mean girth (cm)	Maen girth increment (cm)
0	68.22	9.97
20	69.63	10.39
40	68.14	9.52

Soil samples were collected from the experimental area during the period under report for analysis.

Another trial was laid out with clone RRII 105 during 1988 and the pre-treatment yield and girth recordings were undertaken.

2.1.2 Experiment at Vadakkencherry (Vaniampara estate, clone RRII 105)

The mean yield during 1988 revealed that application of N at 20 kg ha^{-1} gave significantly the highest mean yield during 1988, the second year of the commencement of the fertilizer treatments. However, N applied at 40 kg ha^{-1} resulted in a decline in yield compared to no N application. There was no response in yield to application of both phosphorus and potash. However the highest yield was obtained with 60 kg K_20 ha^{-1} (Table–Ag. 3).

Table–Ag. 3. *Mean yield (g tree^{-1} tap^{-1}1), 1988.*

		Kg N ha^{-1}			
		0	20	40	Mean
Kg $P_2 0_5$ ha^{-1}	0	56.05	67.65	52.81	58.83
	20	58.63	62.31	58.91	57.37
	70	56.23	51.18	58.34	57.82
Kg $K_2 0$ ha^{-1}	0	57.17	59.59	56.82	57.86
	30	56.06	60.37	52.04	56.16
	60	57.67	68.91	53.47	60.02
Mean		56.97	62.96	54.11	

SE = 1.87

CD for comparing N means = 5.50

The absolute girth of trees attained in 1989 and mean girth increment (1988–89) are presented in Table–Ag. 4. Application of N at 20 kg ha^{-1} was found to influence both of these characters. There was a steady increment in girth and girth increment of trees due to phosphorus, whereas, the influence of potassium was inconsistent.

Table–Ag. 4. *Mean girth* (1989) *and girth increment* (1988–89).

Level of N (kg ha^{-1})	Girth (cm)	Girth increment (cm)	Level of P_2O_5 (kg ha^{-1})	Girth (cm)	Girth increment (cm)	Level of K_2O (kg ha^{-1})	Girth (cm)	Girth increment (cm)
0	57.89	5.09	0	58.09	5.02	0	58.79	5.22
20	60.74	5.63	20	58.35	5.31	30	59.24	5.50
40	58.29	5.19	40	60.49	5.59	60	58.90	5.19

2.1.3 Experiment at Thodupuzha (Malaŋkara Estate)

(a) **Clone GT 1**

The mean yield for 1988 is presented in Table–Ag. 5. The data presented above indicate that there was a decline in yield due to application of phosphorus at 20 kg ha^{-1} during 1988, the second year of imposition of fertilizer treatment. The influence of nitrogen and potassium on yield was inconsistent.

Table–Ag. 5. *Mean yield (g tree^{-1} tap^{-1}), 1988.*

		Kg P_2O_5 ha^{-1}			
		0	20	40	Mean
Kg K_2O ha^{-1}	0	42.63	46.11	50.95	46.40
	20	48.68	44.28	46.52	46.99
	60	49.35	41.80	43.17	44.78
Mean		46.89	44.07	46.71	

SE = 0.82
CD for comparing P means = 2.41

(b) **Clone RRII 105**

Table–Ag. 6. *Mean yeild (g tree^{-1} tap^{-1}), 1988*

		Kg N ha^{-1}			
		0	20	40	Mean
Kg P_2O_5 ha^{-1}	0	69.00	67.03	70.67	68.90
	20	63.98	63.31	62.10	63.13
	40	57.18	68.79	68.20	64.56
Mean		63.39	66.21	66.99	65.53

SE = 1.31
CD for comparing P means = 3.85

In the clone RRII 105 (Table–Ag. 6) there was a decline in yield due to phosphorus application at both the levels. Application of both nitrogen and potassium was not seen to affect the yield significantly.

2.1.4 Experiment at Kanyakumari (New Ambady Estate)

(a) **Clone GT 1**

The experiment was started during 1985 and the fertilizer treatments imposed from 1986 onward. The mean yield for 1988 is presented in Table–Ag. 7.

Table–Ag. 7. *Mean yield* (g *tree*$^{-1}$ *tap*$^{-1}$), 1988.

	Kg N ha^{-1}			
	0	20	40	Mean
Kg P_2O_5 ha^{-1}				
0	36.39	39.51	38.26	38.05
20	36.67	37.62	36.14	36.81
40	35.96	38.47	36.76	37.06
Kg K_2O ha^{-1}				
0	37.09	37.35	37.01	37.15
30	36.32	38.30	35.95	36.86
60	35.62	39.95	38.19	37.92
Mean	36.34	38.53	37.05	

Application of nitrogen increased the yield slightly and the highest yield was obtained when it was applied at 20 kg ha^{-1}. Phosphorus application was seen to depress the yield, whereas no definite pattern of influence was noticed for potassium.

(b) **Clone PB 28/59**

It was found that application of phosphorus at both the levels depressed the yield considerably, whereas, the response of nitrogen was inconsistent (Table–Ag. 8). The highest yield was obtained when potassium was applied at 60 kg K_2O ha^{-1}.

Table–Ag. 8. *Mean yield* (g tree^{-1} tap^{-1}), 1988.

	Kg N ha^{-1}			
	0	20	40	Mean
Kg P_2O_5 ha^{-1}				
0	64.85	67.70	68.55	67.03
20	68.36	66.48	65.69	66.84
40	65.30	62.13	65.45	64.29
Kg K_2O ha^{-1}				
0	62.51	63.34	69.61	65.15
30	66.47	64.40	63.76	64.88
60	69.53	68.58	66.32	68.14
Mean	66.17	65.44	66.56	

Soil and leaf samples were collected for nutrient analysis during August 1988 and the work is in progress.

2.1.5 Experiment at Trichur (Pudukad estate, Clone GT 1).

Though there was no significant response in yield due to the application of nitrogen and potash, these nutrients at 20 and 30 kg ha^{-1}, respectively, produced the highest yield (Table–Ag. 9). However, phosphorus caused a decline in yield.

Table–Ag. 9. *Mean yield* (g $tree^{-1}$ tap^{-1}), 1988.

	Kg N ha^{-1}			
	0	20	40	Mean
Kg P_2O_5 ha^{-1}				
0	59.60	61.55	60.68	60.61
20	57.02	58.88	59.35	58.42
40	56.78	64.30	59.19	60.09
Kg K_2O ha^{-1}				
0	55.50	58.57	59.74	57.94
30	61.47	60.96	61.55	61.33
60	56.43	65.19	57.93	59.85
Mean	57.80	61.57	59.74	

Soil and leaf samples were collected from the experimental area during August 1988 and nutrient analysis is in progress.

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

The experiment was done at CES, Chethackal and was concluded during the period under report. The mean yield for 1988 is presented in Table–Ag. 10.

Table–Ag. 10. *Mean yield* (g $tree^{-1}$ tap^{-1}), 1988.

Kg N ha^{-1}	Legume Cover	Kg N ha^{-1}	Natural Cover
0	56.95	0	57.65
20	63.26	40	62.44
40	59.86	80	68.42

The results indicate that application of N above 20 kg ha^{-1} was not advantageous in legume cover area, whereas, there was response in yield to N application upto 80 kg ha^{-1} in the natural cover area. This shows that considerable savings in N fertilizer could be achieved by raising leguminous cover crop during the immaturity period of rubber. The same trend was noticed in the previous years also.

2.3 Multilocation trial on fertilizer use efficiency.

Seven estates were identified for initiating a multilocation trial on fertilizer use efficiency in collaboration with FACT and EID Parry (India) Ltd. Five tapping blocks were identified in each of the estates for this trial. Further action is in progress.

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

The objective of this project is to find out the optimum plant density to achieve early maturity and maximum yield of rubber. Two fertilizer treatments are also included in each plant density to study the nutritional requirement for different densities. The experiment was started at Shaliacary estate, Punalur, in 1985 with the clone RRII 105.

The mean girth of trees was recorded in January 1989 and the mean girth increment during 1987-89 worked out. It is seen that in general, trees do not have additional nutrient requirement with increasing density of population. The highest row to row spacing (6.7 m) recorded a better girth and girth increment compared to the other row spacings. However, the lower plant to plant spacing (3.0 m) gave a slightly higher girth and girth increment compared to the other spacing of 3.4 m. Light interception in the inter and intra row areas was monitored using a quantum radiometer.

4. IRRIGATION AND MOISTURE MANAGEMENT IN RUBBER

Irrigating rubber during summer months could be a means of enhancing the growth of rubber, reducing the rather long immaturity period and increasing yield. As availability of water is very much limited in most of the rubber growing areas during summer, drip irrigation system was adapted for economising the use of water.

4.1 Effect of irrigation on yield-mature phase.

The experiment started at Cheruvally Estate during 1985 was continued. Statistical analysis of the 1988 yield data revealed that there was no significant effect of irrigation during the summer months as given in Table-Ag. 10.

Table-Ag. 10. *Mean yield* (1988).

Treatments	Mean yield 1988 (g tree^{-1} tap^{-1})
Drip irrigation	
5 l tree^{-1} day^{-1}	49.98
10 l tree^{-1} day^{-1}	49.28
15 l tree^{-1} day^{-1}	44.80
20 l tree^{-1} day^{-1}	50.65
No irrigation	41.12
Mean	47.17
S. E.	2.37

4.2 Effect of irrigation and split application of fertilizers on growth of immature rubber.

This experiment was started in Cheruvally Estate during 1987–88. Split application of fertilizers along with irrigation was continued, during January to April, 1988. The mean girth of plants recorded during December 1988 are given below (Table–Ag. 11).

Table–Ag. 11. *Mean girth of plants (December* 1988).

Treatments	Mean girth (cm)
Drip 5 l tree^{-1} day^{-1} + 2 splits of fertilizers	14.85
Drip 5 l tree^{-1} day^{-1} + 6 splits of fertilizers	14.31
Two splits of fertilizers, no irrigation	13.86
Six splits of fertilizers, no irrigation	13.39
Mean	14.10
S. E.	0.38

Statistical analysis of the mean girth in December 1988 did not show any significant difference among the treatments. The experiment is being continued to study the long term effect.

4.3 Evaluation of micro and macro irrigation methods on immature rubber.

This experiment started in a small holding during the summer season of 1988 was continued. The quantity of water applied through drip irrigation was increased to 10 and 15 l plant^{-1} day^{-1} from 5 and 7.5 l plant^{-1} day^{-1} given during the last year. Irrigation was given from 1st January 1989 and continued upto the end of the summer season. The girth recording taken after completion of the irrigation is being analysed.

4.4 Integration of plastic mulches and perfo-irrigation in seedling nurseries.

The experiment was laid out at the Central Nursery, Karikkattoor in November 1988. Two types of plastic mulches, namely 100 gauge HDPE and polythene sheets removed after rain guarding for one season, were tried with subsurface perfo-irrigation. The results are given in Table–Ag. 12.

Table–Ag. 12. *Effect of mulching and irrigation on growth of seedlings and soil moisture content at different depths.*

Treatments	Mean diameter (cm)		Diameter increment (cm)	Percentage of green buddable seedlings (≥0.8 cm dia)	Soil moisture content (%)	
	Pre-treatment	Three months after			0–15 cm	15–30 cm
100 gauge HDPE + perfo-irrigation	0.42	0.82	0.40	34.93	22.09	22.19
Used rainguarding polythene + Perfo-irrigation	0.41	0.81	0.40	56.99	20.06	20.19
Irrigation alone	0.41	0.67	0.26	23.65	14.59	17.63
100 gauge HDPE alone	0.42	0.71	0.29	27.66	15.76	18.27

The results indicate that plastic mulching with perfo-irrigation has increased the diameter and diameter increment of seedlings compared with mulching or irrigation alone. The percentage of green buddable plants was also increased by this treatment. The plots with irrigation alone gave the lowest percentage of green buddable plants. The soil moisture percentage was also the highest in mulching-cum-irrigation treatments compared with either mulching or irrigation alone.

4.5 Integration of plastic mulches and sprinkler irrigation in seedling nursery.

An experiment was laid out at the Central Nursery, Karikkattoor during November 1988 to study the feasibility of three types of plastic mulches as an alternative to conventional plant mulches. The plastic mulches used were 40 and 100 gauge HDPE and used plastic rain guarding (LDPE) material. The results are given in Table–Ag. 13.

Table–Ag. 13. *Effect of mulching on growth of seedlings and soil moisture content at different depths.*

Treatments	Mean diameter (cm)		Diameter increment (cm)	Percentage of green buddable plants (≥0.8 cm diameter)	Soil mositure content (%)	
	Pre-treatment	3 months after mulching			0–15 cm	15–30 cm
100 gauge HDPE mulch	0.39	0.73	0.34	40.73	16.16	17.19
40 gauge HDPE mulch	0.41	0.69	0.28	24.76	18.07	18.45
Used rainguarding polythene	0.43	0.78	0.35	53.79	18.27	17.67
Dry plant mulches	0.41	0.70	0.29	33.26	12.85	16.84
No mulch	0.41	0.61	0.20	9.20	8.57	12.91

It was observed that plants mulched with 100 gauge HDPE and used rainguarding polythene resulted in a higher diameter increment three months after mulching. The girth increment under used rainguard mulching was 75 and 21 per cent higher compared to no mulching and plant base mulched with conventional dry plant mulches, respectively. The percentage of green buddable plants and surface soil moisture content also were the highest in plots mulched by used rainguarding polythene. Observations on micro climate and physiological parameters were also recorded.

4.6 Glass house study on moisture retention and uptake by *Hevea* as influenced by application of "Jalasakthi".

An experiment was undertaken to study the effect of "Jalasakthi" (a polymeric substance) on moisture retention in soil and its influence on growth of rubber. Different doses of "Jalasakthi" with three frequency of irrigation were tried. It was observed, after five months of imposition of treatments, that there was no appreciable change in diameter and height of plants or soil moisture content. Better growth was noticed for plants irrigated once in three days upto five months when compared with daily or weekly irrigation.

5. WEED MANAGEMENT SYSTEMS IN RUBBER

5.1 Herbicide based cover crop establishment in rubber plantation.

An experiment was laid out to evolve a method for the rapid establishment of cover crop, *Pueraria phaseoloides*. A pre-emergence herbicide oxyflourfen (Goal) was applied on clean beds at 96, 240 and 480 g ai ha^{-1} prepared for this purpose. The treatments included single strip, double strip and conventional patch planting of cover crop. In general by strip planting, a higher percentage of spread of cover crop (93 per cent) would be achieved within six months compared to the patch method (70 per cent). The results are being analysed.

5.2 Bio-control of *Chromoleana oderata*.

A technique for large scale rearing of the larvae of *Pareuchaetus pseudoinsulata* for the biological control of the noxious weed, *Chromoleana oderata*, is being attempted.

6. STUDIES ON INTERCROPPING IN RUBBER

The intercropping experiments are in progress. In the observational trial at CES, the growth of cocoa was far from satisfactory. The performance of Sanramon coffee (*Coffea arabica* Var. Sanramon selm 7.3) was also poor. However, the growth of Robusta (*Coffea canefera*) and black pepper (*Piper nigrum*) were satisfactory.

For the intercropping experiment at Nelliyampathy (Palghat district) representing tropical high elevation condition (730 m MSL), electric fencing was done to protect the area from wild animals. Rubber and coffee (intercrop) were planted during 1988. The planting of pepper will be done during the next planting season. The growth of rubber and coffee is satisfactory.

7. STUDIES ON THE AGRO-MANAGEMENT TECHNIQUES OF SOIL AND WATER CONSERVATION IN RUBBER PLANTATIONS

An experiment to study the effect of different agro-management techniques on soil and water conservation was laid out at RRII. Rubber was planted in July, 1988 and the necessary multislot devices to monitor the soil erosion and runoff water were also installed.

8. STUDIES ON WATER REQUIREMENT OF IMMATURE RUBBER THROUGH LYSIMETER TECHNIQUES

A field experiment to study the water requirement of immature rubber by lysimeter was started during 1988 at RRII. Two fibre glass lysimeters (3.5 m diameter and 1.6 m height) provided with tubes for collecting runoff and percolation water were installed and rubber was planted. Periodic measurement of percolation and runoff water was done.

9. FORMS AND METHODS OF FERTILIZER APPLICATION

The project is intended to explore the possibility of efficiency of water soluble and insoluble forms of phosphatic fertilizers on the growth of rubber. Increasing the efficiency of nitrogenous fertilizers by adopting slow-release technology is also aimed at.

9.1 Comparative study on the effect of water soluble and insoluble forms of phosphatic fertilizers on growth of rubber.

The experiment laid out at Boyce Estate, Mundakayam was continued. The results for 1988 is given in Table-Ag. 14.

Table-Ag. 14. *Mean girth increment of rubber as influenced by forms of phosphatic fertilizers.*

Treatments	Mean girth increment (cm) 1985-88
Rock phosphate @ 40 kg P_2O_5 ha^{-1} in 2 splits	29.38
Rock phosphate @ 40 kg P_2O_5 ha^{-1} in 3 splits	29.04
Ammophos @ 40 kg P_2O_5 ha^{-1} in 2 splits	30.54
Ammophos @ 40 kg P_2O_5 ha^{-1} in 3 splits	30.70
Rock phosphate @ 50 kg P_2O_5 ha^{-1} in 2 splits	29.16
Rock phosphate @ 50 kg P_2O_5 ha^{-1} in 3 splits	29.38
Ammophos @ 50 kg P_2O_5 ha^{-1} in 2 splits	30.10
Ammophos @ 50 kg P_2O_5 ha^{-1} in 3 splits	30.61
Control (No phosphorus)	28.44
CD (P = 0.05) 1.02	SE 0.34

The results indicate that application of phosphorus as Ammophos (water soluble) at 40 or 50 kg ha^{-1} has resulted in significantly higher girth increment over the control. However, there was no difference between the levels tried or number of split applications. In general Ammophos appears to be better than rock phosphate.

9.2 Different sources of phosphate for rubber and associated crops.

The project is intended to study the feasibility of using bowl sludge (a waste product from latex centrifuge factory) for manuring cover crops. The results indicate that application of bowl sludge enhanced the uptake of nutrients by the cover crop *Pueraria phaseoloides*.

A field study was also started at TR & T Estate, Mundakayam during 1988 to evaluate bowl sludge as a phosphatic fertilizer for immature rubber.

9.3 Comparison of different nitrogenous fertilizers for rubber seedlings.

The experiment laid out at the Central Nursery, Karikkatoor in 1985 was continued on the same site during 1988 also. The results of soil analysis is furnished in Table-Ag. 15.

Table-Ag. 15. *Total nitrogen, total and available sulphur and pH of soil.*

Treatment	Available S (ppm)	Total S (ppm)	Total N (%)	pH
Ammonium sulphate	256.44	346.67	1.42	4.1
Urea	112.69	166.67	1.65	4.3
50% Ammonium sulphate + 50% Urea	172.99	306.67	1.60	4.2
50% Ammophos + 50% Urea	194.87	263.33	1.49	4.1
SE	24.66	34.65	0.06	
CD (P = 0.05)	74.28	104.38	0.18	N.S.

It was observed that plots applied with ammonium sulphate registered significantly higher amounts of both total and available S as compared with those applied with urea. However, the total N was significantly higher in urea applied plots than ammonium sulphate applied plots. There was no change in soil pH due to the different forms of nitrogenous fertilizers.

The mean diameter and height of plants (Table-Ag. 16) indicate that the mean diameter was significantly higher in ammonium sulphate applied plots than the urea applied plots. But there was no difference in the mean height of plants among the different treatments tried.

Table-Ag. 16. *Plant height and diameter.*

Treatment	Mean diameter (mm)	Mean height (cm)
Ammonium sulphate	14.33	124.18
Urea	11.62	103.26
50% Ammonium sulphate + 50% Urea	12.85	111.53
50% Ammophos + 50% Urea	13.63	120.786
SE	0.59	
CD (P = 0.05)	1.79	N. S.

10. PHYSICO-CHEMICAL AND MINERALOGICAL CHARACTERISTICS OF RUBBER GROWING SOILS

The project aims at characterising the rubber growing soils with respect to chemical, physical and mineralogical properties.

Manganese status of traditional and non-traditional rubber growing soils in India was studied. Soil profile samples were collected from six locations representing traditional and non-traditional rubber growing regions in India and analysed for total and exchangeable manganese content. It was observed that both these forms of Mn were high in Dapchari, Maharashtra region, (1373 and 6 ppm of total Mn and exchangeable Mn, respectively) compared to those in the traditional rubber growing regions. The total Mn was found to be significantly correlated with exchangeable Mn, fine sand, silt and total iron. However, the higher quantities of Mn in soils of Maharashtra may not be problematic as rubber is found to be growing satisfactorily in soils having similarly high Mn status in other countries.

11. POST RECOMMENDATION EVALUATION OF DISCRIMINATORY FERTILIZER APPLICATION

The project intended to evaluate the merits obtained by adoptnig discriminatory method of fertilizer application in rubber estate was continued. Experimental blocks for comparing the yields for discriminatory and general fertilizer application were taken up in Boyce, Lahai, Kundai, Chemoni, Kumbazha and Koney estates. Among the 36 blocks selected, yield was found to be higher in 25 blocks following discriminatory fertilizer application.

12. RESOURCE INFORMATION SYSTEM FOR RUBBER VIA REMOTE SENSING

The toposheets of seven estates (Poonoor, Mooply, Kundai, Boyce, Cheruvally, Shaliacary and New Ambadi) in different agro-climatic regions were procured. They were

reduced to 1 : 50,000 scale by the Kerala State Land Use Board and despatched to Ahmedabad for processing. A methodology for digital analysis of satellite imagery for separating rubber is being developed in collaboration with the Space Application Centre, Ahmedabad.

13. COLLABORATIVE STUDIES

A pulsed nuclear magnetic resonance based rapid method for determining the d. r. c. of ammoniated (one per cent) natural rubber latex was developed by the Spin-echo method with the collaboration of Nuclear Research Laboratory, New Delhi. It was observed that the d. r. c. determined by this rapid technique was comparable with the d. r. c. determined by the standard laboratory method under experimental evaluation.

A collaborative project on guayule cultivation was prepared and the Biocentre, Ahemedabad, was identified for implementing the same.

14. ADVISORY WORK

This Division has analysed 8197 soil and 1905 leaf samples for offering discriminatory fertilizer recommendation to estates and small holdings during the period under report.

MYCOLOGY AND PLANT PATHOLOGY DIVISION

Crop protection is the main field of activity of this Division, which is carried out by Plant Pathology and Entomology Sections. Basic studies of pathogens are made by Mycology Section. Investigations on improving soil fertility with microbes and biological control of pollution are done by Microbiology Section. Crop weather relations including that of diseases are studied by Meteorology Section, which is presently under the administrative control of the Division.

1. ABNORMAL LEAF FALL DISEASE

This disease, caused by *Phytophthora* spp., is the most important leaf disease of rubber in high rainfall areas. This disease debilitate the health of the trees with leaf-fall and die-back of shoot. Various studies are in progress to combat this disease economically.

1.1 Disease assessment.

Very severe disease occurred this year and it prolonged upto the month of September. Heavy leaf-fall was noticed upto an extent of 50% in sprayed areas of susceptible clones.

1.2 Effect of soil fertility on the disease.

Additional dosage of fertilizer was supplied at the rate of Urea 22 kg ha^{-1}, Ammonium Phosphate 50 kg ha^{-1} and mixture of Urea 22 kg, Mussorie Phosphate 50 kg and Potash 17 kg ha^{-1} in 4 locations in two clones, RRIM 600 and PB 86. The results indicate that there was no difference between the treated and the untreated blocks in yield and the extent of defoliation.

2. HIGH VOLUME SPRAYING

High volume spraying is done every year in nearly 65,000 ha mostly small holdings. The cost of spraying is almost double that of low volume spraying. An experiment was conducted in clone GT 1 on the volume of Bordeaux mixture at the rate of 2000, 1200 and 800 l ha^{-1}. The results could not be evaluated as there was frequent rains during spraying itself.

3. SHOOT ROT DISEASE

Shoot rot is a very important stem disease affecting young rubber plants in the nursery and in field upto the third year of growth, affecting normal growth of plants considerably.

In the experiment conducted on the control of this disease in 1988 replanting of clone PB 311, with 11 treatments of different fungicides and one control, it was found that a new

copper fungicide formulation. Instant Bordeaux at 1% and 1% Bordeaux mixture plus 0.5% zinc sulphate, to be most effective. The disease intensity under different treatments are furnished in Table–Path. 1.

Table–Path. 1. *Average disease intensity.*

Treatments	Concentration %	Average disease intensity (%)
Bordeaux mixture	1.0	20.83
Bordeaux mixture	0.5	23.96
Bordeaux mixture + zinc sulphate	1.0 + 0.5	4.17
Bordeaux mixture + zinc sulphate	0.5 + 0.5	18.75
Instant Bordeaux	1.0	2.09
Cobox L	1.0	22.92
Copper oxychloride WP	0.5	6.25
Aliette	0.2	14.59
Foltaf	0.2	44.80
Dithane M. 45	0.2	33.33
Thiride	0.2	39.59
Untreated control	—	55.21

4. EVALUATION OF PANEL/WOUND DRESSING COMPOUNDS

Bark rot disease is not very common in India. It can cause serious damage to the bark in some areas left untreated. Moreover, the recommended organomercurial fungicide is likely to be banned in India due to health hazard. Three new products were subjected to large scale tests and approved for the use as wound/panel dressing compound in rubber plantations.

An experiment was conducted to evaluate the difference between weekly and fortnightly application of the effective fungicides viz., Thiride, Foltaf and Dithane M. 45, against bark rot. Emisan was used as control. The results indicated that none of the treatment was significantly different from the others.

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

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

Yield recording in crown budding experiment at the three locations is being continued. The experiment at Malankara estate is in progress. The bud success in RRII 33 was 76% and in Fx 516 was 82%. Considerable reduction in girth was observed in crown budded plants after one year (Table–Path. 2).

Table–Path 2. *Girth of crown budded plants.*

Crown clones	Girth at 125 cm height (cm)	
	Before budding	1 year after budding
RRII 33	13.00	18.36
Fx 516	13.62	17.93
Control	13.73	23.35

6. CHEMICAL FRUIT THINNING

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. Ethephon at 100 and 600 ppm was tested at two stages of growth of pods for fruit thinning. Pods of size 1.5 ± 0.5 cm and 3.5 ± 0.5 cm were treated. There was no difference in the effect of concentration of Ethephon, but better result was achieved when pods were treated at the early stage of growth.

7. PINK DISEASE

Pink disease is the most important stem disease of rubber during its growth period from the second to the twelfth year. It could be serious when the disease occurs at the forking region of trunk. The disease is widespread in high rainfall areas and in certain clones like RRII 105 and PB 217.

The two carriers of fungicides, a petroleum compound and pidivyl china clay compound, were compared for the efficacy along with the fungicides TMTD and Tridemorph. Comparison was also made between hand-mixed and machine-mixed fungicide in carrier. The results of the experiments are furnished in Table–Path. 3.

Table–Path. 3. *Recovery of treated parts of Hevea from Pink disease.*

Treatments	Number of trees		Mean per cent disease index
	Treated	Recovered	
TMTD 7500 ppm in Sopkot – M. S.	25	23	10.20
TMTD 7500 ppm in Sopkot – H. S.	25	21	21.98
Tridemorph 10000 ppm in Sopkot – M. S.	25	20	28.25
Tridemorph 10000 ppm in Sopkot – H. S.	25	20	24.39
TMTD 7500 ppm in Pidivyl compound	25	14	56.99
Tridemorph 10000 ppm in Pidivyl compound	25	20	24.50
Bordeaux Paste (control)	25	17	40.82

M. S. – Mechanical stirring.

H. S. – Hand stirring.

The results indicate that the petroleum compound, machine mixed with the fungicide, is superior to that of hand mixed in either carrier or machine mixed in pidivyl china clay.

Another experiment was conducted on the extent of recovery by treating the disease at different stages of disease advancement — cobweb, latex oozing and bark rotten. Better results were achieved by treatment in the early stage.

An ayurvedic oil tested for the control of this disease indicated that it was inferior to Bordeaux paste and had effect only in the early stages of the disease.

8. POWDERY MILDEW DISEASE

This disease caused by *Oidium heveae*, is the second most important leaf disease of rubber. In recent years, it is occurring in severe form in areas where it was not at all a problem.

The control of powdery mildew disease in mature area with alternate dusting of calixin 1.5% (10 kg ha^{-1}) and sulphur dust (12 kg ha^{-1}) indicated that better disease control could be obtained with the first round with calixin, next round with sulphur and the third round with calixin.

In the spray trial experiment on young rubber plants, out of the ten fungicidal treatment, Bavistin 0.05%, Bayleton 0.05%, Baycor 0.25% and Topsin 0.07% were significantly superior to the other treatments and control (Table-Path. 4).

Table-Path. 4. *Spray trials for powdery mildew disease control.*

Treatments	Concentration (% ai)	Mean per cent disease index
Bavistin	0.05	16.08
Baycor	0.025	22.33
Bayleton	0.025	15.67
Karathane	0.1	26.42
Saprol	0.03	29.08
Dithane M. 45	0.2	26.33
Topsin	0.07	20.17
Delan	0.075	25.58
Calixin	0.1	26.58
Sulfex	0.2	24.25
Water spray	(control)	28.33
Unsprayed	(control)	28.83

S. E. : 0.20
C. D. (0.05) : 0.60

The intensity of disease incidence was studied in fertilizer trials with different levels of the nutrients N, P and K in three locations. No difference was observed among different treatments. However, in one location, NPK at the rate of 34, 90 and 45 kg ha^{-1}, respectively was observed to significantly suppress the disease.

9. DRY ROT DISEASE

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 has been 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 more expensive.

Two types of application of fungicide were tested. Washing the wound after removal of the disease affected bark with the fungicide solution and application of petroleum compound and applying fungicide mixed petroleum compound directly on such wounds. The latter was found to give better control of the disease. Among three fungicides tried, Bavistin 0.5% was found to be superior. Petroleum compound alone could effect only a very low percentage of control.

10. HIGH PRESSURE INJECTION FOR DISEASE CONTROL

In the studies on wood preservation by pressure injection, copper sulphate injected wood pieces showed no sapstain fungus and insect attack for a period of 24 months, whereas in the untreated wood pieces, severe attack by fungus and insect was noticed. The difficulties encountered for treating the central portion of the wood in large trees was overcome by using longer drill bits and injection needles.

11. BIOLOGICAL TREATMENT OF EFFLUENT FROM RUBBER PROCESSING INDUSTRIES

Effluent samples were collected at hourly intervals from a crumb rubber factory during 24 hours. This was treated in four different ways: without treatment, aeration, inoculation of *Chlorella vulgaris* and combination of aeration and inoculation of *C. vulgaris*. The last treatment considerably reduced the pollution load. The results are furnished in Table–Path. 5.

Table–Path. 5. *Effect of aeration along with algal culturing in crumb rubber factory effluent.*

Parameters	Control		Aeration	*Chlorella*	Aeration + *Chlorella*
	Initial	Final			
pH	5.2	5.7	7.5	7.0	8.2
BOD mgl^{-1}	290	233 (20)	95 (67)	190 (34)	43 (85)
COD mgl^{-1}	720	607 (15.5)	150 (79)	280 (61)	70 (90)
Total Nitrogen mgl^{-1}	45.8	38.5 (16)	30.4 (34)	35.5 (22)	25.0 (45)
Total solids mgl^{-1}	4670	4580 (2)	3245 (31)	4062 (13)	2960 (37)
Suspended solids mgl^{-1}	1650	1480 (10)	968 (41)	1340 (19)	820 (50)
Algae ml^{-1}	—	—	—	25×10^6	45×10^6
Bacteria ml^{-1}	49×10^5	48×10^5 (2)	30×10^4 (93)	24×10^4 (95)	12×10^3 (99)

(Figures in paranthesis indicate the percentage of reduction)

A detailed study on the feasibility of recycling the used water in a PLC factory was in progress.

12. MINOR LEAF-SPOT DISEASES

In the experiment on the control of *Gleosporium* leaf spot disease with 12 fungicide treatments, it was found that Dithane M–45 was significantly superior to all other treatments followed by Bavistin, Baycor and Delan. The results are furnished in Table–Path. 6.

Table–Path. 6. *Fungicides field tested against Gleosporium leaf spot.*

Fungicide	Concentration (%)	Mean disease intensity (%)
Dithane M. 45	0.2	25.06
Bavistin	0.05	28.50
Plantavax	0.1	30.29
Topsin M	0.07	32.74
Delan	0.2	29.89
Baycor	0.025	28.89
Bordeaux mixture	1.0	30.26
Bordeaux mixture + zinc sulphate	1.0 + 0.5	31.32
Bayleton	0.025	30.04
Kitazin	0.048	33.32
Water sprayed	0.00	33.10
Unsprayed	0.00	34.87

C. D. (0.05) : 4.88

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

Large quantities of copper fungicides are 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 properties and microflora.

The copper content was found to be less in dried rubber made after acid coagulation and removal of serum, compared to field coagulated samples. In leaves, copper content was more in areas sprayed with higher dosage of fungicides compared to the normal dosage.

14. ASSESSMENT OF YIELD LOSS DUE TO DISEASES

Crop loss studies are essential to evaluate cost benefit ratio of control operations. In field trials being conducted at the Central Experiment Station, Chethackal in four clones, RRIM 600, RRII 105, GT 1 and RRII 118, the pre-treatment yield recording has been completed.

15. OVER SUMMERING OF *PHYTOPHTHORA*

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

Phytophthora spores were collected from ground surface spore traps, a fortnight before the appearance of leaf-fall. *Phytophthora* culture buried in soil produce chlamydospores after one month and mycelia disintegrated.

16. 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.

The development of *Oidium* on tolerant and susceptible clones of rubber by cut leaf method was studied in laboratory with the tolerant clone PB 86 and susceptible cones PB 5/51, PB 235, Gl 1 and RRII 300. The percentage of germination, germ tube length, length of secondary hyphae, etc. were recorded. It was found that only length of the secondary hyphae varied between susceptible and tolerant clones.

17. 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 disease and timing the control measures to achieve best results.

The weather parameters for triggering abnormal leaf-fall disease was re-evaluated and it was found that a slightly higher maximum temperature could be tolerated by this disease.

18. COLLECTION, CLASSIFICATION AND COMPARATIVE MORPHOLOGY OF REGIONAL ISOLATES

Maintaining the cultures of fungal pathogens and regional isolates of pathogens is essential to carry out various laboratory and field studies.

Cultures of various fungal pathogens of rubber, numbering 130, are being maintained. Out of these, 50 cultures were revived by passing through the host.

21. ROOT DISEASE

Root diseases are not very common in India as in Malaysia. But wherever this disease occurs, the affected plants and trees die.

The experiment on the control of brown root disease by drenching of systemic fungicide is in progress at two estates. In laboratory screening Bayleton and Thiride completely inhibited the root disease pathogens, *Phellinus noxius* and *Poria vincta*, at lower concentrations.

22. LEGUMINOUS COVER CROPS

Soil moisture at 30, 60 and 90 cm depth in fields under *Mucuna bracteata* was slightly higher than those under *Pueraria phaseoloides* during summer in Palghat region.

An experiment was conducted to evaluate the soil moisture in *M. bracteata* fields with slashing and without slashing during summer. It was found that soil moisture at 30 cm depth slightly increased upto third week under slashing. But after fourth week, the level was found less than that in unslashed plots. At 90 cm depth in unslashed plots, the soil moisture was lesser than that in slashed plots during fifth week after slashing.

Nitrogenase activity of six isolates of *Rhizobium* spp. was estimated using gas chromatograph. Two isolates which were found to perform well under field condition, recorded more nitrogenase activity.

Similarly nitrogenase activity on the combined inoculation *Rhizobium* sp. and *Beijerinckia* sp. was studied using gas chromatograph. The acetylene reduction activity was found to be significantly more in the combined inoculation of *Rhizobium* and *Beijerinckia* (Table–Path. 7).

Table–Path. 7. *Effect of dual inoculation with Rhizobium and Beijerinckia.*

Treatment	ARA/plant (n Mol)	Dry weight (mg)
Rhizobium sp.	474.6	422.4
Beijerinckia sp.	389.0	372.8
Rhizobium sp. + *Beijerinckia* sp.	575.6	495.2
Control	342.8	329.4
C. D. (0.05)	28.2	11.1

The technique for mass culturing *Rhizobium* using lignite was standardised.

23. TESTING OF ANTAGONISTIC MICROORGANISMS AGAINST DISEASES OF RUBBER

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.

Antagonic actinomycete against pink disease was tested using maida and gum arabic as carrier and it was found to be as effective as Bordeaux paste.

24. NON-SYMBIOTIC NITROGEN FIXING MICROORGANISMS

Biological fixation of molecular nitrogen can be performed by a number of prokaryotic microorganisms. The free living nitrogen fixing micro-organisms of rubber growing soils

were studied giving special importance to *Azotobacter, Beijerinckia, Derxia* and *Azospirillum* and to find out their use in rubber plantation to maximise the yield at lower cost and without any pollution.

The population of *Azospirillum* sp. of rubber growing soils of four locations were estimated using gas chromatograph. The nutrient activity was found to be almost similar.

25. WHITE GRUBS

The results of the field trial conducted on the control of white grubs using insecticides and entomogenous fungi showed that entomogenous fungi *Beauvaria* spp. are most effective in reducing the damage to plants, and among the insecticides isofenphos was the most effective. The results are furnished in Table–Path. 8.

Table–Path. 8. *Comparative evaluation of biological and insecticidal treatments against Holotrichia serrata* F.

Treatments	Dose (kg–ha)	Mean percentage survival of plants–plot*	Grub population 30 cm^3
Phorate 10 G	25	81.00 (64.18)^c	0.15
Carbofuran 3G	25	80.56 (63.87)^c	0.15
Carbaryl + Lindane (sevidol) 4:4G	25	80.50 (63.91)^c	0.20
Carbaryl 4G	25	61.56 (51.22)^d	0.25
HCH 10D	100	34.60 (36.02)^e	0.35
Phosalone 4D	100	36.26 (36.99)^e	0.30
Carbaryl 5D	100	38.67 (38.43)^e	0.30
Malathion 5D	100	20.46 (26.80)^f	0.40
Isofenphos 5G–25	25	88.50 (70.22)^b	0.10
Beauveria bassiana	10^6 spores-g of soil	92.00 (73.65)^a	0.05
Beauveria brongniartii	10^6 spores-g of soil	92.56 (74.52)^a	0.05
Control	—	9.31 (17.77)^g	1.15
F test	Significant		
S. E. of X	1.24		

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

26. BARK FEEDING CATERPILLAR

This pest is spreading to newer areas in a serious proportion from the southern region of the traditional rubber growing tract. At present it has spread up to Trichur district.

The comparative effectiveness of five insecticidal dusts was evaluated in the field against the bark feeding caterpillar, *Aetherastis circulata*. The dosage tried (15 kg ha^{-1}) was the same for all the treatments. Results are furnished in Table–Path. 9. The most effective and less toxic Fenvalerate 0.4% dust is useful for the control of this pest.

Table–Path. 9. *Efficacy of different insecticides against Aetherastis circulata* Meyr.

Treatments	Mean population reduction (%) after	
	7 days	14 days
Fenvalerate 0.4% dust	99.14 (84.69)*	100.00 (90.00)
Methyl parathion 2% dust	95.75 (78.12)	100.00 (90.00)
Quinalphos 1.5% dust	88.96 (70.99)	96.68 (79.68)
Carbaryl 5% dust	85.77 (68.02)	92.96 (75.38)
HCH 10% dust	75.80 (60.58)	85.36 (67.57)
Control	10.26 (18.67)	6.40 (14.59)
C. D. (0.05)	5.82	5.19

* Figures in parenthesis are angular transformed–values.

27. TERMITES

Termites are generally not a serious pest in rubber. But due to very hot summer in the non-traditional areas, this pest causes appreciable damage.

A field trial was laid out on the control of termites infesting rubber at Regional Research Station, Kamakhyanagar, Orissa with six insecticidal treatments. The trial is in progress.

28. SLUGS AND SNAILS

Slugs and snails attack has been on the increase in recent years. Effective molluscicides are not available in India now.

In repeated field tests, 10% Bordeaux paste was effectively repelling slugs upto a period of 45 to 60 days, after application.

29. NEMATODES

Eventhough very high population of nematodes was observed in the soils of rubber nursery and plantations, it was not considered a problem. But recently root-knot nematodes were recovered from the roots of rubber seedlings at Regional Nursery, Kadackamon. Hence, this study is assuming importance.

The susceptibility of five cover crops to nematodes was evaluated in a pot culture study. The results furnished in Table-Path. 10 indicate that *Mucuna bracteata* is highly resistant and *Pueraria phaseoloides* is highly susceptible to nematodes.

Table-Path. 10. *Susceptibility of leguminous cover crops to root-knot nematode — Meloidogyne incognita.*

Cover crop	Range in category	Root-knot index	Reaction
1. *Mucuna bracteata*	0.0 — 1.0	0	HR
2. *Centrosema pubescens*	1.0 — 2.0	1.76	MR
3. *Mimosa invisa*	3.1 — 4.0	3.20	MS
4. *Calapagonium mucunoides*	4.1 — 5.0	4.4	HS
5. *Pueraria phaseoloides*	4.1 — 5.0	5.00	HS

HR — Highly resistant
MR — Moderately resistant
MS — Moderately susceptible
HS — Highly susceptible
0 — Free
5 — Maximum disease intensity

30. VERTEBRATE PESTS

A variety of vertebrate pests ranging from rats to elephants attack rubber and cause even death of plants and trees. Rats are present in all regions.

Bromadiolone bait at 0.005% concentration was evaluated against three rat species viz. *Bandicota bengalensis, B. indica* and *Rattus meltada* infesting rubber seedlings. Post control census based on active burrow count revealed 100% kill of *B. bengalensis,* 91.30% of *B. indica* and 81.82% of *R. meltada.*

In repeated field testing bromadiolone at 0.005% concentration was found to be effective for the control of rats.

31. BEE KEEPING

Bee keeping is a profitable ancillary industry in rubber plantations and requires only a low initial investment. The extra floral nectory glands at the tip of petioles of rubber leaves secrete a large quantity of nector during December to April.

Klienhovia sp., *Albezzia lebeck* and *Strobilanthus haonianus* were identified as additional bee forage plants for off-seasonal bee management. Mites belonging to *Neocypholaelaps* spp. were found to be the main pollen feeder in the beehives. The alternative bee forage plants belonging to three species are being raised in Central Experiment Station, Chethackal.

PLANT PHYSIOLOGY AND EXPLOITATION DIVISION

Studies on early prediction of high yielding, stress resistant characters of planting materials, biochemical subcomponents of major yield components, biochemical changes associated with different tapping intensities, physiological evaluation of clones in the non-traditional regions of the tropics, crop water requirements, yield constraint analysis in different agroclimates of the traditional regions, exploitation and brown bast, introduction of medicinal plants in mature *Hevea* stands, etc., were the major activities of the division during the period of report.

1. STUDIES ON THE PHYSIOLOGICAL AND BIOCHEMICAL SUBCOMPONENTS OF *HEVEA*

Monitoring of the seasonal changes in yield and associated physiological and biochemical parameters was continued. Observations on monthly changes in yield, plugging index, initial flow rate and dry rubber content showed that during the subsequent seasons also the low yielders have higher plugging index values compared to the high yielders. Clone RRII 105 was found to maintain higher plugging index values in all seasons when compared to clone PB 235. Initial flow rate was found to be markedly higher in RRII 105 than in PB 235.

In general, definite clonal variations were not observed in the levels of sugars in the C–serum samples, except during the period of wintering. During this period there was a marked decline in the level of reducing sugars in the high yielders (RRII 105 and PB 235), compared to the low yielders (Ch 4 and Pil B 84). However total soluble proteins in the C – and B – serum samples were high in the high yielders (Table–Phy. 1). Among the two high yielders, the serum samples of RRII 105 contained more proteins.

Table–Phy. 1. *Total soluble protein contents in the C – and B – serum samples of high and low yielding clones of Hevea.*

Clones	C–serum protein (mg ml^{-1})		B–serum protein (mg ml^{-1})	
	December	March	December	March
Ch 4	9.89	7.21	11.46	10.67
Pil B 84	9.88	6.56	11.86	11.24
RRII 105	12.15	9.64	14.10	13.76
PB 235	10.92	8.05	13.77	13.75
CD (0.05)	0.331	0.267	0.362	0.216

2. IDENTIFICATION OF PHYSIOLOGICAL AND BIOCHEMICAL PARAMETERS FOR EARLY PREDICTION OF YIELD POTENTIAL AND RESPONSE TO DROUGHT

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

Latex samples were collected from young plants (3½ years) belonging to six clones, viz., RRII 105 and RRIM 600 (high yielders), GT 1 and RRII 118 (medium yielders) and RRII 38 and HP 20 (low yielders), in December 1988. Total lipids, sterols, triglycerides and phospholipids were estimated in whole latex and the data are given in Table–Phy. 2. The data show that the contents of total lipids, triglycerides, sterols and phospholipids are significantly high in high and medium yielders except in clone RRII 118.

Table–Phy. 2. *Lipid composition in the latices of six clones of Hevea in the immature phase.*

Clones	Total lipids (g 100 g^{-1} dry weight)	Phospholipids (g 100 g^{-1} dry weight)	Sterols (mg 100 g^{-1} dry weight)	Triglycerides (mg 100 g^{-1} dry weight)
RRII 105	6.01	1.67	896.77	839.05
RRIM 600	5.83	1.84	915.36	794.91
GT 1	6.03	1.61	979.25	806.08
RRII 118	4.63	1.50	685.40	359.51
RRII 38	5.39	1.51	742.96	705.59
HP 20	5.16	1.54	627.46	649.41
CD (0.05)	0.117	0.062	41.50	21.73

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

The results on visual scoring for precoagulation, reported in the previous annual report, were obtained in 32 month old plants in the month of March 1988. The same observations were again made during test tappings conducted in December 1988. The data is presented in Table–Phy. 3. The data show that though the clonal differences are still maintained the extent of difference was found to be decreased with the age of the plant.

Table–Phy. 3. *Percentage of plants showing precoagulation in six clones during test tapping (December 1988).*

Clone	Precoagulation (%)
RRII 105	10.00
RRIM 600	15.00
GT 1	20.00
RRII 118	16.25
RRII 38	68.75
HP 20	32.50
CD (0.05)	0.203

During the period under review studies using the technique of electrophoresis were initiated to identify proteins/isozymes associated with clonal characteristics.

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

The studies were continued in four locations on clone GT 1. During the reporting period maximum annual yield and per tap yield were obtained from trees in New Ambadi estate, Kanyakumari area (Table–Phy. 4). These values were lowest in Kinalur estate (Calicut area). The higher yield in New Ambadi was associated with high initial flow rate,

Table–Phy. 4. *Annual yield (kg* ha^{-1}*) and mean per tap yield (kg) of 1977 R. P. GT 1 during 1988–89.*

Estate	Annual yield	Yield tap^{-1}
New Ambadi	1463.30	13.30
Kinalur	1004.10	8.58
Perinad	1314.43	10.03
Kundai	1368.50	9.64

total volume and dry rubber content. The girth increment figures recorded in different locations were similar. The data on rainfall pattern and soil moisture percentage (Table–Phy. 5) indicate a drier situation in Kinalur estate than in New Ambadi during Dcember to May season.

Table–Phy. 5. *Seasonal changes in soil moisture percentages at different depths in New Ambadi and Kinalur estates during* 1988–89.

Month	Kinalur			New Ambadi		
	0–30 cm	30–60 cm	60–90 cm	0–30 cm	30–60 cm	60–90 cm
1988 April	11.40	13.38	15.87	20.58	21.67	23.84
1988 May	13.09	15.77	18.14	14.79	16.77	19.57
1988 June	20.47	19.61	21.84	17.75	21.27	25.40
1988 July		Saturated		20.30	21.55	24.37
1988 August	20.39	19.77	18.80	17.46	20.91	26.02
1988 September		Saturated		19.53	21.90	27.52
1988 October	18.03	16.53	17.66	17.29	20.77	23.45
1988 November	19.63	20.05	20.11	20.11	22.68	25.88
1988 December	18.23	16.57	15.82	15.44	18.64	22.35
1989 January	12.18	13.61	16.72	11.18	18.87	22.00
1989 February*	—	—	—	—	—	—
1989 March	10.44	12.28	13.73	16.99	19.37	23.23

* Rest period.

The turgor pressure was always high in the trees in New Ambadi when compared to that of trees in Kinalur estate during the observed months (August 1988 — December 1988). The higher turgor pressure values are associated with lower osmotic potential of the latex.

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

Growth recordings were continued in the 1982 multilocation trials, at different locations. In addition to growth, mid-day leaf water potential (Ψ_l) and stomatal resistance (R_s) were recorded in different seasons. The absolute girth attained by different clones in November/ December 1988 and seasonal girth increment for different locations (February-November 1988) are given in Table–Phy. 6 and 7. The physiological parameters are given in Table–Phy. 8 to 11. In the present data, clones RRII 105, RRII 118 and RRIM 703 at Dapchari were eliminated as the plants were damaged due to special circumstances.

Table-Phy. 6. *Growth (6th year) of different Hevea clones at different agro-climatic regions (girth in cm)*

Clone	CES	Dapchari	Mudigere
RRII 300	43.4	39.0	25.6
PB 235	41.4	37.3	26.5
RRII 105	41.1	—	24.7
RRIM 600	40.4	42.2	27.6
GT 1	38.1	37.4	27.0
PR 107	30.8	38.1	22.6
Gl 1	37.9	37.5	20.3
RRIM 501	36.8	39.5	22.5
RRII 118	43.4	—	24.3
RRIM 703	41.7	—	29.5
Tjir 1	43.1	36.0	25.1
RRIM 612	42.1	40.8	27.5
Mean	40.0	38.6	25.2

Table-Phy. 7. *Rate of girth increment* (cm) *in different Hevea clones during different seasons at different agro-climatic regions.*

	CES			DAPCHARI			MUDIGERE		
Clone	Feb–May	May–Aug	Aug–Nov	Feb–May	May–Aug	Aug–Nov	Feb–May	May–Aug	Aug–Nov
RRII 300	2.60	3.61	2.04	0.78	2.90	2.6	0.84	0.68	2.45
PB 235	1.37	1.31	3.48	0.99	2.33	3.1	0.90	1.93	1.25
RRII 105	3.12	3.53	1.96	—	—	—	0.45	1.95	1.77
RRIM 600	2.32	3.30	1.84	1.11	2.77	1.7	0.45	1.50	1.97
GT 1	2.10	3.96	2.52	1.28	1.78	3.6	0.42	1.36	0.84
PR 107	1.49	2.41	2.01	1.87	2.15	2.4	0.83	2.15	1.66
Gl 1	1.88	4.32	2.53	1.79	2.33	3.1	0.44	0.88	2.46
RRIM 501	1.79	4.13	3.15	1.75	3.24	3.5	0.58	0.96	1.82
RRII 118	1.83	4.92	2.83	—	—	—	0.54	1.83	1.15
RRIM 703	0.99	1.91	3.39	—	—	—	0.63	0.80	1.99
Tjir 1	3.00	3.21	2.23	1.57	2.96	2.6	0.35	1.27	1.95
RRIM 612	2.78	1.97	4.69	1.10	2.85	2.3	0.39	2.51	2.97
Mean	2.10	3.22	2.72	1.36	2.59	2.76	0.55	1.48	1.85

Table-Phy. 8 *Leaf water potentials (–MPa) in leaves of Hevea clones grown at CES in different seasons.*

Clone	Nov 1987	May 1988	Aug 1988	Nov 1988
RRII 300	1.735	1.802	1.587	1.563
PB 235	1.753	1.742	1.605	1.855
RRII 105	1.078	1.365	0.985	1.020
RRIM 600	1.240	1.275	1.240	1.308
GT 1	1.513	1.440	1.358	1.418
PR 107	1.693	1.823	1.668	1.783
Gl 1	1.220	1.710	1.370	1.278
RRIM 501	1.788	2.128	1.700	1.838
RRII 118	1.790	2.198	1.610	1.525
RRIM 703	1.685	1.800	1.767	1.645
Tjir 1	1.610	2.680	1.435	1.550
RRIM 612	1.625	1.850	1.508	1.633
Mean	1.560	1.817	1.486	1.534

Table-Phy. 9. *Leaf water potentials (–MPa) in leaves of Hevea clones grown at Mudigere in different seasons.*

Clone	Nov 1987	May 1988	Aug 1988	Nov 1988
RRII 300	1.365	1.723	1.448	1.355
PB 235	1.625	2.008	1.488	1.630
RRII 105	1.100	1.437	1.025	1.088
RRIM 600	1.205	1.358	1.030	1.103
Gl 1	1.258	1.438	1.408	1.305
GT 1	1.345	1.550	1.550	1.340
RRIM 501	1.785	2.080	1.560	1.515
PR 107	1.820	2.190	1.423	1.268
RRII 118	1.883	2.188	1.560	1.515
Tjir 1	2.050	2.585	1.490	1.540
RRIM 703	1.398	1.605	1.513	1.148
RRIM 612	1.773	2.133	1.178	1.173
Mean	1.550	1.857	1.391	1.330

Table–Phy. 10. *Stomatal resistances (s cm^{-1}) of Hevea clones grown at CES in different seasons.*

Clone	Nov 1987	May 1988	Aug 1988	Nov 1988
RRII 300	9.48	9.49	7.36	9.24
PB 235	8.85	8.18	4.68	10.68
RRII 105	11.96	16.26	12.05	16.25
RRIM 600	8.72	10.10	8.33	10.10
Gl 1	8.90	8.79	7.09	8.79
GT 1	9.93	11.73	5.38	11.73
PR 107	6.51	5.89	3.74	7.64
RRIM 501	10.14	7.09	4.33	7.09
RRII 118	6.13	5.73	6.13	5.73
RRIM 703	8.20	6.55	8.19	6.55
Tjir 1	4.43	6.22	4.43	6.19
RRIM 612	9.66	9.08	9.66	8.83
Mean	8.57	8.76	6.77	9.07

Table–Phy. 11. *Stomatal resistances (s cm^{-1}) of Hevea clones grown at Mudigere in different seasons.*

Clone	Nov 1987	May 1988	Aug 1988	Nov 1988
RRII 300	17.82	13.29	4.40	13.18
PB 235	12.00	13.20	5.53	13.62
RRII 105	16.24	19.58	18.65	16.21
RRIM 600	15.27	18.72	12.05	12.13
Gl 1	14.01	16.55	6.47	14.62
GT 1	13.09	17.39	13.51	13.59
RRIM 501	5.89	6.32	4.27	7.88
PR 107	7.63	8.85	6.34	9.06
RRII 118	5.82	10.34	6.35	5.68
Tjir 1	6.98	6.82	4.29	6.17
RRIM 703	11.66	14.91	10.43	7.20
RRIM 612	6.73	9.69	5.06	6.46
Mean	11.17	12.97	8.11	10.96

Of all the clones at CES, RRII 118, RRII 300 and Tjir 1 attained maximum girth (43 cm), followed by RRIM 612, PB 235, RRII 105, RRIM 703 and RRIM 600 (40.42 cm). Clone PR 107 (30.77 cm) was found to show the lowest growth.

In Dapchari, the cumulative growth depression was around 4%, when compared to the growth at CES. The reasons for narrowing down of this difference when compared to the previous year are good irrigations given during 1987 and 1988 summer months. Among the three seasons studied, minimum growth rates are observed from February to May. The growth rates in the remaining periods are almost comparable to that of CES. Clones RRIM 600, RRIM 612, RRIM 501, RRII 300 and PB 107 showed better performance when compared to the other clones.

At Mudigere the growth performance was very poor due to the environmental constraints such as high elevation and low temperature. Around 37% growth reduction was noticed compared to the girth of plants at CES. Girth increment rates were reduced drastically when compared to those at both CES and Dapchari. In Mudigere maximum reduction in growth was observed in clones RRIM 501, PR 107, RRII 300 and Gl 1, followed by Tjir 1, PB 235 and RRII 105. However, highest absolute girth was recorded in RRIM 703, RRIM 600, RRIM 612 and GT 1.

In general, clone RRIM 600 was found to perform well at Dapchari as well as at Mudigere. Based on growth performance clones RRIM 612, RRII 300, RRII 118, PR 107 etc. appear to be suitable for the Konkan region.

The mean mid-day leaf water potentials at CES was comparable to the values recorded at Mudigere during November 1987 and May 1988. But in August 1988 and November 1988 the leaf water potentials were higher at Mudigere. The lack of marked seasonal variations in mid-day leaf water potentials at CES was due to better distributed rainfall received in summer months. The data show that in both plains and high elevations clones RRII 105, Gl 1, GT 1 and RRIM 600 maintain higher leaf water potentials. However, in spite of maintaining higher leaf water potentials, in general, in the high elevation growth is very poor. This indicates direct effect of low temperature on growth. This is also supported by the absence of any relation between clonal variation in growth at high elevation and clonal variation in leaf moisture status. As reported earlier the stomatal resistance was higher at high elevation in all seasons studied, compared to the values obtained from plants grown in CES. The higher stomatal resistance in the high elevation situation in spite of higher leaf water potentials indicates direct effect of low temperature on mechanisms involved in stomatal opening.

5. PERFORMANCE OF *HEVEA* CLONES AT HIGH ELEVATIONS

The trial started in 1981 with 16 clones planted at Mullenkolly (Wynad), at an elevation of about 850 m MSL and at Poonoor in the plains as control, with an aim to identify clones suitable for growing at high elevation areas and other marginal lands was continued. Periodic monitoring of growth of all the clones was done and work on certain physiological parameters was initiated.

Data on mean girth in the seven year old plants are given in Table–Phy. 12. Majority of the clones attained tappable girth at Poonoor whereas plants at Wynad showed around 26.8% inhibition compared to those at Poonoor. Even among the clones, at Poonoor RRII 118, LCB 1320, RRIM 623, RRII 105 and RRII 203 showed girth of more than 50 cm. At high elevations, RRII 118, RRIM 623, RRIM 600 and RRII 203 showed higher absolute girth compared to other clones. When the per cent inhibition is taken, clones GI 1 and RRIM 600 showed lesser inhibition (9–10%), while maximum inhibition was noticed in RRII 105, PB 6/9 and LCB 1320 (33–39%) compared to those of Poonoor.

Table–Phy. 12. *Growth of Hevea clones at Poonoor (plains) and Wynad (high altitude) (Girth in cm as on 7th year).*

Clone	Location	
	Wynad	Poonoor
PB 28/59	35.47	46.32
RRII 203	38.13	50.04
PB 6/9	24.13	38.46
RRII 105	31.56	51.13
RRIM 612	36.02	49.86
RRIM 501	33.25	49.41
RRIM 605	31.84	44.92
GI 1	34.05	37.40
PB 5/51	32.03	44.88
PR 107	32.52	39.10
GT 1	33.22	47.86
RRIM 600	36.71	40.59
RRIM 623	37.51	51.47
Tjir 1	34.21	44.77
LCB 1320	34.62	52.30
RRII 118	39.49	55.98
Mean	34.05	46.53

6. DROUGHT INDUCED CASUALTIES IN MODERN *HEVEA* CLONES

In the *Hevea* Breeding Station, Nettana which is in the northern end of the traditional rubber growing area, rainfall received in 1988-89 season was below normal. In this region under normal situation also there is a prolonged dry season due to weak north-east monsoon. Severe casualties were observed in 1989 in the experimental plantings done in 1987. The percentage of casualties observed in five modern *Hevea* clones are presented in Table–Phy. 13. It was observed that clones RRII 300 and RRII 105 are more susceptible to drought compared to the PB clones. No life saving irrigation was given.

Table-Phy. 13. *Drought induced casualties in different Hevea clones at Hevea Breeding Station, Nettana.*

Clone	Per cent casualty*
RRII 300	19.6
RRII 105	20.5
PB 311	1.8
PB 260	1.3
PB 235	2.8
CD (0.05)	15.0

* Significant at 5% error.

7. PROSPECTS OF IRRIGATING *HEVEA* IN DIFFERENT AGROCLIMATIC ZONES OF THE TRADITIONAL AREA

Potential evapo-transpiration figures were worked out for the southern, central and nothern parts of the traditional rubber growing areas using Blaney and Criddle model. The daily water requirements, the quantities of irrigation water and frequencies of irrigation required were worked out with various assumptions. The relative transpiration ratio reported earlier for wet season was taken as crop coefficient. The estimated mean frequency of irrigation in the southern part is once in 3.7 days, in the central part once in 3.0 days and in the northern part once in 2.5 days for mature stands. The estimated mean daily water requirements in summer months are 95.0, 99.2 and 109.4 litres per tree for these regions respectively. Non availability of large quantities of water for irrigation in summer months and methods of irrigation in the slopes are problems. Well laid out irrigation experiments are in progress in the Regional Research Stations at Dapchari and Orissa.

8. EFFECT OF DIFFERENT EXPLOITATION SYSTEMS ON THE YIELD OF MODERN *HEVEA* CLONES

The trial was continued and data on dry rubber yield obtained in different years from clone RRII 105 under different tapping systems are given in Table-Phy. 14. The cumulative yield data for 45 months show that production from trees under $\frac{1}{2}$S d/3 system of tapping is around 18 per cent less compared to $\frac{1}{2}$S d/2 system. The lowest yield was recorded from trees under quarter spiral change over system of tapping. Incidence of brown bast was lowest among trees under half spiral third daily tapping system. The experiment is in progress and two more exploitation systems ($\frac{1}{4}$S d/6 and $\frac{1}{2}$S d/1) were incorporated. Biochemical investigations were also initiated.

Table-Phy. 14. *Dry rubber yield* (kg ha^{-1}) under different tapping systems – Clone RRII 105.*

Tapping system	1985–86 (9 months)	1986–87 (12 months)	1987–88 (12 months)	1988–89 (12 months)	Total (45 months)	Brown bast (%)
$\frac{1}{4}$S d/2	1027.25	1491.00	2030.50	3328.79	7876.00 (100%)	12.5
$\frac{1}{2}$S d/3	845.50	1246.98	1737.28	2631.95	6458.00 (81.99%)	5.8
2 x $\frac{1}{4}$S d/2 (t,t)	704.00	1201.03	1374.82	2169.39	5449.00 (68.18%)	9.6

*300 trees ha^{-1}

9. EFFECTS OF DIFFERENT REST PERIODS ON YIELD

The trial, consisting of rest periods in summer and rainy season, was continued. Unlike in the first year, the yield obtained from trees under various treatments did not show any significant difference. The trial is being continued.

10. CALCIUM CARBIDE STIMULATION

The trial initiated in January 1988 was continued during the year. No stimulation was given in the months of February and March 1989 because of wintering and drought. Since puncture tapping was not promising, it was discontinued. The yield obtained with $\frac{1}{2}$S d/2 + ethephon and $\frac{1}{2}$S d/2 + calcium carbide was 22.2% and 44.7% higher respectively compared to yield from $\frac{1}{2}$ S d/2 control.

The results of one year indicated better effectiveness of calcium carbide as a latex yield stimulant. A few on farm trials are proposed to be conducted during 1989–90.

11. EFFECT OF AYURVEDIC OIL TREATMENT ON THE INCIDENCE OF BROWN BAST

No consistant curative or preventive effect could be observed in two block level field experiments. However, a preventive effect was reported by certain farmers who participated in the on-farm trials. Further trials are proposed to be taken up.

12. INTERCROPPING MEDICINAL HERBS IN RUBBER PLANTED AREAS

The large planting material source raised at CES was maintained. Arrangements were made for on-farm trials. The biological bunds raised with *Strobilanthus haenianus* were found to perform well in conserving soil and water. *Strobilanthus* sp. was also found

to attract honey bees for four months. *Rauwolfia serpentina*, *Holostemma annulare*, *Sida rhombifolia* and *Peuraria* sp. (Kattu payar) did not perform well under mature canopy. *Adathoda bedommie*, *A. vasica*, *Strobilanthus haenianus*, *Plumbago rosea*, *Kaempferria rotunda*, *K. galanga* and *Alpinia galanga* were found to come up well under deep shade.

13. MULTIDISCIPLINARY STUDY ON BROWN BAST

Latex samples from trees categorised as dry, partially dry, late dripping and normal were collected from clones RRII 105, RRIM 600, GT 1, PB 28/59 and PB 235. Soil samples were also collected from the vicinity of such trees. The soil samples were analysed for organic carbon, available P, K, Ca and Mg. Latex samples were analysed for N, P and K. No pattern could be obtained from such study.

Total soluble protein contents were estimated in the C-serum fractions of latices obtained from trees under different tapping intensities (clone RRII 105). The data show that full recoupment of C-serum proteins occurs within 24 hours. There was no significant difference in the protein contents in the samples obtained from trees under $\frac{1}{2}$S d/1 and $\frac{1}{2}$S d/6 tapping systems, though significant differences were noticed in dry rubber yield (per tap) and dry rubber content.

One dimensional SDS–poly-acrylamide gel electrophoretic pattern of C-serum sample obtained from latices of trees under different tapping intensities was done. No difference was observed in the protein patterns.

RUBBER CHEMISTRY, PHYSICS AND TECHNOLOGY

1. DEVELOPMENT OF SOLAR DRIER FOR SHEET RUBBER

The evaluation of the solar drier installed at the RRII was continued. Solar intensity, average temperature inside the chamber, temperature at the blower side, relative humidity, firewood consumption, etc., were measured. Trials were also continued by varying the speed of the blower. The heat efficiency calculations for the solar drier were worked out and the results are as follows:–

(1) Efficiency of the solar collector, Es = 53.6%

(2) Efficiency of heat circulation, Ec = 88.0%

(3) Overall efficiency of the drier, E = 13.3%

2. STUDIES ON EPOXIDATION OF NATURAL RUBBER

Different batches of ENR have been prepared at different conditions. All the products have been characterised using NMR spectroscopy. Reaction conditions for the preparation of ENR–25 as well as ENR–50 with negligible side reactions have been identified. On the basis of this, bench scale batches of ENR–25 and ENR–50 have been prepared and characterised. Samples from these batches were compounded and their vulcanizate properties studied. Attempts have also been made to find out a suitable recipe to prepare ENR above room temperature, with a view to reducing the overall reaction time. Attempts have also been made to identify a simple and cheap method of coagulation of ENR latex.

3. STUDIES ON COMPRESSION SET OF NR VULCANIZATES

To study the influence of the type and amount of fillers on compression set, three varieties of fillers were chosen at different levels: (i) HAF black at 0, 5, 10, 20, 40, 50 and 60 phr, (ii) china clay at 0, 20, 40, 80, 100, 150 and 200 phr, and (iii) precipitated silica at 0, 5, 10, 20, 40, 50 and 60 phr. Only the conventional cure system was tried. The compression set values were determined at 70, 50, 30, 20, 10, 0, –5, –10, –20°C for 22 hours and 96 hours.

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

The resistance of NR–1, 2–PB blends to irradiation was evaluated. Both unfilled and filled blends were studied. It was observed that radiation resistance of the blends is generally inferior to that of natural rubber. As a result of irradiation modulus of the blends increased, but tensile strength and elongation decreased significantly.

5. STUDIES ON THE USE OF 1, 2–PB AS A SUBSTITUTE FOR HIGH STYRENE RESIN IN MICROCELLULAR SOLES

To evaluate the suitability of 1, 2–PB as a substitute for high styrene resin in microcellular sole, the following studies were conducted:–

(1) Effect of concentration of 1, 2–PB on the technical properties of microcellular soles in comparison with the conventional sole made out of a 70/30 blend of NR and SBR–1958. From this study a 70/30 blend of NR–1, 2–PB was selected for further studies. The mixes studied and their technical properties are given in Tables–Chem. 1 and Chem. 2.

(2) Effect of fillers in different combinations on the technical properties of soles made from a 70/30 blend of NR–1, 2–PB.

(3) Effect of different concentrations of blowing agent on the technical properties of the soles made out of a 70/30 blend of NR–1, 2–PB with three different filler combinations.

(4) Cell characteristics of the soles made out of NR, 70/30 blends of NR/SBR–1958 and NR–1, 2PB using scanning electron microscope. Effects of different fillers and concentration of blowing agent on cell characteristics were also included in the study.

From the studies it was observed that blending of 1, 2–PB with natural rubber can contribute higher output, lightness, higher flex life and less blooming. M. C. soles prepared from a 70/30 blend of NR–1, 2–PB show slightly inferior technical properties compared to the SBR–high styrene based one. This can be attributed to the slow cure rate and the lower degree of crosslinking of 1, 2–PB compared to styrene butadiene rubber. China clay/silica/aluminium silicate in the proportion 60/30/15 was found to be an acceptable filler combination for NR–1, 2–PB based soles. Of the mixes studied, a 70/30 blend of NR–1, 2–PB with 7.0 phr of blowing agent and with the above filler combination gave the best set of properties required for the M. C. soles. Though the reduction in blowing reduced the output, it improved the technical properties of the product. Scanning electron microscopic studies serve as supporting evidence for the observed variation in the properties of the different products.

6. DEVELOPMENT OF CHEMICAL RESISTANT NR COMPOUNDS

To study the effect of ageing of NR vulcanizates in phosphoric acid media, six compounds were prepared. Formulations are given in Table–Chem. 3. The vulcanizates prepared from these mixes were immersed in a 40% solution of phosphoric acid at 70°, 80° and 90°C for different periods. The properties of the samples were evaluated after ageing. It was observed that there is no significant reduction in properties even after ageing for two weeks at 70°C and 96 hours at 80°C. Ageing at 90°C for one week causes considerable reduction in properties (Table–Chem. 4). It is found that retention of tensile properties is much better in the case of the mixes containing barytes.

7. PREPARATION AND PROPERTIES OF DEPOLYMERISED NATURAL RUBBER

The existing depolymerisation apparatus was modified to avoid large variation in depolymerisation parameters. Conditions for preparation of liquid natural rubber was standardised and products of different viscosities could be prepared by controlling the extent of mastication, temperature of depolymerisation, stirring, additives and depolymerisation time. By choosing appropriate conditions, liquid natural rubber of desired viscosity could be produced.

Use of liquid natural rubber as a reactive plasticiser for nitrile rubber was studied by evaluating the rheological properties of compounds plasticised from 0–20 phr in comparison with dibutyl phthalate (DBP). The technological properties of the mixes containing liquid natural rubber and DBP were also evaluated. It was found that incorporation of liquid natural rubber improves properties such as green strength, mill shrinkage and compression set. Rheological studies showed that liquid natural rubber systems at high temperatures and high shear rates have lower viscosity than the corresponding DBP compounds. Die swell also decreased with the incorporation of liquid natural rubber.

8. STUDIES ON DEGRADATION OF NATURAL RUBBER

A project was initiated, to study degradation of natural rubber under different environments and methods of improving performance of NR vulcanizates.

8.1 Effect of chelating agents in the presence of non-black fillers.

EDTA with calcium oxide at different proportions were tried as a chelating agent for pro-oxidants like iron present in china clay-filled NR compounds. However, the retention of properties after ageing of the vulcanizates was found to be negligible.

8.2 Effect of bound antioxidants.

4–Nitroso diphenylamine and 4–nitrosophenol were evaluated for their bound antioxidant characteristics, in comparison with conventional antioxidants, (4020 NA) and TDQ (HSL). The formulation of the mixes are given in Table–Chem. 5.

The leaching characteristics of the antioxidants in the vulcanizates were evaluated after ageing the samples at 100°C in 1% soap solution for 96 hours. As the initial screening did not show any clear trend, dosage of curatives, cure temperature, etc. were varied. But the performance of all the vulcanizates was only comparable. Further trials are being carried out.

8.3 Effect of fillers.

To study the contribution of fillers on degradation of NR vulcanizates, six fillers (HAF black, precipitated calcium carbonate, precipitated silica, whiting, mica and talc) were evaluated. The retention in tensile properties of the vulcanizate, volume fraction (Vr), sole content, etc. were evaluated after ageing at 70°C and 100°C for different time intervals (6, 12, 24, 48, 72 and 96 hours). Studies are being continued to correlate the data on the observed degradation in tensile properties with the network structure.

8.4 Effect of antioxidant on green strength.

To study whether degradation of NR has any effect on green strength of rubber compounds, different compounds have been prepared with and without antioxidants. Green strength of the compounds were measured at a regular time interval of 30 days. The studies are in progress.

9. STRUCTURE PROPERTY RELATIONSHIP IN NR LATEX VULCANIZATES

Properties of a rubber vulcanizate depend very much upon its structure and by manipulating the structure it is possible to prepare vulcanizates of desired properties. A number of studies on structure property relationship in vulcanizates prepared from dry rubber had been made. However such studies are very scanty in the case of latex vulcanizates. Therefore a project was initiated to study the network structure of different types of latex vulcanizates and their technical properties. Cast films from prevulcanized and postvulcanized latex compounds were prepared and the tensile properties determined. Attempts were made to study the morphology of the films using scanning electron microscope. The effect of leaching in water on the tensile properties was also evaluated.

10. STUDIES ON FACTORS AFFECTING TRANSPARENCY OF LATEX VULCANIZATES

The preparation of transparent rubber products is a matter of interest particularly to certain latex products manufacturers. In latex product manufacture ingredients like vulcanizing agents, fillers, etc. change the optical properties of the polymer. So special attention is required in the choice of different ingredients for preparing transparent rubber vulcanizates. A method for measuring transparency of latex vulcanizates using a UV–visible spectrophotometer was standardised. The effects of various additives on the transparency of latex vulcanizates are being assessed.

11. STUDIES ON THERMOPLASTIC NATURAL RUBBER

A project was initiated to develop thermoplastic rubber compounds from natural rubber/polypropylene blends. The effect of various cure systems for the dynamic vulcanization of the rubber phase was studied with a view to improving the interfacial bonding between the two polymer phases, and also to improve the overall physical properties. The compositions studied are given in Table–Chem. 6. The processing characteristics of these blends are given in Table–Chem. 7. and other physical properties in Table-Chem. 8. It was found that the blends containing phenol formaldehyde resin as curing agent did not flow as freely as the other blends. It was not possible even to measure the melt flow index in those cases. The flow behaviour index as given in Table-Chem. 8, also confirmed that the flow properties of the blends containing phenol formaldehyde resin were severely affected. The physical properties of the blends containing the resin system are comparable to those with the mixed crosslinking systems and significantly better than those containing dicumyl peroxide.

12. DEVELOPMENT OF RUBBER COMPOUNDS/PRODUCTS

(i) Carpet backing formulations based on NR latex specifically meant for polypropylene fabric, (ii) Rubber 'O' rings for watches and (iii) NR based solution adhesive for puncture sealing of cycle tubes were developed.

Table-Chem. 1. *Formulaton of mixes.*

Ingredients	Mix Numbers							
	1	2	3	4	5	6	7	8
Natural rubber	70	35	100	90	80	70	60	40
SBR — 1958	30	30	—	—	—	—	—	—
SBR — 1502	—	35	—	—	—	—	—	—
1, 2-Polybutadiene	—	—	—	10	20	30	40	60
Stearic acid	2	2	2	2	2	2	2	2
Zinc oxide	5	5	5	5	5	5	5	5
Titanium dioxide	5	5	5	5	5	5	5	5
Antioxidant SP	1	1	1	1	1	1	1	1
Precipitated silica	30	30	30	30	30	30	30	30
China clay	60	60	60	60	60	60	60	60
Aluminium silicate	15	15	15	15	15	15	15	15
Diethylene glycol	2	2	2	2	2	2	2	2
Naphthenic oil	10	10	10	10	10	10	10	10
MBTS	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
TMTD	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sulphur	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
DNPT	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0

Table-Chem. 2. *Effect of concentration of* 1, 2–*PB on technical properties of microcellular soles.*

Property	Mix Numbers							
	1	2	3	4	5	6	7	8
Rheometric maximum torque (dN. M)	51	57	60	53	46	45	40	30
Rheometric minimum torque (dN. M)	8	17	11	12	10	10	6	5
Time for optimum cure (minutes)	4.7	4.5	3.4	3.2	3.4	4.5	4.9	6.4
Cure rate index	55.5	55.5	58.8	58.8	58.8	33.3	33.3	22.2
Relative density	0.502	0.54	0.75	0.71	0.65	0.48	0.45	0.38
Hardness (Shore A)	43	47	35	34	32	30	29	27
Change in hardness (After ageing at 100 ± 1°C, 24 hours)	1	1	–1	0	0	2	2	0
Compression set (%)	20.0	19.0	8.2	8.8	12.5	24.7	29.5	34.5
Split tear strength (N)	36.0	54.0	49.5	48.0	45.0	35.0	33.0	32.0
Expansion ratio	1.7	1.327	1.326	1.348	1.398	1.770	1.795	2.179
Abrasion loss (mm^3)	320	255	158	199	214	337	358	434
Water absorption (%)	12.5	16.7	7.2	9.5	11.0	34.5	33.5	38.3
Shrinkage at 100 ± 1°C, 1 hr, (%)	1.2	0.65	0.65	0.91	0.99	1.76	1.98	3.1
Room temperature shrinkage (%)	0.33	0	0.34	0.32	0.33	0.33	0.33	0.33
Flex resistance (Kilocycles to crack initiation)	300	500	800	800	800	800	800	800

Table–Chem. 3. *Formulation of mixes.*

Ingredients	Without antioxidant			With antioxidant		
	I	II	III	IA	IIA	IIIA
Natural rubber	100	100	100	100	100	100
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

Table-Chem. 4. *Changes in tensile properties after ageing under phosphoric acid at 90°C for different periods.*

Sample	Original					90°C — 24 hrs					90°C — 48 hrs					90°C — 168 hrs				
	M100	M200	M300	T.S. (MPa)	E.B. (%)	M100	M200	M300	T.S. (MPa)	E.B. (%)	M100	M200	M300	T.S. (MPa)	E.B. (%)	M100	M200	M300	T.S. (MPa)	E.B. (%)
I	1.94	4.33	7.83	26.78	697	3.2	7.5	13.3	28.4	529	3.1	7.2	12.6	27.1	531	2.5	5.7	10.5	13.8	370
IA	2.30	3.2	9.3	27.3	697	3.1	7.1	12.4	29.3	528	3.1	7.1	12.3	27.1	550	2.7	6.2	11.0	13.6	361
II	1.58	3.06	4.9	13.7	646	2.0	3.5	5.2	15.3	673	1.8	3.2	3.98	14.7	698	1.3	2.04	2.8	10.8	772
IIA	1.37	2.53	3.9	13.96	685	1.95	3.4	5.1	16.5	693	1.7	2.8	3.98	14.7	697	1.6	2.2	2.8	9.4	722
III	0.90	1.2	1.64	15.2	893	1.3	1.8	2.5	16.8	783	1.3	1.8	2.4	18.2	813	1.1	1.46	1.9	15.5	895
IIIA	0.53	1.30	1.80	14.3	850	1.3	1.83	2.6	17.2	780	1.3	1.8	2.5	18.6	816	1.1	1.37	1.85	15.9	15.9

Table–Chem. 5. *Formulation of mixes.*

Ingredient	1	2	3	4	5
Natural rubber	100	100	100	100	100
Stearic acid	2	2	2	2	2
Zinc oxide	5	5	5	5	5
4–nitroso diphenylamine	—	1	—	—	—
4–nitrosophenol	—	—	1	—	—
Antioxidant 4020NA	—	—	—	1	—
Antioxidant HS (TDQ)	—	—	—	—	1
Precipitated calcium carbonate	20	20	20	20	20
Talc	5	5	5	5	5
MOR	1.2	1.2	1.2	1.2	1.2
TMT	0.3	0.3	0.3	0.3	0.3
Sulphur	1.0	1.0	1.0	1.0	1.0

Table–Chem. 6. *Composition of samples.*

Ingredients	1	2	3	4	5	6	7
Natural rubber	60	60	60	60	60	60	60
Polypropylene	40	40	40	40	40	40	40
Dicumylperoxide	—	3	0.6	—	—	—	—
Zinc oxide	—	—	3.0	2	3	1	—
Stearic acid	—	—	1.2	—	—	—	—
CBS	—	—	0.6	—	—	—	—
TMTD	—	—	0.75	—	—	—	—
Sulphur	—	—	0.09	—	—	—	—
SP 1045	—	—	—	4	6	2	4
$SnCl_2$	—	—	—	—	—	—	1

Table–Chem. 7. *Processing characteristics.*

Sl.No.	Properties	1	2	3	4	5	6	7
1.	MFI g/10 mts (200°C and 2.16 kg load)	3.7	1.25	0.055	No material flow			—
2.	Flow behaviour index n'	0.34	0.34	0.23	0.25	0.21	0.18	0.20

Table–Chem. 8. *Physical properties.*

Sl.No.	Properties	1	2	3	4	5	6	7
1.	Modulus at 100% elongation	6.00	4.45	8.80	8.45	9.10	7.40	8.75
2.	Tensile strength (N/mm^2)	6.23	4.92	18.30	14.35	11.7	10.6	13.4
3.	Elongation at break (%)	130	152	378	250	167	200	275
4.	Tear resistance (N/mm)	54.6	85.4	84.6	85.7	103.4	83.2	88.0
5.	Hardness (Shore A)	83.5	86.0	85.0	89.0	90.0	88.5	91.5
6.	Abrasion loss (mm^3) DIN–LOAD 5N	146	68.6	78.4	83.1	81.7	130.4	92.1
7.	Specific gravity	0.92	0.92	0.94	0.93	0.94	0.93	0.925
8.	Tension set (%) at 25 ± 2°C	36	36	12	12	8	20	24
9.	Stress relaxation at 100% elongation after 10^4 secs.	79.78	80.21	62.6	65.12	61.59	—	—
10.	Compression set (%) at 25 ± 2°C	20	3.6	6.8	6.9	5.6	18	6.3
11.	Rebound resilience (%)	32.63	36.81	40.07	40.29	42.59	37.35	35.24

AGRICULTURAL ECONOMICS DIVISION

The Agricultural Economics Division is undertaking studies connected with economics of rubber plantation industry. Studies connected with evaluation of planting materials, by-products from plantations, management aspects, etc. were in progress.

1. EVALUATION OF PLANTING MATERIALS UNDER COMMERCIAL PLANTING

Evaluation of planting materials under commercial planting was continued. Monthly yield data were collected from forty estates.

Short term study was undertaken to assess the potential of seven new clones in large plantations. Accordingly visits were made to six estates of M/s Harrisons Malayalam Limited and data collected on PB 217 and PB 235.

Popularity of different planting materials has been assessed based on the data of 40 estates. Taking popularity and yield as criteria, 10 planting materials have been selected for a detailed econometric analysis. The final yield statement for the third report has been prepared.

Yield of selected planting materials in one of the largest rubber planting companies in India was analysed. This analysis was further extended to examine whether the planting policy of the company was in tune with the yield performance of the selected materials. The influence of two variables viz., the year of tapping and the density on the yield, was also analysed.

2. STUDIES ON PRODUCTION AND UTILIZATION OF RUBBER WOOD

Studies were carried out regularly with a view to help the present and the prospective users of rubber wood and to increase the industrial potential. These have generated an awareness of the vast scope for utilisation of rubber wood. The fact that the industry is worth around Rs. 400 million has also been brought out from the studies. The estimated consumption of rubber wood was ascertained by visiting important centres of rubber wood use.

3. STUDIES ON PRODUCTION AND UTILIZATION OF RUBBER SEED OIL

The scope and potential of rubber seed oil and oil cake manufacturing sector were brought out by the studies. The studies showed that the contribution of this sector to the national economy is around Rs. 70 million annually. The estimate of rubber seed oil production was made by visiting important production centres such as Virudhunagar and Madurai in Tamil Nadu. The production of rubber seed oil during 1988 was estimated at 4750 tonnes.

4. COMMERCIAL PRODUCTION OF HONEY FROM RUBBER PLANTATIONS

The fact that 40% of Indian honey is produced from rubber plantations was brought out by the study. The estimate of production of honey was made by visiting the important honey producing centres. The study also examined the economics of bee keeping in rubber plantations.

5. CO-OPERATIVE SOCIETIES AS NODAL POINT FOR DISSEMINATION OF SCIENTIFIC INFORMATION

The study has been completed and it was revealed that the rubber growers were giving leadership for agricultural development through co-operative societies in Kerala.

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

The study is being continued. Visits were made to branches of nine banks at Palai. Details of rubber growers who had availed of agricultural term loans during 1980 to 1988 were collected by visiting 120 sample holdings.

7. STUDY OF BROWN BAST

This study is an attempt to quantify the losses due to brown bast and also to investigate the importance of different symptoms in the field. Visits were made to two large estates and 20 small holdings and data were collected.

8. ROLE OF GOVERNMENT AND STRUCTURAL CHANGES IN RUBBER PLANTATION INDUSTRY

The study was taken up to understand the structural changes (ownership and size) in the rubber plantation industry since 1950–51 upto 1985–86. The study has been completed and a paper was published. The policies followed by the government were found to have significant consequences on the structure of the industry in terms of changes favouring growth of a dominant small holding sector. Planting of rubber in the traditional and the non-traditional areas by government agencies has resulted in marginal changes in the geographical distribution of area under rubber and significant changes in ownership pattern in the estate sector.

9. STUDY ON REPLACEMENT OF NR BY PLASTICS IN INDIA

The objectives of the study are to understand the extent of replacement of NR by plastics in selected industries, to identify the different forms of plastics which are making inroads into the NR market, to assess the growth potential of the selected industries and the trends in the consumption of NR and plastics and to estimate the prospective share of NR and plastics in the selected industries. Visits were made to CIPET, Madras and basic data required for the study were collected.

10. CENSUS OF UNREGISTERED RUBBER SMALL HOLDINGS IN A WARD IN PULIYANNOOR VILLAGE

The study analyses the conditions of unregistered rubber small holdings to identify the reasons for not registering with the Rubber Board. Visits were made to 175 farmers in Ward No. 1 of Puliyannoor Village and collected the data.

11. CONDITION OF WORKERS IN THE RUBBER PROCESSING FACTORIES

In order to have adequate data on the above subject a study has been taken up. Visits were made to 65 crepe mills in Kerala and data were collected by the interview method.

12. SCALE OF PRODUCTION, LOCATION AND THE TRENDS IN COST OF PROCESSING — A CASE STUDY OF BLOCK RUBBER PROCESSING INDUSTRY IN INDIA

The main objective of the study is to understand the existing relationship between the size of the units, capacity utilization, location and the average cost of processing among the various size groups of crumb rubber factories. Visits were made to 15 units to collect data.

13. STUDY ON COVER CROPS AND THE SAVINGS IN COST OF PRODUCTION

The survey is being continued. Sixty two farmers were contacted in Palai region and data were collected.

14. ECONOMICS OF DIFFERENT LEVELS OF FERTILIZER APPLICATION

The survey is being continued. Eighty one farmers were contacted in Palai region to collect the data.

15. ECONOMICS OF RAINGUARDING

A study on the economics of two types of rainguarding materials was also taken up. For this purpose, data were collected from seven large estates and 50 small holdings. The results of the study are being analysed.

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. About 875 genotypes of wild Brazilian germplasm collections received from the Malaysian Centre were established and maintained in the source bush nursery at the Station.

A total rainfall of 3375.3 mm (Table–CES. 1) was received at the Station during 1988–89 period.

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

Month	Rainfall (mm)
April 1988	327.2
May 1988	196.3
June 1988	499.7
July 1988	569.5
August 1988	577.9
September 1988	597.6
October 1988	171.8
November 1988	245.5
December 1988	59.7
January 1989	19.2
February 1989	3.8
March 1989	107.1
Total	3375.3

There are 194 permanent workers and 212 temporary casual workers attached to the Station. The crop produced during the period under review was 2,89,451.13 kg.

RESEARCH COMPLEX FOR NORTH EASTERN REGION

The Research Complex of the Rubber Research Institute of India with its headquarters at Guwahati and Regional Research Stations in Assam, Meghalaya, Mizoram and Tripura continued the efforts to evolve agrotechnology against the agroclimatic constraints prevailing in the North-Eastern Region. The thrust areas of research are to breed and identify clones suitable for different agroclimatic conditions, evolving agromanagement techniques suitable for local conditions, selection of suitable intercrops to provide income during immature phase, etc. Constant watch on new diseases and pests and attempts to evolve suitable techniques for their control were also continued. Studies on nutritional requirements of rubber and survey of fertility status also formed a major area of research. Attempts to create variability to broaden the base for selection were made through biotechnology.

REGIONAL RESEARCH STATION, ASSAM

This station concentrated on evaluation of clones and investigations on nutrition, pests and diseases including their control. Embryogenesis was attempted in the biotechnology wing. The research farm is located at Sarutari, 25 km away from Guwahati, at 26°05' N latitude and 91°54' E longitude, at an elevation of 50 m from MSL.

1. MULTIDISCIPLINARY EVALUATION OF CLONES

Thirty plants from each clone were selected, from the 1985 trial laid out in a single tree single plot, completely randomised design with 50 replications, for recording periodic observations. Girth was recorded four times in a year, i.e. last weeks of February, May, August and November in order to find out the effect of low temperature and soil moisture stress on growth. RRII 118 recorded maximum average girth (24.95 cm) closely followed by RRIM 600 (24.7 cm), PB 235 (24.5 cm) and RRIM 605 (23.59 cm), whereas Gl 1 recorded minimum average girth (18.9 cm), in February, 1989.

In terms of annual girth increment PB 235 registered the maximum (10.30 cm) closely followed by RRIM 605 (10.24 cm), RRII 118 (10.15 cm) and RRIM 600 (10.0 cm). Gl 1 recorded minimum girth increment. Percentage girth increment in the descending order was of RRIM 605 (76.8%) followed by PB 235 (72.5%), Gl 1 (70.1%), PB 86 (70.2%), and RRII 105 (68.2%). Clones PB 86 and Gl 1 performed well during December to February, while the performance of RRII 203 was the least.

The second trial was started in 1986 with another set of ten clones keeping RRII 105 and RRII 118 as common. As in the previous year, RRII 118 recorded maximum girth (15.62 cm) followed by PB 310 (14.35 cm). Performance of clones, like RRIC 102, RRII 208, RRII 105 and PB 311, was comparable. PCK 1 recorded the least girth (11.76 cm). Percentage girth increase during winter period (Dec–Feb) was maximum for RRII 118 (17.17%), while RRIC 105 registered the minimum value (5.2%). Clones like RRII 105 and PB 260 which attained 26–28 per cent of annual girth increment in the winter of 1987–88 performed poorly during this winter period.

In order to study the performance of modern high yielding clones in farmers field, seven clones have been planted in three agroclimatically different locations.

2. NUTRITIONAL STUDIES (IMMATURE PHASE)

Hevea tree responds to addition of fertilizers, particularly in soils which are low in nutrient status. The physico-chemical properties of the soils and the agroclimatic factors prevalent in this region are quite different from those in the traditional region. This warrants specific nutrient management.

To find out the optimum requirement of fertilizers for *Hevea* grown in association with natural ground cover, an on farm trial with nitrogen, phosphorus and potassium at three levels each laid out at Mandipather (East Garo Hills, Meghalaya) with clone RRIM 600 was continued. The initial observations suggest good response to higher levels of applied nitrogen. However, from the existing data a clear response to P and K could not be established though an increase in girth for K at 20 $kgha^{-1}$ has been noticed.

Another trial was laid out in 1987 with factorial combinations of nitrogen at four levels (0, 20, 40 and 60 $kgha^{-1}$) and phosphorus and potassium at three levels (0, 20 and 40 $kgha^{-1}$) each with natural ground cover and the clone being RRII 105, at Nayekgoan (Dhubri, Assam). The data on mean girth increment show that young rubber plants respond to higher levels of nitrogen in general. Similar trend was indicated in plants receiving highest levels of phosphorus and potassium. For assessment of initial nutrient status, soil samples collected from the trial are under analysis.

The objects of the third trial located at Borgang Rubber Plantation, Rampur, Sonitpur, Assam are to assess the optimum nitrogen requirement of rubber under three ground covers and the effect of ground covers on the physico-chemical properties of soil. The experimental details are as follows:

Whole plot : Ground cover management
Pueraria
Mucuna
Natural cover.

Sub plot : Nitrogen levels for the first four years.
N_1 40 kg ha^{-1} N_2 80 kg ha^{-1}

Sub sub plot : Nitrogen levels from fifth year
N_0 0 kg ha^{-1} N_3 75 kg ha^{-1}
N_1 25 kg ha^{-1} N_4 100 kg ha^{-1}
N_2 50 kg ha^{-1} N_5 125 kg ha^{-1}

Number of replications : 3

Clone : RRIM 600

Plot wise soil samples were collected to study the pre-treatment nutrient status and physical properties of the experimental area. A profile was opened for profile description

and initial characterisation. Changes in physico-chemical properties of soil and nutrient enrichment are envisaged to be studied with relevance to its impact on growth of *Hevea*.

3. STUDIES ON THE INTERACTION BETWEEN POTASSIUM AND MAGNESIUM

This study was initiated in two locations (Sarutari, Guwahati and Nayekgoan, Dhubri, Assam) in 1987 with clone RRII 105. Pre-treatment height and girth were recorded. Routine cultural operations were carried out and the required treatments were incorporated. Potassium and magnesium were applied in the form of MOP and MgSO4, respectively at the rate of 0, 20 and 40 kg $K_2O\ ha^{-1}$ and 0, 7.50 and 15 kg $MgOha^{-1}$, respectively. Girth and height was recorded twice in a year.

4. COMPARISON OF ROCK PHOSPHATE AND SUPER PHOSPHATE AS SOURCE OF P FOR YOUNG RUBBER

The trial at Sarutari started in 1986 with clone RRIM 600, to compare the efficiency of different sources of phosphatic fertilisers and their combinations used for rubber in its immature phase, was continued. Periodic observations on girth and height of plants are being taken twice (June and December) in a year. Application of fertilisers as per treatment combinations was undertaken twice. Routine cultural operations were followed in the experimental area. The data collected so far are being summarised and studied.

The second trial was started at Nayekgoan, Dhubri as an on-farm trial in 1987 with clone RRII 600. Pre-treatment collection of soil was done for analysis. Routine cultural operations including cover crop maintenance were carried out. Fertilizer application was made as per treatment schedule. The data collected are being studied.

5. EMBRYOGENESIS/ORGANOGENESIS FROM EXCISED ORGANS OF *HEVEA*

An experiment was started to produce adventitious buds/embryos from various explants of *Hevea*. Very tender parts of budgrafted plants were used. Several phytohormones individually or in combinations were tested. Some of the combinations showed callus formation from cut ends of stem and leaf petiole. Direct organ formation on explants was not observed. However, callus produced from leaves regenerated globular heart type structures similar to early stages of embryo development. These structures did not develop further in the 15 media tested.

6. ANTHER CULTURE AND PLANTLET REGENERATION

Anther culture of a few important clones was continued. Nutritional requirement for induction of callus from anther was standardised. The medium named S–4 was formulated on the basis of information gathered through trials. About 350 phytohormone combinations were tested for the induction of callus in the presence of light as well as in dark. Some combinations of hormones in S–4 medium induced callus formation from anthers. It was observed that callus induced in dark proliferates faster than the callus induced in light when cultured in the presence of light. Rate of chlorophyll synthesis was also faster in callus induced in dark.

Since none of the phytohormone combinations tested for induction of callus showed morphogenesis, it became essential to change the medium. Callus in morphogenic medium regenerated globular and heart shaped structures which further developed into different stages of androgenic embryo forms. The embryo development stages observed were heart, trumpet, torpedo and cotyledon types. It was also noticed that these different forms of embryos ceased growth or differentiation when kept in the same medium. After separating the embryos from callus they were transferred to plantlet forming medium. A few of the embryos grew further forming single tap root and cotyledonary leaf. Studies of the development of complete plants from somatic embryos are in progress.

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

Studies involving *Agrobacterium tumefaciens* as carrier depends upon the morphogenic potential of undifferentiated tissue of the crop under study. Fortunately, morphogenic potential of anther derived undifferentiated tissue of *Hevea brasiliensis* has been established. Our earlier studies have demonstrated that two strains of *A. tumefaciens* can transform young *Hevea* stem cells *in vivo*. Both strains transformed the cells resulting in actively growing crown galls characteristic of T–DNA transfer into host cell genome. Anther derived callus was treated with both the strains. It was observed that the tissue proliferated faster than untreated ones and the tissues showed similar growth when gradually brought stepwise to hormone free medium. Growth in hormone free medium confirmed that the cells have been transformed.

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

The survey of various diseases and pests was carried out during summer, rainy and winter months. Several plantations in Assam, Meghalaya and Tripura were visited and on the spot assessment of incidence and intensity of various diseases and pests affecting rubber was made.

Leaf diseases of rubber caused by *Drechslera heveae* (bird's eye spot), *Gloeosporium alborubrum* and *Colletotrichum gleosporiodes* (secondary leaf fall) and *Corynespora cassiicola* were observed in some of the plantations of Assam, Meghalaya and Tripura. The intensity of these diseases was very mild except in nursery and very young rubber plantations. However, heavy defoliation and die-back was recorded this year also in one of the mature plantations in Meghalaya (Umling). Secondary leaf fall caused by *Gloeosporium* was observed in different locations of North Eastern Region, especially in nursery and young plantations. Leaf spot disease caused by *Alternaria* sp. was noticed in germpalsm nursery at RRS, Guwahati farm and pathogenicity of this fungus was established by Koch's postulation studies.

Abnormal leaf fall disease caused by *Phytophthora* spp. was noticed in Patichery and Pathalia rubber estates of Tripura. Infection of pods by *Phytophthora* spp. was also observed in the locations surveyed in Sorutari and Ouguri in Assam, Umling and Baghmara in Meghalaya and in Patichery, Pathalia, Takmachera, Khomai and Madhuban in Tripura. Samples were collected and pathogen isolated in culture.

Powdery mildew disease caused by *Oidium heveae* was observed in plants of all stages during winter months in most of the plantations surveyed. Intensity was very low in older plantations compared to nurseries and immature fields. The agrometeorological data collected from 10 locations revealed that the prevailing temperature (10–15°C), mist with heavy dew formation and high relative humidity (75–80%) in this region during the time of refoliation favours the incidence of this disease.

Bark rot disease caused by *Phytophthora* spp. was observed in RRIM 600 plantations at Madhuban in Tripura. Other stem diseases like pink disease etc. have not been noticed so far in Tripura.

Brown root rot disease caused by *Phellinus noxius* was observed in a few plants in North–Eastern Region.

Problems due to attack of white ants have been reported from all parts of North Eastern Region where rubber is being grown. Incidence of scale insects was reported from Borgaon, Ouguri and Sorutari plantations of Assam during December to April. Slugs, snails and caterpillar were observed in Borgaon rubber estate.

9. ISOLATION OF PLANT PATHOGENS OF RUBBER, THEIR IDENTIFICATION AND MAINTENANCE

Phytophthora spp. (10 isolates), *Gloeosporium alborubrum* (7 isolates), *Drechslera heveae* (3 isolates), *Curvularia* sp. (2 isolates), *Alternaria* sp., *Botryodiploidia* sp., *Phellinus* sp., *Phellinus noxius*, *Corticium solmonicolor* and *Guignardia* sp. were isolated from samples collected from various regions in North–East. Some of these organisms are mild pathogens and to confirm their pathogenicity further studies are in progress.

10. CHARACTERISATION OF THE AGRO-TOPOCLIMATE OF NORTH-EASTERN REGION OF INDIA FOR RUBBER CULTIVATION

For an assessment of the agroclimatic potential of North-East India for rubber cultivation, ten climatological stations, representative of all the agroclimatic regions of the area, were selected and data on rainfall, air temperature (maximum and minimum), relative humidity, sunshine hours, wind, pan evaporation, etc. were collected and analysed in the light of the agro-climatic requirements of rubber. Based on these studies crop-weather calendars for rubber have been prepared. Study of the mean annual rainfall over the area reveals that even in the driest years the rainfall received is adequate enough to meet the total potential evaporation requirements. Rainfall received was found to be less than evapotraspiration demand during the months of December, January, February and March only, of which December–February (winter months) is period of least growth rate for rubber during which consumptive use of the crop is very less. Temperature well below 10°C lasting for three to four weeks has been observed at most of the places during winter seasons and this has been identified as the most important climatic constraint to rubber cultivation in the Nroth–East. Except in Agartala, wind speed observed were not severe enough to cause mechanical damage to rubber plants. Wind speeds of the order of 3m sec^{-1} were reported from Agartala. Relative humidity observed were found to be within range and not to be a factor limiting growth.

Seasonal and annual maps of rainfall and temperature (maximum and minimum) for the region were prepared. Procurement of the agroclimatological data from the region on magnetic tapes from the National Data Centre, India Meteorological Department and topo-maps of North-Eastern Region from Survey of India are in progress.

11. ESTABLISHMENT OF AGROMETEOROLOGICAL OBSERVATORIES

Class–II agrometeorological observatories have been established and existing ones strengthened in the Regional Rubber Research Stations at Sarutari in Assam, Ganolgre and Darachikgre in Meghalaya and Taranagar in Tripura. Observations on the weather parameters viz. rainfall, temperature, humidity, wind, sunshine, dewfall, evaporation, etc., from these stations are being recorded, tabulated and analysed.

12. MAINTENANCE OF GERMPLASM

3000 genotypes have been imported so far from the germplasm source bush nursery in Malaysia. Budding success was very low due to reasons beyond control. 1048 genotypes from the collections have been established in the budwood nursery at Sorutari farm, Assam and at Taranagar farm, Tripura.

REGIONAL RESEARCH STATION, TRIPURA

The Regional Research Station, Tripura was established in 1979. The station has an administrative office, library, a laboratory and also a farm 66.04 ha in extent at Taranagar, 22 km from Agartala town at 23° 53' N latitude and 91° 15' E longitude at an altitude of 16.6 m above MSL. To extend the facility of discriminatory fertilizer usage, a mobile soil and tissue testing laboratory also is attached to the station. A seedling nursery of two ha and a bud-wood nursery with 5000 points are being maintained by the station besides a germplasm collection of 800 points

1. NUTRITIONAL STUDIES ON RUBBER

The trial was started in the year 1980 laid out in a 3^3 factorial confounded design with RRIM 600 as the clone. Girth recording was regularly carried out. Analysis of soil and leaf had been carried out and the data had been processed to assess the influence of applied nutrients on soil nutrient status as well as plant up-take, manifested by the leaf nutrient status.

Table – NET. 1. *Changes in soil and leaf nutrient status at various levels of fertilizer application.*

Treatment levels	Soil (mg 100 g^{-1})			Leaf (%)**		
	0	1	2	0	1	2
N	0.87*	0.84*	0.89*	—	—	—
P	0.47	2.43	7.27	0.15	0.19	0.22
K	4.58	5.94	10.93	0.74	0.87	0.88

* Percentage organic carbon.

** Leaf nitrogen could not be estimated.

The data (Table – NET. 1) reveals a higher nutrient status in both soil as well as leaf, in plots receiving higher levels of nutrients. Phosphorus and potassium have been observed to be high in the treatments where higher doses of nutrients have been provided, the change of phosphorus being conspicuous with change in levels. It is also observed that soil and leaf calcium increased with higher doses of phosphorus the reason being input of calcium through phosphate rock. Increase of calcium available in soils has been substantial and the pH also has been found to change in plots receiving higher doses of phosphorus. A slight depression in soil as well as leaf magnesium is noticed in plots receiving higher levels of potassium (Table-NET. 2).

Table – NET. 2. *Changes in calcium and magnesium at different levels of applied P and K.*

Treatment	pH	Calcium Soil* (mg $100g^{-1}$)	leaf (%)	Treatment	Magnesium Soil** (mg $100g^{-1}$)	leaf (%)
P_0	4.44	6.18	1.02	K_0	3.74	0.35
P_1	4.48	11.08	1.10	K_1	2.98	0.31
P_2	4.53	16.44	1.24	K_2	3.06	0.32

* Available Calcium.
** Available Magnesium.

The levels of phosphorus (P_2O_5) provided were 0, 30 and 60 kg and that of potassium (K_20) 0, 20 and 40 kg per ha. It is seen from the analytical results that the above levels are rather inadequate to maintain a leaf nutrient level in the medium range as per the critical levels currently followed.

2. STUDIES ON PLANTING TECHNIQUES

This trial was commenced in 1981. Data on girth recorded in April and November 1988 and comparison between different treatments are given in Table – NET. 3.

The treatments with 14 months old green budded polybag plants is found to be superior. Trees in this treatment have reached tappable girth, but were affected by hailstorm.

Table – NET. 3. *Girth, girth increment and percentage increase in girth.*

Treatments	Girth (cm) April 88	Nov. 88	Increment (cm)	% Increase
1. Conventional brown budded stumps from 1980 nursery budded during 1981	39.66	44.21	4.55	11.47
2. Brown budded stumps from 1979 nursery budded during 1980 and allowed to grow in nursery till planting season, 1981	39.71	46.37	6.60	16.20
3. Brown budded stumps from 1979 nursery budded during 1981.	41.48	45.99	4.51	10.87
4. Two months old green budded polybag plants	41.18	46.58	5.40	13.11
5. Fourteen months old green budded polybag plants.	46.46	50.25	3.79	8.15

3. STUDIES ON INTERCROPPING

The experiment was laid out in 1987 as an 'on-farm trial' at Takarjala about 55 km away in the plantation of the Tripura Rehabilitation Plantation Corporation. The trial had banana, pineapple, arhar and maize as intercrops and a treatment with covercrop as the control. The performance of banana as well as pineapple had been satisfactory and in terms of girth of plants during November 1988 the treatment with pineapple was superior. Due to various management problems the trial has to be discontinued. However, from the data generated hitherto economics of the various intercrops is being worked out.

4. STUDIES ON HIGH DENSITY PLANTING

The trial started in the year 1983 and later replanted in 1987 is being maintained. A large number of vacancies resulted due to extreme winter during 1988-89 season and replanting of the vacant points had been done. The area is being maintained and nutritional treatments were also incorporated. The trial has two clones under three densities with three fertilizer schedules.

5. EVALUATION OF FORMS OF PHOSPHORUS AT THE IMMATURE PHASE

This field experiment was initiated to compare the efficiency of different sources and combinations of phosphatic fertilizers being used in rubber. From the data on girth so far available, a combination of water soluble and water insoluble sources (50 per cent each) is best.

6. NUTRIENT REQUIREMENT DURING THE IMMATURE PHASE OF *HEVEA* PLANTED USING POLYBAG PLANTS

This field experiment was started in 1986 as an on-farm trial at Tulakona in the demonstration farm of the NRETC. The data generated had been pooled and statistically analysed. It was found that during immature phase a higher quantity of fertilizer is required. While polybag plants are used for planting a higher quantity of fertilizer will definitely help in accelerating growth. Water soluble source of phosphorus has also been found to favourably influence growth.

7. NUTRITIONAL TRIAL IN SEEDLING NURSERY

This trial was taken up with a view to evolving a suitable fertilizer recommendation for rubber seedling nursery. 72 factorial treatment combinations (N, P, K, Mg) were tried. The data generated during the second season also reveal that the treatment combination N, P, K_2, MgO (166, 125, 121 and O kg/ha, respectively of N, P_2O_5, K_2O and MgO) was the best. The trial was repeated in 1988-89 season and the results are awaited.

8. DENSITY CUM NUTRITIONAL TRIAL IN SEEDLING NURSERY

This trial, started in 1986, is being concluded after repeating for three seasons. The data of the season will be available by September 1989. The trend of girth and percentage buddable plants reveal that a density of 188 plants per bed (30 cm x 25 cm spacing) is the best and also that at higher planting density a higher fertilizer dose would help in increasing the number of buddable plants.

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

This experiment was taken up with a view to comparing two locally available sources of rock phosphate, namely Purulia and Mussoorie rock phosphates with a water souble source, super phosphate. The trial which started in the year 1987 has been through two seasons. The girth data of the second season is summarised below:

Table – NET. 4. *Girth and increment in girth (cm)*

Treatment	(N:P:K) I	II	III	IV	Girth 1988 March	October	Girth increment
T_1	10:10:5	40:40:20	50:50:25	40:40:20	10.57	16.39	5.82
T_2	10:10:5 (5)*	40:40:20 (20)	50:50:25	40:40:20	10.49	16.51	6.52
T_3	20:20:10	40:40:20	50:50:25	40:40:20	11.03	16.85	5.82
T_4	20:20:10 (10)	40:40:20 (20)	50:50:25	40:40:20	10.39	16.51	6.12
T_5	20:20:10	50:50:25	60:60:30	50:50:25	11.05	17.54	6.49
T_6	20:20:10 (10)	50:50:25 (25)	60:60:30	50:50:25	10.88	18.09	7.21
CD (P = 0.05)						1.52	

* Figures in parenthesis show water soluble form.

Table – NET. 5. *Girth and girth increment under different sources of phosphorus in seedling nursery.*

Source of fertilizer	Mean girth (cm)	% increase over control
1. Mussoorie rock phosphate	10.19	3.06
2. Purulia rock phosphate	10.67	7.89
3. Super phosphate	10.69	8.30
4. Control (no phosphorus)	9.87	—

10. SOIL MOISTURE NUTRIENT INTERACTION IN *HEVEA*

The trial was laid out towards the end of 1987. As envisaged soil moisture levels at different tensions were maintained for the first five months in 1988. Due to gusty winds the poly shade was damaged which subsequently was maintained and the trial continued. Morphological and physiological parameters were recorded. A higher leaf water potential was recorded in treatment receiving higher level of nutrients at the same moisture regime compared to treatment receiving lower amounts. The girth of plants in the treatments under 15 bar was lower. However, between treatments with moisture level 1/3, 1 and 5 bar much difference in girth could not be observed. The data are under processing.

11. SOIL MOISTURE DEPLETION PATTERN UNDER DIFFERENT GROUND COVER MANAGEMENT

The trial was started in 1987 and establishment of cover crop was completed. Moisture depletion pattern will commence from 1990. Girth of rubber plants has been recorded.

12. STUDIES ON NUTRIENT MANAGEMENT

(a) Placement of fertilizer: In the on-farm trial in Mohanpur started in 1988, to compare three methods of application - broadcasting in band and pocket application at two depths, morphological parameters like girth, height and number of whorls were recorded. Influence of magnesium is also monitored. Analysis of soil for initial nutrient status had been carried out. Periodic foliage analysis is envisaged.

(b) Dissolution pattern of different sources of phosphatic fertilizer in soils under *Hevea* in Tripura: A laboratory incubation study was initiated with five sources of phosphatic fertilizer (one water soluble and four water insoluble) to study the dissolution pattern and release of phosphorus in soils under *Hevea* in Tripura. Soil collected from a ten year old plantation was used. Availability was assessed by using Bray II extractant. Data upto 240 days is summarised in Table – NET. 6. The behaviour of single super phosphate is quite contradictory to the reported literature on this subject in the soils of Tripura, as evidenced by comparatively steady extraction. Crop uptake study using *Pueraria* as test crop and phosphate sorption - desorption study also have been initiated.

13. PHYSICOCHEMICAL CHARACTERISTICS OF THE RUBBER GROWING AND POTENTIAL RUBBER GROWING SOILS IN THE NORTH EASTERN REGION.

Studies on the influence of rubber on ecorestoration and recuperation of soils subjected to shifting cultivation were initiated. As a preliminary study differences in physical properties of soils under jhumming practice and rubber have been observed with profile samples collected from the three districts in Tripura.

The data (Table – NET. 7) show that there is a remarkable variation in moisture retention capacity, soil inside the plantation having a higher retention suggesting better

Table – NET. 6. *Dissolution pattern of different sources of phosphorus* (*Av. P mg* $100\ g^{-1}$)

Fertilizer	Period (days) 0	10	20	30	40	55	70	85	100	120	150	180	210	240
1. Mussoorie rock phosphate	0.15	5.08	3.72	3.77	2.68	3.62	2.50	3.57	2.90	2.90	2.28	2.12	2.04	2.63
2. Udaipur rock phosphate	0.15	3.08	1.90	2.25	2.25	2.20	2.30	2.57	2.33	2.80	2.00	1.37	1.40	2.82
3. Purulia rock phosphate	0.15	3.12	1.32	1.41	1.63	2.20	1.46	1.77	1.57	2.00	1.50	1.00	1.40	0.53
4. Maton rock phosphate	0.15	2.30	2.20	1.77	1.65	2.16	1.60	1.73	1.83	2.17	2.10	1.08	1.50	1.41
5. Super phosphate	0.15	3.67	3.20	2.17	2.51	2.90	2.15	2.80	2.50	3.50	1.50	1.44	1.50	2.32
6. Control (no fertilizer)	0.15	0.15	0.15	0.16	0.16	0.10	0.10	0.20	0.10	0.10	0.10	0.10	0.10	0.10

Table – NET. 7. *Soil moisture retention data (South Tripura).*

Depth (cm)	Tension											
	0.033 MPa		0.1 MPa		0.3 MPa		0.5 MPa		1.0 MPa		1.5 MPa	
	I	O	I	O	I	O	I	O	I	O	I	O
0 – 15	21.05	17.05	19.92	14.94	15.44	10.69	11.69	9.94	11.21	7.94	10.69	6.26
15 – 30	22.14	18.72	20.12	16.02	17.66	12.95	14.53	12.30	14.02	9.91	13.62	8.92
30 – 60	23.81	22.52	21.87	19.78	18.06	17.33	15.26	15.95	14.58	13.98	14.14	12.91
60 – 90	24.47	26.12	22.61	22.66	18.81	19.86	16.16	19.09	15.76	16.20	15.07	16.15
90 – 120	22.88	26.38	22.91	22.88	19.26	20.37	16.67	18.51	15.98	16.66	15.65	15.83
120 –150	23.89	25.50	21.52	22.31	17.88	19.56	15.28	18.22	15.14	16.40	15.02	16.00

(I — Inside plantation; O – Outside plantation soils subjected to jhumming.)

Table – NET. 8. *Fertility rating* (%)

	Depth (cm)	Tripura (439)			Assam (137)			Meghalaya (15)		
		L	M	H	L	M	H	L	M	H
Organic carbon	0–30	56.6	32.33	11	36.0	59.0	5.0	N	100.0	N
	30–60	75.0	25.0	N	67.0	37.4	1.6	40.0	60.0	N
Av. phosphorus	0–30	95.5	4.5	N	95.8	4.2	N	80.0	20.0	N
	30–60	97.0	2.0	N	97.0	2.0	1.0	90.0	10.0	N
Av. potassium	0–30	51.2	47.0	1.8	30.0	66.0	4.0	50.0	50.0	N
	30–60	58.0	42.0	N	30.0	67.0	3.0	60.0	40.0	N
Av. magnesium	0–30	4.0	21.0	75.0	N	1.5	98.3	10.0	N	90.0
	30–60	7.0	26.0	67.0	N	1.0	99.0	10.0	N	90.0

Figures in parenthesis indicate number of samples considered.

moisture conservation. The marked influence is seen in the top 60 cm layer. Further studies on physical parameters are being pursued.

For a thorough study on various physico-chemical properties, electrochemical properties were ascertained. The CEC of soils ranged from 7.88 to 320 mg 100 g^{-1}. The differential thermal analysis pattern obtained for the random samples reveal an illite dominant clay minerelogy.

A fertility rating of the soils under *Hevea* in three states in the North Eastern region has been done (Table – NET. 8).

Based on the data generated from these studies and also depending on the trend of the results of the various field trials besides cashing on the experience gained while offering discriminatory fertilizer recommendations, a new fertilizer recommendation had been evolved for immature rubber for this region which is under publication.

14. STANDARDISATION OF ANALYTICAL METHODS

Monthly collection and analysis of foliage samples of 15 clones to optimise collection of foliage samples was carried out to monitor clonal as well as seasonal variation of nutrients. Difference between sun and shade leaves and chlorophyll content were also estimated.

Bray II is not found to correlate with plant available P considering the growth of *Pueraria* and hence a trial on soil test crop response for P also is under way.

15. SPECIAL AGROMANAGEMENT PRACTICES IN SEEDLING NURSERY.

Trials on observational basis were initiated to mitigate the stress effects in nursery with shading and mulching (polythene sheets and dry mulch) and simultaneously regulating the frequency of irrigation. Shading has been found to increase the buddable plants by 25 per cent and reducing the frequency of irrigation to nearly 60 per cent. Detailed economics of these are being worked out and analysed to make specific recommendations.

16. CLONE TRIAL

This field trial was laid in 1979. Girth recording from the 15 clones was conducted during May, August, November (1988) and Februay (1989). The data were processed and the percentage increment in girth in each quarter was calculated (Table – NET. 10). Bark thickness was also recorded from all the trees. It is found that RRIC 105 still ranks first in girth, RRII 105 ranking 8th (Table – NET. 9). Wintering pattern of the clones is also being recorded.

17. MULTI-DISCIPLINARY EVALUATION OF CLONES

This trial was laid out with 16 clones in 1987 planted with polybag plants. observations on plant height, girth and number of whorls were recorded. Leaf area was recorded during May, August and November 1988. Plant height recording is discontinued from November 1988 onwards since the plants have attained more than 1.25 m height.

Table – NET. 9. *Girth (cm) and girth increment (%).*

	May 1988		August 1988		November 1988		February 1989	
	Girth	Increment	Girth	Increment	Girth	Increment	Girth	Increment
RRII 5	51.71	1.99	53.10	2.68	53.25	0.28	53.99	1.39
RRII 105	55.17	2.93	56.99	3.29	57.49	0.88	57.85	0.63
RRII 118	61.19	0.89	62.95	2.88	63.44	0.78	63.78	0.54
RRII 203	55.75	7.92	57.94	3.93	58.87	1.61	59.45	0.98
RRIM 600	55.35	3.73	57.38	3.67	57.42	0.07	57.87	0.78
RRIM 605	57.27	2.30	59.15	3.28	59.64	0.83	60.06	0.70
RRIM 703	51.14	0.71	53.05	3.74	53.24	0.36	53.86	1.16
PB 86	51.65	2.62	53.76	4.06	54.46	1.30	54.97	0.94
PB 5/51	50.52	1.49	52.38	3.68	52.68	0.57	53.36	1.29
PB 235	59.85	3.40	61.17	2.21	61.53	0.59	62.13	0.98
Gl 1	45.16	1.21	47.12	4.34	47.29	0.36	47.52	0.49
GT 1	54.68	2.22	56.62	3.55	56.95	0.58	57.42	0.83
RRIC 52	58.99	2.63	61.23	3.80	62.18	1.55	62.93	1.21
RRIC 105	65.08	3.43	66.57	2.29	67.14	0.86	67.61	0.70
Haiken 1	47.73	2.42	49.31	3.31	49.67	0.73	49.76	0.18

Due to extreme low temperature during winter, a large number of plants died off, the maximum number being in RRIM 501 (54.35%) followed by RRII 105 (43.47%).

Physiological parameters were recorded during April 1988, October 1988 and January 1989. SLW, RWC and chlorophyll contents were estimated during April 1988 and October 1988. Soil moisture (gravimetric) data at 0–15 cm, 15–30 cm and 30–60 cm depth were recorded.

Seasonal differences were observed during dry (April) and wet (October) months (Table – NET. 10 and 11). Stomatal conductance, transpiration rate, RWC and photosynthesis were found to be higher during dry season whereas SLW decreased during the wet season. Chlorophyll contents increased in some of the clones during wet season. Maximum photosynthetic rate was observed in RRII 203 (10.7 μ mol $m^{-2}s^{-1}$) and RRIM 600 (10.63 μ mol $m^{-2}s^{-1}$) during dry season.

18. PERFORMANCE OF STRESS TOLERANT CLONES IN TRIPURA

This trial, laid out in September 1987 using 12 clones, was continued. Data on plant height, girth, number of whorls and leaf area were recorded. Plant height recording was discontinued from November 1988 onwards. During the winter of 1988–89, a large number of plants died. Leaf fall was minimum in the two Chinese clones S–88–13 and SCATC 93–114 and in PB 86.

Physiological parameters were recorded during April 1988, October 1988 and January 1989. SLW, RWC and chlorophyll contents were estimated during April and October 1988. Soil moisture data at 0–15 cm, 15–30 cm and 30–60 cm depth were recorded.

Seasonal differences were observed during April (dry) and October (wet) (Table–NET. 12 and 13). Transpiration rate, photosynthetic rate and specific leaf weight (SE) were higher during dry season. As regards chlorophyll contents clonal differences were observed. Highest photosynthetic rate was observed in the Chinese clone SCATC 93–114. Stomatal conductance was found to be high in SCATC 88–13.

19. GROWTH AND YIELD OF POLYCLONAL SEEDLINGS

A population of 490 plants raised from polyclonal seeds are being maintained for observation and selection. Growth attributes are being recorded periodically.

20. INDUCTION OF MUTATION

Girth and number of whorls of plants established from treated buds were recorded. The population was also screened for any morphological abnormalities but none could be spotted.

21. MOTHER TREE SELECTION

Mother trees selected from three locations were under observation. Attempts are being made to collect budwood and multiply for further studies.

Table – NET. 10. *Stomatal characteristics of different clones during dry and wet seasons at RRS, Agartala (recorded on 8.4.1988 and 29.10.1988)*

Clone	Transpiration m mol $m^{-2}s^{-1}$		Stomatal conductance m mol $^{-2}s^{-1}$		Specific leaf weight 10^{-3} g cm^{-2}		Relative water content (%)	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
RRII 105	3.72	11.33	109.67	510.00	5.36	7.43	94.67	92.20
RRII 118	3.19	6.59	104.83	349.67	4.89	6.77	91.22	90.03
RRII 203	4.18	6.37	124.80	375.67	4.55	6.59	91.90	86.89
RRII 300	4.85	5.22	181.10	487.33	4.09	6.50	95.38	82.34
RRIM 501	5.60	7.66	177.50	331.33	4.96	6.90	91.28	62.05
RRIM 605	3.32	7.56	104.43	427.67	4.70	6.36	94.58	76.89
RRIM 600	6.52	7.50	215.33	362.00	6.10	7.50	89.66	90.38
RRIM 703	3.24	3.55	102.17	286.67	5.54	6.49	95.05	93·36
RRIM 612	3.45	9.24	94.60	459.33	7.37	6.94	91.93	82.41
PB 86	2.40	11.15	75.83	497.67	5.92	7.94	89.80	90.85
PB 5/51	2.93	1.97	159.73	249.20	4.83	6.97	92.10	86.45
PB 235	3.77	8.21	124.30	522.33	5.35	6.74	92.31	85.86
GT 1	4.04	7.22	124.10	351.67	5.85	7.78	91.10	88.80
Gl 1	2.51	7.26	83.07	411.67	4.21	7.28	92.98	72.12
PR 107	1.76	10.29	52.50	456.00	3.84	7.08	93.05	05.07
Tjir 1	2.90	5.31	93.17	276.00	4.67	7.00	92.97	89.20
Mean	3.65	7.28	120.49	397.14	5.14	7.02	92.49	85.30
SEM I	0.30	0.64	10.79	21.82	0.22	0.12	0.44	2.16

Table – NET. 11. *Photosynthesis and chlorophyll contents of different clones during dry and wet seasons at RRS Agartala (recorded on 8.4.1988 and 28.10.1988).*

Clone	Photosynthesis $\mu_s$mol $m^{-2}s^{-1}$		Total chlorophyll mg g^{-1} (fw)		Chl. 'a' mg g^{-1} (fw)		Chl. 'b' mg g^{-1} (fw)		Chl. 'a/b' ratio	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
RRII 105	6.00	3.522	3.289	2.790	1.673	1.556	1.616	1.234	1.04	1.26
RRII 118	4.166	3.749	2.430	3.158	2.397	1.787	1.033	1.369	1.35	1.30
RRII 203	10.79	6.604	2.888	2.046	1.499	1.719	1.389	1.327	1.08	1.29
RRII 300	7.150	4.525	3.069	2.945	1.697	1.680	1.372	1.265	1.24	1.33
RRIM 501	2.297	1.469	1.958	2.685	1.136	1.532	0.821	1.153	1.38	1.33
RRIM 605	4.738	4.165	3.429	2.631	1.920	1.513	1.509	1.118	1.27	1.26
RRIM 600	10.63	9.039	3.093	2.886	1.744	1.715	1.349	1.171	1.29	1.46
RRIM 703	6.25	4.115	2.780	2.884	1.575	1.645	1.205	1.470	1.30	1.33
RRIM 612	4.598	3.623	2.772	2.518	1.778	1.466	0.994	1.052	1.79	1.39
PB 86	3.587	2.465	1.844	2.179	1.069	1.243	0.775	0.936	1.38	1.33
PB 5/51	2.266	1.771	2.239	2.005	1.273	1.159	0.967	0.846	1.32	1.37
PB 235	6.916	4.962	2.350	3.423	1.372	1.953	0.978	1.470	1.40	1.33
GT 1	6.701	4.178	2.726	3.180	1.514	1.750	1.212	1.430	1.25	1.22
Gl 1	7.644	7.141	3.813	3.376	2.115	1.897	1.698	1.479	1.25	1.28
PR 107	6.126	4.472	3.895	3.737	2.215	2.157	1.680	0.846	1.32	1.37
Tjir 1	2.681	2.583	2.788	3.033	1.585	1.698	1.203	1.335	1.32	1.27
Mean	5.78	4.280	2.835	2.842	1.598	1.655	1.238	1.219	1.31	1.32
SEM I	0.65	0.49	0.148	0.123	0.08	0.06	0.074	0.054	0.04	0.015

fw — fresh weight.

Table – NET. 12. *Stomatal characteristics and water relations of clones during dry and wet seasons at RRS, Agartala (recorded on 21.4.1988 and 26.10.1988).*

Clone	Transpiration m mol $m^{-2}s^{-1}$		Stomatal conductance m mol $m^{-2}s^{-1}$		Specific leaf weight 10^{-3} g cm^{-2}		Relative water content (%)	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
SCATC 88–13	2.75	7.86	326.67	496.00	5.43	8.19	90.36	92.22
SCATC 93–114	2.40	7.39	283.00	402.33	5.66	7.59	92.39	85.94
Haiken 1	1.92	6.19	238.67	357.33	5.10	8.64	91.37	94.72
RRII 105	2.15	7.73	258.33	424.67	4.45	8.41	93.11	93.09
RRII 118	1.59	2.41	186.43	476.67	4.14	7.92	90.15	96.39
RRII 208	2.17	5.73	215.00	307.67	4.69	7.05	89.62	93.64
PR 107	2.06	11.68	268.00	553.00	4.87	8.20	91.14	89.29
PB 5/51	2.45	5.68	294.67	398.67	4.16	7.48	91.86	94.26
PB 86	2.18	7.35	272.33	511.00	4.24	7.94	90.65	84.78
Gl 1	2.90	4.60	336.00	302.67	3.48	7.65	92.65	91.79
GT 1	2.67	9.18	309.67	481.33	3.94	7.56	89.63	92.85
RRIM 600	1.75	5.54	221.00	460.33	3.72	7.21	90.09	89.14
Mean	2.25	6.78	267.48	430.97	4.24	7.82	91.09	91.51
SEM I	0.116	0.677	13.30	23.03	0.368	0.14	0.346	1.02

Table – NET. 13. *Photosynthesis and chlorophyll contents of clones during dry and wet seasons at RRS, Agartala (recorded on* 21.4.1988 *and* 26.10.1988).

Clone	Photosynthesis μ mol $m^{-2}s^{-1}$		Total chlorophyll mg g^{-1} (fw)		Chl. 'a' mg g^{-1} (fw)		Chl. 'b' mg g^{-1} (fw)		Chl. 'a/b' ratio	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
SCATC 88–13	6.843	2.62	3.536	2.055	1.896	1.172	1.640	0.883	1.16	1.33
SCATC 93–114	20.43	5.78	3.287	3.69	1.788	1.569	1.499	1.190	1.19	1.32
HAIKEN 1	13.09	4.10	2.527	2.886	1.415	1.800	1.112	1.086	1.27	1.66
RRII 105	16.02	8.19	2.717	2.495	1.479	1.500	1.238	0.995	1.19	1.50
RRII 118	8.57	7.34	3.417	1.953	1.898	1.185	1.519	0.680	1.25	1.54
RRII 208	9.767	6.23	2.507	2.541	1.425	1.503	1.082	1.038	1.32	1.44
PR 107	7.66	4.29	2.512	2.013	1.405	1.362	1.107	0.651	1.27	2.09
PB 5/51	10.05	5.78	3.204	2.396	1.808	1.184	1.396	0.582	1.29	2.03
PB 86	4.319	4.60	3.388	2.142	1.818	1.323	1.570	0.822	1.68	1.60
GI 1	5.486	5.26	3.391	2.187	1.827	1.273	1.564	0.914	1.17	1.39
GT 1	12.36	9.78	2.755	2.562	1.471	1.502	1.184	1.060	1.33	1.42
RRIM 600	10.25	8.63	3.274	2.403	1.811	1.433	1.463	0.970	1.24	1.48
Mean	10.40	6.05	2.78	2.366	1.678	1.400	1.365	0.913	1.28	1.52
SEM I	1.31	0.60	2.593	0.86	0.058	0.054	0.059	0.052	0.04	0.073

Table – NET. 14. *Commencement and termination of flowering* (1989).

Clone	Date of first flowering	Date of last flowering
RRII 105	12th February	10th June
RRII 5	12th February	10th June
RRII 203	29th January	10th June
RRII 118	23rd February	4th May
RRIM 600	23rd February	13th May
RRIM 605	12th February	10th June
RRIM 703	12th February	19th May
RRIC 105	12th February	25th June
RRIC 52	12th February	25th June
PB 235	12th February	10th June
PB 86	28th December	25th June
PB 5/51	8th January	10th June
GT 1	12th February	10th June
Gl 1	23rd February	10th June
Haiken 1	12th February	25th June

22. OPTIMUM SEASON FOR BUDDING IN TRIPURA

Weekly budding was carried out and initial and final success were assessed. During January and February 1989 budding could not be done since peeling was not possible due to extreme cold.

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

Observations on flowering were recorded once in ten days from the 1979 clone trial. The percentage of trees flowered in each clone, commencement and termination of flowering (Table – NET. 14) etc. were recorded. Details of clones showing offseason flowering during August–September were also recorded.

24. PROGENY ANALYSIS IN *HEVEA*

This project was initiated in 1987. Seed collected from trees in 1979 clone trial were raised. Morphological observations on plant height, girth, etc. were recorded once in two months. Budding was carried out to study the stock-scion interaction and the budded plants were observed for morphological characters. Arrangements are being made for test tapping the progenies to assess juvenile yield.

25. RELATIONSHIP BETWEEN GIRTH AND BIOMASS

The trial was continued. Plant height and girth were recorded and destructive harvest done periodically in every three months. It has been observed that RRII 118 has slight superiority over RRIM 600 as regards average build up of biomass per unit girth.

26. EFFECT OF AGROMETEOROLOGICAL FACTORS ON PHYSIOLOGICAL PARAMETERS RELATED TO GROWTH

This study was undertaken to find out the various aspects of the interaction between agrometeorological factors and growth of *Hevea*. Studies on the growth analysis of five clones (RRII 118, RRIM 600, GT 1, PB 235 and RRII 105) showed that CGR is maximum in RRIM 600 (7.10) and minimum in RRII 118 (0.68). Leaf area ratio (LAR) was maximum in PB 235.

An experiment was carried out to find out the effect of environmental parameters influencing photosynthesis and water relations in young plants. Morphological and physiological parameters were recorded periodically during June, July, August, November, December (1988), January and March (1989). SLW, RWC and chlorophyll contents were also estimated during the same period. Soil moisture at three different depths were estimated during the recording period. Diurnals of stomatal behaviour and leaf water potential were recorded. Seasonal differences were observed during dry and wet seasons.

Another experiment was carried out to find out the influence of irrigation on factors influencing photosynthesis and water relations of young plants. Five litres of water twice a week was applied using drip irrigation system. Physiological and morphological parameters were recorded periodically.

An experiment was laid out in 1979 clone trial to find out the differential response of sun and shade leaves to environmental variations. Physiological parameters were recorded and soil moisture at three different depths was estimated, during different seasons. Seasonal variation has been observed in both sun and shade leaves of five different clones. Transpiration rate and stomatal conductance was less in shade leaves during wet season. Chlorophyll content was higher in shade leaves. During dry season also transpiration rate and stomatal conductance (except in case of RRII 118) was found to be higher in the sun leaves. LWP was high in sun leaves. SLW was also higher in sun leaves during dry season, except in RRII 118.

27. BLOCK PLANTING OF CLONES

Two replicated clone trials, one in West distrcit in Tripura and other in Karimganj district in Assam with eight clones each were planted and the area is being maintained.

28. ADVISORY

696 soil samples received from small holdings were analysed and recommendations were given during the period under report. 230 samples were also collected, from various nurseries and farms of the Rubber Board in the region, analysed and appropriate recommendations were offered.

REGIONAL RESEARCH STATION, MEGHALAYA

The Regional Research Station, Meghalaya, established in 1985 has two experimental farms, one at Ganolgre (600 m MSL) and the other at Darechikgre (1100 m MSL). During the year 1988–89 air temperature went down to 5°C in all places due to severe winter and wintering period was prolonged (from November to mid March). Due to severe cold, many plants dried up and die back phenomenon was also observed. Two polyhouses were constructed and budded stumps of RRIM 600 were kept inside and outside to observe wintering effect.

1. MULTIDISCIPLINARY EVALUATION OF CLONES

Girth of the ten clones in the 1985 trial recorded during different seasons and the girth increment are shown in Table–NEM. 1. It has been noticed that RRIM 605 recorded maximum girth (204.8 mm), closely followed by RRII 118 (202.5 mm) and RRII 203 (200.3 mm). The increment of girth in RRIM 605 was maximum (75.3 mm) and minimum in PB 5/51 (56.0 mm). Generally all clones showed maximum girth increment during the period June to August, except RRII 118 and PB 86 (it was in September to November). The unpredicted low temperature during the last winter season has adversely affected the growth of all clones and there was almost 100% defoliation.

Girth of clones in the 1986 trial was also recorded during different seasons and the girth increment worked out. Maximum girth was recorded in RRII 208 (10.19 cm), followed by RRII 118 (10.24 cm) while PCK 1 showed minimum girth (7.22 cm) among the ten clones. It has been noticed that all clones showed maximum girth increment during the period March to May.

2. ASSESSMENT OF POTENTIAL INTERCROPS

Paddy, maize, cotton, ginger, pineapple and banana were included for the assessment. Paddy, maize, cotton and ginger were cultivated for the second round. The banana plots were damaged by elephants and gaps were also filled up. It has been noticed that paddy and cotton cannot be grown successfully in the same plot for more than once. However, ginger, maize, pineapple and banana could be grown successfully.

3. NITROGEN REQUIREMENT UNDER DIFFERENT GROUND COVERS

For reasons beyond control it is necessary to have a re-layout of the trial for which polybag nursery has been developed with clone RRIM 600.

4. RUBBER BASED CROPPING SYSTEM

Under this trial rubber, tea, orange and coffee are included. Tea and orange are growing vigorously while rubber and coffee are not growing well.

5. NUTRITIONAL TRIAL IN SEEDLING NURSERY

Girth was recorded at monthly intervals till the seedlings were budded during the month of November/December 1988.

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

Clone	Mean girth (mm)					Girth increment (mm)				
	Feb 88	May 88	Aug 88	Nov 88	Feb 89	Mar to May 88	June to Aug 88	Sep to Nov 88	Dec 88 to Feb 89	Total
RRII 105	119.7	132.0	154.6	174.0	182.5	12.3	22.6	19.4	7.5	61.8
RRII 118	139.8	149.9	168.0	198.1	202.5	10.1	18.1	30.1	4.4	62.7
RRII 203	137.6	145.2	171.6	193.3	200.2	7.6	26.4	21.7	6.9	62.6
RRIM 600	128.0	137.9	166.7	187.0	195.6	9.9	28.8	20.3	8.6	67.6
RRIM 605	129.5	151.3	179.9	197.6	204.8	21.8	28.6	17.7	7.2	75.3
PB 86	114.8	122.5	142.8	169.4	171.2	7.7	20.3	26.6	1.8	56.4
PB 235	126.5	138.1	166.8	185.7	190.5	11.6	28.7	18.9	4.8	64.0
PB 5/51	101.1	109.7	131.4	147.2	157.1	8.6	21.7	15.8	9.9	56.0
GI 1	108.9	122.8	146.3	163.9	168.8	13.9	23.5	17.6	4.9	59.9
GT 1	130.0	136.6	161.3	182.1	186.7	6.6	24.7	20.8	4.6	56.7

6. SELECTION FROM POLYCLONAL SEEDLINGS

The maximum girth increment (0.49 cm) was recorded during the month of June to August. Altogether 934 plants exist in the field. Due to severe winter there was complete defoliation and 340 plants showed die back of which 54 plants did not sprout again.

7. ON FARM TRIALS

Under this trial 1429 numbers of budded stumps of 10 clones were planted in polybags during the month of July 1988 at NRETC, Janggitchekgre out of which 1150 plants sprouted during the month of July/August 1988. Due to wintering some plants got dried up and during the month of March 1989, all plants were damaged due to arson at NRETC.

Under this trial seven clones of *Hevea brasiliensis* were planted in the field (approximately 4 ha) during the month of July 1988. But due to cattle grazing and poor management some plants were damaged while the rest of the plants got dried up during winter. In the month of February/March 1989 a separate polybag nursery of RRIM 600 and RRII 105 was raised for the next planting season.

8. PLANT PATHOLOGY AND MUSHROOM CULTURE

A clone observation has been made during the year to assess the incidence of rubber diseases. It has been seen that some of the diseases like abnormal leaf-fall and pink disease, which are prevalent in the traditional rubber belt, are completely absent in this non-traditional rubber growing area. Only a few leaf-spot diseases caused by *Corynespora cassiicola, Drechelera heveae* and *Gloeosporium alborubrum*, though of minor importance, were infecting the tender leaves in nursery plants. The diseases were also seen infecting the four year old rubber plants. However, the occurence of diseases was quite negligible. Fungicides like Dithane M-45 (0.25%) and Bavistin (0.12%) were sprayed regularly to check the disease. Table–NEM. 2 indicates the percentage disease index (PDI) of leaf-spot diseases of 1985 planting at Ganolgre.

Table–NEM. 2. *Percentage disease index of leaf-spot disease at Ganolgre farm (1985 planting)*

Clone	Nov. 1988	Dec. 1988	Jan. 1989	Apr. 1989
RRII 105	4.64	4.64	3.96	5.99
RRIM 600	3.32	4.64	3.30	3.99
RRII 118	3.30	3.98	5.30	4.66
RRIM 605	3.96	2.66	4.62	2.66
RRII 203	3.32	4.66	4.62	3.99
GT 1	2.66	3.96	4.62	4.66
Gl 1	0.66	3.88	4.64	3.99
PB 235	0.00	6.62	4.62	6.66
PB 86	4.62	4.64	4.62	3.99
PB 5/51	3.96	1.98	3.96	5.33

At HRS, Darechikgre, the coffee plants were very susceptible to leaf-spot diseases, probably caused by *Cercospora* sp. Fungicides were sprayed (Dithane M-45) to check the disease.

A small thatched house was constructed at Ganolgre for mushroom culture. The first culture was carried out on an experimental basis in July. So far, only three cultures have been completed successfully. There is always a discontinuation in the culture because of non-availability of spawn in time and therefore, a plan of work has been initiated to carry out the spawn preparation at the Plant Pathology Laboratory, NERS, Guwahati.

9. PHYSIOLOGICAL STUDIES

(a) Growth Performance of Polybag Plants in Polyhouse.

One polyhouse at 600 m and another at 1100 m altitudes were constructed during the winter season of 1988 and RRIM 600 polybag plants were kept inside and outside the polyhouse to observe the effect of winter. Growth parameters like girth, height and leaf number were recorded at monthly intervals. Maximum and minimum air temperature inside and outside were also recorded. Polyhouse showed maximum air temperature at both the altitudes than outside but at low altitudes maximum air temperature was always higher than that at the higher altitude. It has been noticed that plants in the polyhouse showed higher growth rate, higher rate of leaf production and survival potential while the plants maintained outside dried at both the altitudes due to severe winter. It has been noticed that prolonged low temperature affected plant growth and their survival potential and also that the effect is more at higher altitude as compared to low altitudes. The studies are hence continued.

(b) Growth Performance of Three Clones at Different Altitudes.

In the month of July 1988 three clones (RRIM 600, GT1 and RRII 105) of *Hevea brasiliensis* were planted in polybags at 1100 m, 900 m, 700 m, 500 m and 300 m altitudes to study the altitudinal effects. Growth parameters such as girth, height, and leaf number were recorded at monthly intervals. Generally it has been noticed that with increasing altitudes, plant height, leaf number and girth decreases in all the three clones. The growth performance of RRIM 600 and GT 1 is better than that of RRII 105 at 500 m and 300 m altitudes. Above 500 m all clones dried up during winter season while defoliation was noticed at 500 m and 300 m. This study indicated that below 700 m where wintering effect was not severe, GT 1 and RRIM 600 can grow successfully.

(c) Diurnal Pattern of Leaf Temperature, Stomatal Conductance and Transpiration Rate at Two Altitudes.

The diurnal pattern of leaf temperature, stomatal conduction and transpiration rate were recorded (porometer) during the month of November 1988 in RRIM 105 clones (1985 trial) at 600 and 3600 m MSL. It was observed that leaf temperature was always higher at lower altitudes than at high altitudes, in both the clones and also that the maximum was recorded at 12.00 noon. Maximum stomatal conductance was also recorded high in RRIM 600 at low

altitudes. In general, during morning hours conductance was more in both the clones at the two elevations. Transpiration rate was higher during morning hours at both the altitudes.

(d) **Photosynthesis Rate at Two Altitudes.**

Diurnal photosynthesis rate in ten clones at two elevations were recorded from the 1985 clone trial during the month of November 1988 by a closed flow portable Photosynthesis system. Maximum photosynthesis rate was recorded in morning hours (9 to 10 AM) at 600 m and 1100 m altitudes in RRIM 600 and RRII 105.

REGIONAL RESEARCH STATION, MIZORAM

A polyclonal seed garden was laid out and evaluation of clones and studies on intercropping, effect of physiographic features on growth of *Hevea* and on rubber based cropping system were continued. Cultural operations in all the trials were done properly. Seedling nursery expansion was undertaken in an area of nearly 1.5 ha and budwood multiplication nurseries were started for generation of planting materials.

Observations on girth were recorded quarterly in the trial on multidisciplinary evaluation of clones and the data are under study. In the studies on intercroppi ng, an attempt has been made to assess paddy, maize, pineapple and banana as intercrops among rubber (RRII 600). For rubber, in spite of carrying out all cultural operations the casualty rate has been very high. Cultural operations, including sowing of cover crops, were carried out in the trial on the effect of physiographic features on the growth of *Hevea*. Routine cultural operations were carried out in the trial on rubber based cropping system. To establish a polyclonal seedgarden, 2200 polybagged plants belonging to seven clones were planted adopting a two-dimensional poly-cross design.

Fertilizer application and other cultural operations were also carried out in the nurseries. Over 1000 budded stumps were provided to three growers in the locality, with technical help from time to time.

REGIONAL RESEARCH STATION, WEST BENGAL

It has been revealed that certain areas in Jalpaiguri district, Siliguri and Naxalbari subdivisions of Darjeeling district and certain portions of Islampur, Balurghat and Raiganj subdivisions of West Dinajpur district can be initially taken up for rubber plantation development. Keeping this in view, a Regional Experiment Station at Nagrakata with an area of 117.7 acres of land is under establishment to study location specific problems of the crop, to select cultivars best suited for northern parts of West Bengal and to evolve a suitable package of agromanagement practices for the region. Field experiments are proposed to be laid out during 1990 planting season.

OTHER REGIONAL RESEARCH STATIONS

The RRII has established Regional Research Stations in Maharashtra, and Orissa in addition to those in the North-Eastern States. A Heavea Breeding Station has also been established with a substation each in Tamil Nadu and Karnataka.

REGIONAL RESEARCH STATION, MAHARASHTRA

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

1. PHYSIOLOGICAL EVALUATION TRIAL

The trial is an ongoing one and being continued. When irrigation of 150 l/t during 1986–87 and 250 l/t during 1987–88 was given, clones RRIM 600, RRIM 501, PR 107, RRII 300 and RRIM 612 have recorded comparatively more growth rates (Table: Dap–1). Leaf size and the rate of leaf expansion are also being studied in the different clones. Leaf transpiration and stomatal conductance values were recorded during predawn and afternoon periods. These parameters are being monitored in different seasons.

2. DRY-FARMING TECHNIQUES

The study started during 1986 was continued. To achieve more pronounced difference, quantity and frequency of irrigation was raised to 320 l/10 d, 15 d and 20 d intervals. Deep irrigated plants had shown better growth compared to that of the control.

Table–Dap. 1. *Mean girth and girth increment of different Hevea clones* (*6th year*)

Clone	Mean girth (cm)		
	Dec 1987	Dec 1988**	% Increase
PB 235	28.1	37.2	32.4
RRII 300	30.3	39.0	28.7
GT 1	28.1	37.4	33.1
RRIM 501	28.6	39.5	38.1
Gl 1	28.2	37.5	33.0
RRIM 612	31.5	40.8	29.5
Tjir 1	26.6	36.0	35.3
PR 107	29.6	38.1	28.7
RRIM 600	33.1	42.2	27.5

*Mean of 15 values except in clone RRIM 501 which is mean of 11 values.

** Treatment differences are significant at 1% error.

Plants in the other treatments did not exert pronounced effect on growth. Deep irrigated plants showed only 50% of leaf margin drying compared to scorching and leaf fall in other cases. These visual effects are gradually pronounced from medium to severe from treatment pit irrigation at the rate of 50 1/10 d to non-irrigated control plants. To evaluate the growth during early stages, polybagged plants of clone RRII 105 was given 2 $l\ t^{-1}$ day^{-1} irrigation using subsoil injector and observations are being taken.

3. CONTACT SHADE TRIAL

The experiment was continued and the girth data showed better girth increment of plants belonging to all treatments (shading with coconut leaves and china clay spray 5%, 10% and 15%) compared to the control without any shade and spray. All spray treatments resulted in increased chlorophyll content. It is indicated that 5% and 10% china clay spray over leaf surface can replace conventional shading with coconut leaves. Although 15% china clay spray resulted in high chlorophyll content increase, this is likely to affect rate of photosynthesis due to shade adaptation.

4. MULCHING TRIAL

To conserve soil moisture and prevent heating up soil atmosphere, a trial was started to achieve normal growth of plants after application of appropriate quantity of mulching material. RRIM 600 plants with six treatments laid randomly with single tree single plot design with fifteen plants in each treatment.

Table: Dap–2. *Effect of contact shading on the chlorophyll content of leaves.*

Treatment	Chlorophyll content $\mu g\ mg^{-1}$ fresh wt $\pm$ S. D.	% increase over control
Control without shade basket	1.25 $\pm$ 0.05	—
Control (shading with coconut leaves)	1.33 $\pm$ 0.24	6
China clay 5%	1.50 $\pm$ 0.08	20
China clay 10%	1.47 $\pm$ 0.03	18
China clay 15%	1.65 $\pm$ 0.12	32

The treatments included normal mulch (15-20 kg grass $plant^{-1}$) with heavy mulch (twice the normal quantity) and control without mulch, with and without irrigation. In irrigation 100 1/10 day interval was given. Girth and height were monitored. Results indicate that heavily mulched irrigated plants attained more girth when compared to others. Visual scoring of leaf indicated that irrigated heavy mulch plants showed leaf fall with yellowing of leaves. However, irrigated control and normal mulch did not apparently exert any effect. Further observations are being continued.

5. BASIN/DRIP IRRIGATION TRIAL

To standardise and to evaluate the advantages of drip irrigation system over basin irrigation in terms of water saving and total economy in the quantity of water and methods of irrigation, an experiment was started on clone RRII 105.

6. COST EVALUATION TRIAL

To compare the additional expenditure incurred in non-traditional regions, a trial was started with two blocks of RRIM 600. One block was given life saving irrigation of 150 l/t at 10 day interval from December–February and at 7 day interval upto May. Another block of 250 plants were maintained without irrigation. All management practices and costs involved are being monitored.

7. EVALUATION OF YIELD AND YIELD COMPONENTS OF LATEX UNDER NORTH–KONKAN REGION

A trial was initiated to evaluate the yield potential and yield components under North Konkan region. Observations were started in two clones, GT 1 and RRIM 600. The trees are nine year old and opened for tapping in March 1989. Rubber yield, initial flow rate, rubber content and plugging index along with some physiological parameters will be recorded at monthly intervals.

8. POLYCLONAL PLANTATION

2500 polyclonal seedlings planted during 1985 and 3500 planted during 1987 were maintained for observations and selection purpose.

REGIONAL RESEARCH STATION, ORISSA

Activities of the Regional Research Station, at Annapurna village (Dhenkanal District, Orissa) was continued. Polyclonal seedlings showed comparatively better performance in field establishment and growth compared to RRIM 600, GT 1 and RRII 105. In spite of vacancy filling, heavy casualties occurred in the clone cum fertilizer trial. A block planting of RRII 105 was taken up for commercial evaluation, but there again casualties were very high. Planting materials were prepared and maintained for laying out field experiments on irrigation, intercropping and density.

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. At the Karnataka Station, comprising 50 ha land, the field trial on growth, yield and exploitation systems laid out during 1987 in an area of 7.0 ha was maintained properly. During drought period of 1989, 200 plants were lost due to intense heat. A small area planted with polyclonal seed material has been growing well. During 1988 planting season, two field trials were laid out. One trial on studies on growth, yield and exploitation system, was planted in an area of 3 ha using polybag plants of five clones. Another trial laid out in the same season was a small scale trial of selected ortet clones in an area of 2.38 ha. The trial is composed of 3 small scale trials

and a total of 47 ortet clones selected from small holdings are included along with control clones. The source bush nursery was maintained and arrangements were made to bring in more clones from RRII for establishing in the station. A small seedling nursery was also established for raising stock plants. The experimental areas were properly maintained and cultural operations carried out timely. A meteorological observatory was established and meteorological data were recorded. Polybag plants of 14 modern clones were being raised, to lay out a large scale clone trial during 1989.

The sub-station at Paraliar in Tamil Nadu has an area of 23.1 ha land. A breeding orchard with 26 clones was established during 1987. Gap filling was done, wherever necessary and the area was maintained. Another set of 25 clones were planted during 1988 with the same design, to raise another breeding orchard. A source bush nursery established earlier was maintained. A stock seedling nursery was also raised. A few seedling plants from the seedling nursery which apparently tolerated flood situation were vegetatively multiplied and planted in flood affected areas to screen for any desirable genotypes. Cultural operations in all areas were carried out timely.

AGROMETEOROLOGY UNIT

1. WEATHER CONDITIONS AT EXPERIMENT STATIONS

The general weather conditions during 1988 at RRII and four of the Regional Research Stations were summarised. The pre and post monsoon rainfall received at Chethackal provided better moisture availability in the root zone than at Kottayam. About 50 per cent of the normal rainfall was received during May in the traditional regions. At Dapchari (Konkan region of Maharashtra) the rainfall distribution had been far from satisfactory due to continuous downpour. An amount of 1630 mm was received in July itself. The total rainfall was 2923 mm and more than 75 per cent was lost as run-off water. Due to prolonged moisture deficit and high ambient temperature, coupled with low humidity and high wind speed during March to May, high evaporation rates of the order of 7 to 10 mm per day was recorded.

At Agartala (North-Eastern region) due to prevailing low temperature during January to March, the evapotranspirational demand was low and the marginal drought conditions experienced were comparable to that of traditional regions.

2. AGROCLIMATIC ASPECTS OF RUBBER CULTIVATION

The available meteorological data for 25 years (1961–85) of all the revenue districts of Kerala was collected and the influence of rainfall pattern on yield of rubber was studied. The availability of soil moisture resultant of rainfall is found to be the controlling factor. About 21 to 64 per cent of the annual rainfall gets lost as run-off water. This run-off water can be harvested to enhance the moisture availability during pre and post monsoon periods, which will reduce the impact of drought on rubber trees for growth as well as production.

Attempts were made to estimate the potential water requirements of rubber tree at different growth stages in the traditional and non-traditional regions. Monthly potential evapotranspirational rates were estimated (Table–Agromet. 1) with five different agro-climatic models and compared with observed potential evaporation for five years (1983-87) in the traditional region (Kottayam) and a non-traditional region (Agartala). Under adequate soil moisture, low vapour pressure deficit and small diurnal range in temperature, all the models were over estimated by 6 to 46% of pan evaporation. The radiation dependent models provide best estimates under wide seasonal and diurnal variations in air temperature experienced in North-East India.

Table–Agromet. 1. *Simple correlation coefficients between observed monthly pan evaporation and estimated reference evapotranspiration by different models at Kottayam and Agartala.*

Model	Kottayam	Agartala
Penman	0.9419**	0.7529**
Radiation	0.9532**	0.8978**
Blaney-criddle	0.9953**	0.7016**
Hargreaves	0.8905**	0.8789**
Thornthwaite	0.6716**	0.4334**

** Significant at 1% error.

For assessing the prospects of irrigating *Hevea* in traditional and non-traditional regions the evapotranspirational rates were worked out with penman model. By taking into consideration, the area to be irrigated at different growth phases and the effectiveness of rainfall during the drought period, the quantum, frequency and number of irrigations required per plant at a density of 400 trees per hectare are worked out.

During the immature phase, the mean irrigation water required varies from 9 to 53 litres $tree^{-1}$ day^{-1} in the traditional region and 10 to 92 litres $tree^{-1}$ day^{-1} in the non-traditional regions. About 26–41 per cent more water is required in the non-traditional regions of central India. The frequency of irrigation varies from 4 to 11.4 days and 2.3 to 10.5 days in the traditional and non-traditional regions, respectively. During mature phase, the average number of irrigations required are 79 in the traditional and 104 in the non-traditional regions, in the absence of any precipitation. However, scanty rains occur which would reduce the frequency to 46 at Kottayam and 81 at Kamakhyanagar. Due to complete absence of rainfall at Dapchari, the frequency as well as number of irrigations required remain the same.

Attempts are also being made to identify the agroclimatic analogues for technology transfer among the rubber growing areas.

3. STUDIES ON CROP WEATHER RELATIONS

Considering the influence of climate on rubber production in different agroclimatic regions, attempts are being made to collect the past rainfall data from estates spread all over the traditional region. The monthly yield data of different clones at different years of exploitation under different agroclimates are also being collected.

In order to evaluate the optimum climatic conditions required for potential growth and production of rubber plantation, the meteorological data from the rubber growing regions of the world are also being collected.

The diurnal microclimatic variations viz., ambient air temperature, humidity inside and above the seedling canopy and soil temperature at three depths, were monitored hourly under different mulch treatments. Significant changes were noticed.

4. ESTABLISHMENT OF AGROMETEOROLOGICAL OBSERVATORIES

Two Regional Meteorological Observatories, one at Hevea Breeding Station, Nettana (South Canara District) and the other at Manikal Estate of TR & T Company Limited, Mundakayam (Idukki District) were established. Arrangements were made for establishment of one unit at Keeriparai (Kanyakumari District). Action is in the final stage for procuring an area at Palapilly (Trichur District) region. Two persons were trained in collection and compilation of meteorological data as well as maintenance of observatory.

LIBRARY AND DOCUMENTATION CENTRE

The library continued to maintain a good collection of documents on rubber and related areas. The total collection of books exceeded 20,200 and the bound periodicals 13,100. The library subscribed to about 500 periodicals.

Various services were provided based on the information intake. The library and documentation centre also organised translation of articles, procurement of photocopies, compilation of weekly price reports, news clipping service, publication of Rubber Alert, Documentation list, 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 1.5 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 industry. Research Scholars and students from Universities and Colleges also utilized the services of the library. Scientists from other national research institutions also visited the library for consultation and reference.

BUDGET

Sl. No.	Head of Account	Approved Budget (Rs. in lakhs)	Actual Expenditure (Rs. in lakhs)
	Non Plan		
1.	Pay and allowances	77.72	80.56
2.	Contingencies	15.77	17.20
3.	Other charges (Including RRII Estate & Nursery)	42.51	36.99
4.	Non Plan Schemes	9.00	6.68
5.	Non Plan Projects (CES Chethackal)	35.00	40.59
	TOTAL NON PLAN	180.00	182.02
	Plan		
6.	Plan schemes	36.00	29.30
7.	NERDS Research Component	100.00	85.28
	TOTAL PLAN	136.00	114.58

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Radha Lakshmanan, M.Sc. (Ag.)	.. Research Assistant
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Joshua Abraham, M.Sc.	.. Research Assistant
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T. Thanka	.. Section Officer

ADMINISTRATION SECTION

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C. M. Abraham, B.A.	.. Administrative Officer
B. Lakshmanan	.. Assistant Section Officer
P. Vijayalakshmy	

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STATISTICS SECTION

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EXPERIMENT STATION AT RRII

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