ISSN 0970-2490
CODEN ARRIEU

RUBBER RESEARCH INSTITUTE OF INDIA
ANNUAL REPORT 1991-92

Rubber Research Institute of India

Annual Report 1991-92

ISSN 0970 2490

CODEN ARRIEU

Publisher
Dr. M. R. Sethuraj

Cover
New Rubber Board Complex building at Agartala, Tripura

March 1993

The Rubber Research Institute of India (RRII), under the Rubber Board (Ministry of Commerce, Government of India) had its inception in 1955. With a very modest beginning, the RRII is now capable of handling most of the problems associated with natural rubber (NR) production technology, processing aspects and product applications. The steady growth of the RRII in its scientific worth and research contributions has won it the recognition as one of the international centres of excellence on NR research.

Location

The RRII is located on a hillock 8 km east of Kottayam in Kerala State and is easily accessible by road. Kottayam is connected to all major cities in the country by rail. The nearest airport is at Cochin, 70 km north. The capital of the state is Trivandrum, 160 km south where there is an international airport. The distance to New Delhi, the capital of the country, is 2950 km.

Functions

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

Organisation

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

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ANNUAL REPORT
1991-92

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

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THE RUBBER BOARD

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

Organisation

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

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Rubber Production Commissioner

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Director

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3. Prof. B. Datta, Department of Agricultural Engineering, IIT, Kharagpur-721 302.
4. Dr. U. S. Sreeramalu, Professor of Soil Science, Water Technology Centre, Tamil Nadu Agricultural University, Coimbatore-641 003.

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DIRECTOR'S REVIEW

The priority areas of investigation of the Rubber Research Institute of India (RRII) centered around productivity increase in existing plantations by adopting appropriate exploitation techniques and agro-management practices, development of clones with higher yield potential and desirable secondary attributes, evaluation and development of clones suitable for non-traditional areas, identification of appropriate agrotechnology for different agro-climatic zones and conservation of natural rubber by imparting improvement in the service performance of products and chemical modification of natural rubber. Multidisciplinary research on tapping panel dryness was also initiated as a part of the proposed international programme under International Rubber Research and Development Board (IRRDB).

The Agronomy and Soils Division continued its research activities on nutritional requirements on different high yielding clones at various stages of growth in different agro-climatic regions, irrigation and moisture management, studies on soil conservation, weed management and intercropping systems. Studies on Diagnostic and Recommendation Integrated system (DRIS) were continued. Computerisation of fertilizer recommendation is in progress. The Biotechnology Division concentrated on somatic embryogenesis, identification of somaclonal variants and successful development of a cell culture technique. A few plants derived from anther culture were planted in the field. The emphasis of the Botany Division was on breeding and selection of planting materials, anatomy, propagation and cytogenetics. Clonal screening with the ultimate objective of identifying the most appropriate component planting materials in different clone composites was initiated. Special attention was given for genetic studies, evaluation of clones having comparable or higher yield and better secondary characters than RRII 105. A new technique of benchgrafting is being perfected. For hybridization programme parents were selected based on yield components. Structural parameters were identified for selection of drought tolerant and high yielding clones. Mitotic studies confirmed that the tetraploid trees (2n = 72) maintain the ploidy level even at the vM 25 generation. The Germplasm Division initiated juvenile evaluation of wild genotypes and wide variability was noted among the materials. For further evaluation and cataloguing, 493 genotypes were planted. On the basis of a bilateral clone exchange programme five promising IRCA clones were introduced from Ivory Coast. The Plant Physiology and Exploitation Division concentrated on research activities in exploitation, intercropping, crop physiology, stress physiology and biochemistry. Controlled upward

tapping (CUT) was recommended, after detailed studies on this system. The phospholipids in the bottom fraction of latex samples were significantly high in the high yielders compared to that of the low yielders. Mycology and Plant Pathology Division continued its research activities in mycology, pathology, microbiology and entomology. In the yield loss assessment study for powdery mildew disease of rubber, it was estimated that the cost involved in effective protection against this disease is justified even at the mere increase of 2 per cent in crop, which is easily achievable. Rhizobium inoculation augumented the biomass production in Pueraria. The entomopathogen Beauveria brongniartii proved to be the most effective treatment against root grub and chafer beetles.

Research on improvement of primary processing, chemical modification of natural rubber and rubber technology were the thrust areas of the Rubber Chemistry, Physics and Technology Division. Emphasis was also given for the implementation of solar drying systems and studies on the corrosion aspects of using sulphuric acid (in the context of scarcity for formic and acetic acids) for making sheet rubber. Evaluation of 180 precured retreaded tyres received from MRPRA, UK was completed. The Agricultural Economics Division continued its research activities on economic aspects of natural rubber cultivation, processing, marketing and end uses. Due importance was given for the studies on economics of ancillary products.

The Regional Research Stations of RRII continued to concentrate on location specific research in Assam, Tripura, Meghalaya, Maharashtra, Mizoram, Orissa and West Bengal. Evaulation of clones suited for local conditions and evolution of agro-management techniques for each region were the prime activities. The Regional Research Station at Tripura has set up full fledged laboratories for all major disciplines in the new Rubber Board Research Complex building at Agartala.

Two issues of the Indian Journal of Natural Rubber Research were brought out during the year. The RRII co-ordinates the research programmes on tapping panel dryness initiated by the IRRDB. The institute also maintained academic linkage with several universities and other institutions of research and learning.

The RRII organised an International Natural Rubber Conference at Bangalore during February. Scientists engaged in natural rubber research from countries across the world participated in the conference. Eminent scientists gave lead talks on new frontiers of research. The conference presented a venue for taking stock of the achievements and for identification of future thrust areas.

The Institute also organised a National Seminar on Biological Control in Plantation Crops at Kottayam during June which was the first attempt on focusing attention on biological alternatives in protection of plantation crops. A National Symposium on Recent Advances in Drought Research was organised during December, which generated useful interaction between scientists engaged in drought research on various crops.

The Department of Training organised training courses for planters, product manufacturers, estate supervisory personnel and technical staff of the Rubber Board in which the scientists and officers of the RRII have served as faculty members. The Institute was regularly visited by groups of farmers to whom the scientists explained ongoing research programmes.

AGRONOMY AND SOILS DIVISION

The Agronomy and Soils Division engaged in investigations on nutritional requirements of high yielding clones of rubber at various stages of growth in the different agroclimatic regions of South India. Irrigation and water requirement, soil moisture management, soil conservation, intercropping, weed management, forms and methods of fertilizer application and standardization of analytical methods were also under investigation. In order to improve the interpretation of foliar analytical values, work on Diagnosis and Recommendation Integrated System (DRIS) was continued. Discriminatory fertilizer recommendations were offered to rubber growers, for which eight regional laboratories, the central laboratory at RRII and four mobile soil and tissue testing laboratories were engaged.

1. Nutritional studies (immature phase)

1.1 The three experiments located in three agroclimatic regions were continued. Soil analysis in the experimental area at Mundakayam indicated that application of P at 60 kg P_2O_5 ha^{-1} increased the available P content and application of K at both 20 and 40 kg K_2O ha^{-1} increased the available K content of soil.

1.2 The three experiments laid out in three locations to assess the fertilizer requirement of clone RRII 105 were in progress. In the experiment at Kodumon estate, Pathanamthitta district, the highest girth (January, 1992) and girth increment (January 1991 to January 1992) were obtained by the combined application of 30 kg each of N and P_2O_5 ha^{-1} and 20 kg K_2O ha^{-1}.

1.3 The two experiments laid out at Koney estate and RRII farm in 1988 and 1989 respectively with a view to assess the nutrient requirement of RRII experimental clones were continued. Significant clonal differences were noticed in the case of girth (1992) and girth increment for two years (1990-1992) in the experiment at Koney estate (Table-Ag. 1), clones RRII 203 and RRIC 100 being superior.

In the experiment at RRII farm significant clonal differences were noticed for girth, 1992 (Table-Ag. 2). Clones RRII 118 and PB 260 were superior to the other two clones tried.

Table-Ag. 1. Mean girth and girth increment (cm)

Clone	Girth	Girth increment
RRII 5	31.07	20.53
RRII 105	29.22	18.64
RRII 203	37.28	24.01
RRII 208	30.32	19.35
RRII 300	28.48	18.27
RRII 308	26.06	15.69
PCK 1	27.48	18.13
PCK 2	30.60	18.69
PB 311	32.47	21.08
RRIC 100	35.78	23.66
SE	1.54	1.05
CD	4.92	3.35

1.4 Two polybag nursery trials were conducted during the period. In one trial where a complete nutrient formulation 'Plantab' in the form of small sticks was compared with the usual practice of application of fertilizer mixture for polybag nursery plants, it was found that application of two sticks each of 'Plantab' every month for seven months gave the best growth of polybag plants. In the other experiment, application of cake-o-meal, an organic manure, as a single basal application at 200 g bag^{-1} was found to be on par with the usual application of fertilizer mixtures in terms of growth.

Table-Ag. 2. Mean girth

Clone	Mean girth (cm)
RRII 118	20.38
PB 260	19.87
PB 217	18.29
RRII 5	18.12
SE = 0.26	CD = 0.90

2. Nutritional studies (mature phase)

2.1 Clonal/regional requirements

Seven field experiments in four locations on three high yielding clones were in progress. In the experiment at Kinalur estate with clone GT 1, application of K at 60 kg K_2O ha^{-1} significantly increased the available K content of soil (Table-Ag. 3). Application of N at 40 kg ha^{-1} also significantly increased the available K content.

Table-Ag. 3. Available K content of soil (mg 100 g^{-1} soil)

Kg N ha^{-1}	Kg K_2O ha^{-1}			
	0	30	60	Mean
0	3.08	3.81	5.79	4.23
20	3.46	5.54	6.04	5.01
40	4.17	4.76	9.63	6.19
Mean	3.57	4.70	7.15	5.14

For comparison of N and K means SE = 0.42; CD = 1.23.

It was also seen in the same experiment that application of P as Mussoorie rock phosphate at both 20 and 40 kg P_2O_5 ha^{-1} levels significantly increased the available Ca content of soil (Table-Ag. 4).

Table-Ag. 4. Available Ca content of soil (mg 100 g^{-1} soil)

Kg P_2O_5 ha^{-1}	Available Ca
0	12.60
20	16.32
40	17.62
SE	1.25
CD	3.67

2.2 Multilocational trial on fertilizer use efficiency

This experiment, conducted for three years in seven locations, was concluded by the end of 1991. Neither the mean yield during any of the years nor the mean annual yield during the three years showed significant difference among the treatments (Table-Ag. 5).

Table-Ag. 5. Effect of treatments on mean yield

Treatments	Mean yield (kg ha^{-1} year^{-1}) **			Mean
	1989	1990	1991	
Ammophos (Factomphos NP 20:20) +Muriate of potash	1884	1765	1873	1841
Paramphos (Ammophos NP 16:20) + Urea + Muriate of potash	1723	1606	1896	1742
Urea + Mussoorie rock phosphate + Muriate of potash	1741	1593	1665	1666
NPK 10:10:10 mixture	1665	1624	1826	1705
Estate practice (discriminatory fertilizer use based on soil and leaf analysis)	1756	1570	1690	1672
SE	80.9	69.1	259.7	60.2

** Mean of seven locations.

All treatments except estate practice were equivalent to NPK 30:30:30 kg ha^{-1}yr^{-1}. Therefore, sources of fertilizers may be decided based on cost and other considerations. A combination of urea, Mussoorie rock phosphate and muriate of potash would be cheap. If discriminatory fertilizer recommendation is followed, the doses of these fertilizers could be reduced in many cases and cost of manuring can be further reduced.

2.3 Micronutrient experiments

A field experiment was initiated during 1991 in Cheruvally estate (Erumely) on clone RRIM 600 to find out the effect of 'Boracol BSF - A', a micronutrient mixture containing Fe, Zn, Cu, Mo and B on the yield of rubber. Graded doses of Boracol at 50, 100, 150 and 200 g tree^{-1} are being compared with no Boracol as control. The major nutrients were uniformly applied at recommended rates. Yield and girth of the trees are being recorded.

3. Density of planting, growth and yield

The experiment at Shaliacary estate (Punalur) is in progress. The effects of density of planting, manuring and their interactions were not significant in the case of mean girth of trees as on January 1992 (Table-Ag. 6). Additional nutrient requirement with increasing density of population was also not indicated.

Table-Ag. 6. Mean girth

Spacing (m)	Desnity (plants ha^{-1})	Mean girth (cm) Levels of NPKMg (kgha^{-1}) 40:40:16:6	60:60:24:9	Mean
6.7 x 3.4	445	46.07	48.71	47.39
6.7 x 3.0	489	47.16	47.13	47.14
6.1 x 3.4	489	45.61	47.52	46.56
6.1 x 3.0	539	43.40	46.23	44.81
5.5 x 3.4	544	45.43	46.21	45.82
5.5 x 3.0	598	47.42	47.41	47.42
Mean		45.85	47.20	46.52

SE for density = 0.58 SE for manuring = 0.48

4. Irrigation and moisture management

4.1 Immature rubber

Girth recorded in 1992 did not indicate any response to irrigation. During 1990 and 1992 irrigation could not be

7.4 Indigenous rock phosphates and phosphorous dissolution pattern

The two field trials started in two locations are in progress. A glass house study was also conducted using *Pueraria phaseoloides* as test crop. Three and a half months after planting the plants were uprooted. Nodules were counted and uptake of P determined in plant parts. The relative agronomic effectiveness was also calculated. The effectiveness of the different phosphates in terms of P uptake, dry matter and nodule weight of *Pueraria phaseoloides* is given in Table-Ag. 12. Among the indigenous rock phosphates tried, Mussoorie rock phosphate was on par with Jordan rock phosphate in dry matter production, nodule weight and uptake of P.

Table-Ag. 12. **Effect of different phosphorous sources on P uptake, dry matter yield and nodule weight of *Pueraria phaseoloides***

Treatments	Dry matter yield (g pot^{-1})	Nodule weight (g pot^{-1})	Phosphorous uptake (g pot^{-1})
Control (no P)	15.62	0.05	0.016
Jordan	53.47	1.57	0.119
Mussoorie	49.06	1.39	0.106
Maton	30.97	0.34	0.048
Purulia	36.40	0.59	0.060
Udaipur	35.72	0.63	0.055
Partially acidulated Maton	42.57	1.10	0.080
Single super phosphate	42.00	0.95	0.076
CD at 5% level	6.95	0.18	0.03

7.5 Sources of phosphorous for rubber and associated cover crops

The field study initiated in 1988 to evaluate the effectiveness of bowl sludge, a waste product from latex centrifuge factory, is being continued. Girth increment data for the period 1988-91 is furnished in Table-Ag. 13.

The results indicate that bowl sludge is on par with super phosphate and Mussoorie rock phosphate in increasing the girth of rubber plants. Soil samples were also collected from all the plots and analysed for available P, available Mg and pH. Results given in Table-Ag. 14 indicates that available Mg is significantly higher in bowl sludge applied plots.

Table-Ag. 13. **Effect of different sources of phosphorous on girth increment**

Treatment	Girth increment (cm)
Super phosphate	24.40
Mussoorie rock phosphate	24.05
Bowl sludge	24.76
Control	21.64
SE = 0.54	CD = 1.63

Table-Ag. 14. Nutrient status of soil (mg 100g^{-1} soil)

Treatment	Av. p	Av. Mg
Super phosphate	9.14	1.96
Mussoorie rock phosphate	13.55	2.89
Bowl sludge	9.23	3.46
Control	1.41	1.65
SE	2.63	0.32
CD	7.98	0.97

7.6 Dynamics of K in rubber growing soils and other related studies

The field experiment laid out in 1990 to study the effect of different levels of K on yield and latex flow is in progress. Analysis of pretreatment soil samples revealed low K status in the experimental area. The treatments (0, 15, 30, 45, 60, 75 and 90 kg K_2O ha^{-1}) were incorporated in two split doses. The volume of latex, dry rubber content and plugging index were recorded periodically. The soil and leaf samples were collected and analysed for nutrient status.

8. Physico-chemical properties of rubber growing soils

Data on available nutrient status obtained from the regional laboratories and the mobile unit of RRII were compiled. The soils were classified as low, medium and

high based on soil fertility index. A soil fertility map of Kottayam district was also prepared. Nutrient index of rubber growing soils of Kerala is given in the Table-Ag. 15. The nutrient index values in general indicate that organic carbon and available Mg status is medium or high and available P and K low in all the districts.

In another study to investigate the important N fractions in rubber growing soils, soil samples were collected from the selected treatments in one of the factorially laid out fertilizer trials on mature rubber. Soil samples were also collected from adjacent fields from different age groups and analysed for total N, inorganic N (NH_4-N and NO_3N), organic N, total hydrolysable N and available N. Further studies to work out the correlations between the above fractions of N and available N are in progress.

Table-Ag. 15. Soil nutrient indices for different districts of Kerala

District	No. of samples	Nutrient indices			
		OC	Av.P	Av.K	Av.Mg
Kasaragod	497	2.71 (H)	1.14 (L)	1.53 (L)	2.88 (H)
Canannore	2973	2.61 (H)	1.17 (L)	1.29 (L)	2.76 (H)
Calicut	1404	2.60 (H)	1.1.5 (L)	1.43 (L)	2.53 (H)
Malappuram	994	2.30 (M)	1.10 (L)	1.27 (L)	2.73 (H)
Palghat	1037	2.15 (M)	1.13 (L)	1.48 (L)	2.71 (H)
Trichur	1054	2.11 (M)	1.26 (L)	1.84 (M)	2.88 (H)
Ernakulam	1848	1.91 (M)	1.36 (L)	1.36 (L)	2.27 (M)
Idukki	550	2.36 (H)	1.18 (L)	1.29 (L)	1.76 (M)
Kottayam	3432	2.38 (H)	1.55 (L)	1.43 (L)	2.05 (M)
Quilon	4111	1.98 (M)	1.37 (L)	1.43 (L)	2.15 (M)
Trivandrum	1550	2.09 (M)	1.23 (L)	1.36 (L)	1.96 (M)

L = Low M = Medium H = High

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

DRIS norms for the nutrients N, P, K, Ca and Mg for rubber were derived from the 30 combinations of each pair of the nutrients N, P, K, Ca and Mg based on the standard methodology. Based on these norms DRIS indices were calculated for samples with different levels of N, P, K, Ca and Mg and these indices are giving better indication of the nutritional status of the foliage. These indices are to be verified through progressive diagnosis in the factorially laid out field experiments.

10. Standardisation of analytical technique

The possibility of using dilute HCl for extraction of K, Ca and Mg in *Hevea* foliage was investigated. The values obtained were correlated with dry ashing method. Significant positive correlation was obtained between the two methods.

11. Collaborative studies

The division participated in the indepth study on nutritional aspects of tapping panel dryness.

12. Advisory work

Analysis of 7790 soil and 1822 leaf samples were conducted in the regional laboratories for offering fertilizer recommendations. In the central laboratory at RRII, 2000 leaf and 3000 soil samples were analysed and fertilizer recommendations were offered.

BIOTECHNOLOGY DIVISION

1. Somatic embryogenesis

Plants generated through somatic embryogenesis, utilizing integumental tissue were planted out in the field. This system may enable the perfection of a pathway for the large scale production of rubber clones by tissue culture.

2. *In vitro* propagation by shoot tip culture

This is an ongoing programme for generating plants by tissue culturing shoot tips asceptically. Marked difference in girth measurements between shoot tip culture derived plants and the bud grafted plants were observed during the first year in the field. As reported in many other tissue culture derived crop plants, in rubber also it was observed that the tissue culture derived plants have had an accelerated growth during the first season.

3. Anther culture

This is also an ongoing programme. A population of anther culture derived plants were planted in the field during June 1991.

4. Protoplast culture

Several clones and plant materials were evaluated for generating suitable explant source for protoplast culture. Leaf mesophyll tissues have been observed as a good source of explant for this purpose. Microcalli have been observed in culture.

5. Enzymology

Several enzymes are being studied in tissue culture derived plants vs plants generated from traditional propagation.

BOTANY DIVISION

The Botany Division continued to concentrate on genetic improvement through hybridization and clonal selection. Special emphasis was given to ortet selection and genetic studies. Investigations on propagation, anatomy and cytogenetics were also in progress.

1. Evolving high yielding clones for traditional area

1.1 Hybridization and clonal selection

Monthly yield recordings were carried out in 1982 and 1983 small scale trials of hybrid clones resultant of 1979 and 1980 hybridization programmes. From among 63 hybrid clones of the 1982 programme (1985 small scale trial) 15 clones showing comparatively more yield than RRII 105 at the age of four and a half years (Table-Bot. 1) were multiplied and established in source

Table-Bot. 1. Mean yield and girth of hybrid clones at the age of $4^1/_2$ years

Clone	Yield (g tree^{-1} tap^{-1}) ± SE	Girth (cm) ± SE
82/2	13.60 ± 1.03	33.75 ± 1.26
82/3	13.83 ± 1.13	35.63 ± 1.44
82/7	17.52 ± 1.54	35.63 ± 1.52
82/10	15.96 ± 1.18	36.17 ± 0.95
82/14	19.03 ± 1.64	39.88 ± 1.87
82/17	15.03 ± 1.08	34.84 ± 1.05
82/22	19.58 ± 1.42	33.50 ± 1.47
82/27	17.08 ± 1.28	37.96 ± 0.84
82/29	20.17 ± 1.75	38.84 ± 1.58
82/30	15.19 ± 1.29	35.16 ± 1.26
82/34	16.20 ± 1.33	30.55 ± 1.63
82/46	12.67 ± 0.87	34.40 ± 1.80
82/49	14.36 ± 0.73	34.13 ± 0.84
82/53	16.36 ± 1.13	30.55 ± 0.69
82/54	13.99 ± 0.84	34.83 ± 1.19
RRII 105 (control)	9.85 ± 3.11	31.13 ± 1.20

bush nurseries for laying out a large scale trial during 1993 planting season.

One hundred and seventy four clones resultant of 1983 HP were subjected to one round of test tapping three years after field planting. Girth was recorded prior to yield recording. Juvenile growth characters and yield were recorded from 295 clones, resultant of 1986 HP along with their corresponding parents, established in 12 small scale trials. Data on juvenile growth and yield were recorded from 1989 HP seedling progenies. From among a total of 19 families, nine families recorded juvenile yield above the general mean (4.07 g tree^{-1} tap^{-1}). Juvenile yield was the highest in the family RRII 105 x RRII 118 (6.85g), followed by RRIM 600 x PB 242 (6.25g). Girth was the highest in RRIM 600 x PB 242 (17.56cm) with 11 families recording values above the general mean (14.78cm). Selected seedlings of 1986 and 1988 hybridization programmes were multiplied and a polybag nursery was established for further studies.

1.2 Ortet selection

Experiments on ortet selection programme are in progress. Annual girth recording, four years after field planting in three trials laid out at Cheruvally estate revealed that 35 clones recorded girth above that of the control clone GT 1. Girth recording of 46 ortet clones in two trials at Mundakkayam estate was done two years after field planting. At Koney estate a trial comprising 47 clones was laid out in a suitable statistical lay out. Casualties were enumerated in the source bush nursery at Kodumon estate and selected clones were multiplied. Sufficient bud grafted plants of ortets selected from small holdings, were raised for laying out a small scale trial.

1.3 Special techniques in breeding

Monthly yield recordings were done in the trials of the polyploid population and selected clones developed from seed irradiation programme. Yield for first five years of tapping, along with the secondary characters of clones developed from mutation were tabulated and subjected to statistical analysis. Significant variation with regard to yield among these clones was noted. Two clones showed numerically more yield than RRII 105. Mean yield for first five years and girth increment on tapping are given in Table-Bot. 2. There was no significant variation among clones with regard to girth increment on tapping. The trees in the clone trial (irradiated material) of 1985 planting have attained tappable girth. Polybag plants were maintained properly for gap filling in 1991 trial on selections from progeny of male sterile clones and mutagen treated population.

2. Evaluation of clones

2.1 Large scale trials

Monthly recording of yield and annual recording of girth and secondary characters were carried out in all mature large scale trials. Among the 10 clones in a trial laid out in 1968, RRII 108 recorded the highest mean yield of 55.38 g tree^{-1} tap^{-1} over 16 years folowed by RRII 119 (54.28g) in comparison to 48.59g for the control Tjir 1 (Table-Bot. 3).

In the 1971 clone trial consisting of another set of clones, Harbel 1 recorded the highest yield (53.51g) during the 12th year in comparison to 48.12g for PR 107 (control). Among the ten clones in the 1976 clone trial, RRIC 100 recorded the highest yield (49.73g) in comparison to 46.60g for the control clone GT 1, during the 8th year of tapping. Of the ten clones in the 1981 mixed clone trial, PCK 1 continued to record the highest yield (51.06g) during the second year of tapping in comparison to 48.68g for RRII 105. Girth recording was done from the two clone trials

Table-Bot. 2. Yield and girth increment of clones developed through mutation

Clones (code no.)	Mean yield over five years (g tree^{-1} tap^{-1})	Girth increment on tapping (cm yr^{-1})
1	19.11	3.17
2	46.78	4.30
3	28.34	3.06
4	41.04	3.57
5	33.21	5.77
6	30.80	4.39
7	28.39	3.32
9	50.28	5.95
10	52.15	4.80
11	34.67	3.35
14	36.16	3.34
15	53.82	3.91
16	56.65	6.36
17	31.06	3.94
18	28.98	3.50
19	68.01	4.41
20	28.09	5.25
21	38.18	4.97
22	35.49	2.51
23	33.46	3.13
24	34.94	4.09
25	30.24	4.29
26	66.79	4.93
27	27.75	4.96
28	55.00	4.78
29	25.16	4.42
31	25.95	3.49
32	43.26	6.41
33	38.97	4.13
37	21.02	5.18
41	32.77	4.65
42	38.15	4.22
43	52.13	4.97
44	37.45	2.04
45	42.39	3.72
46	64.11	2.58
General mean	39.19	4.22
SE	6.13	0.85
CD	17.25	—

Table-Bot. 3. Yield of some RRII clones

Clones	Yield over 16 years tapping (g tree^{-1} tap^{-1})
RRII 1	42.35
RRII 2	40.80
RRII 19	49.80
RRII 20	44.65
RRII 21	48.31
RRII 108	55.38
RRII 112	51.49
RRII 115	45.76
RRII 119	54.28
Tjir 1 (control)	48.59
General mean	48.15
SE	3.88
CD	13.97

planted in 1989 at Central Experiment Station. In trial I, out of the nine clones PB 235 recorded the highest girth followed by PB 312, whereas in trial II, out of the eight clones, RRIM 600, KRS 25 and SCATC 93/114 recorded comparatively higher values, during the second year. Among 14 clones in the 1989 clone trial at HBSS, Nettana, RRII 203 recorded the highest girth in the 2nd year, while PCK 1 recorded the lowest value. Monthly girth was recorded from the two multidisciplinary trials of modern clones at RRII. Juvenile yield was also recorded from the first trial, and the data revealed SCATC 88-13 to record the highest mean. Among the 13 clones in each trial, the highest mean girth was recorded from RRII 118 (19.17cm) in trial 1 and PB 314 (20.18cm) in trial II. Data recorded from trial I on juvenile growth characters viz., plant height, girth, number of flushes and number of leaves at 18 months' growth revealed significant clonal differences for all the characters. Significant positive correlations of the four growth characters with juvenile yield were also revealed.

2.2 On-farm evaluation

Recording of yield and/or girth and secondary characters was continued from a

total of 23 block trials at different locations. RRII 105 continued to record the highest yield in all the trials in the mature phase. The 1981 block trial at Desamangalam was opened for tapping. Among five clones, RRII 203 recorded the highest girth (55.3 cm) at commencement of tapping. Girth recorded from the block trial at Mannarghat estate revealed that PCK 1 had the highest value among six clones. Yield recording was commenced in the 1985 block trial consisting of 12 clones at Chithelvetty estate. PB 235, PB 260, RRIC 52, PB 311 and PCK 1 recorded comparatively higher girth at opening.

3. Performance of clonal composites

Thirteen clones — RRII 105, RRIM 600, GT 1, PB 235, PB 28/59, PB 217, RRIM 703, PCK 1, PCK 2, RRII 5, PB 260, PB 280 and PB 311—were multiplied and raised in polybags for taking up trials during 1992 planting season to study the performance of multimodel clone blends in comparison to monoclone population of RRII 105. Budwood plants of these clones were raised for taking up on-farm trials. Nucleus quantities of budwood of the above clones were raised for taking up onfarm trials. Nucleus quantities of budwood of the above clones were distributed to five large estates and to four nurseries of the Board for further multiplication.

4. Polycross progeny evaluation

Evaluation of progeny of prepotent clones was initiated. Seedling progeny of nine clones, identified as prepotents, are being vegetatively multiplied for laying out a field trial for adult progeny analysis.

5. Breeding for clones with high yield and compact canopy

The natural variant having short stature and close internodes identified from a seedling population was confirmed to be a genetic variant. Observations on the four morphotypes resultant of open pollination were carried out. The growth attributes of these progenies are being further evaluated. With a view to evolving a clone with high yield and compact canopy hybridization programme was initiated incorporating high yielding and vigorous clones in cross combinations with the genetic variant.

6. Breeding for drought tolerance

A study on forty clones was initiated for identifying those which are tolerant to the stress situation in summer months in terms of yield and girth increment.

7. Breeding for powdery mildew resistance

With a view to screening clones for their reaction to powdery mildew, a total of 16 clones were selected. Multiplication of these clones was initiated for laying out a nursery experiment along with spreader rows of a susceptible clone. Seedling progenies resultant of 1986 hybridization programme were cut back for initiating flushes for screening and selection of *Oidium* resistant clones.

8. Estimation of genetic parameters in *Hevea*

8.1 Variability, correlation and heterosis for yield and yield components

The nature and magnitude of genetic parameters and heterosis were assessed in 23 F1 hybrids of the cross involving clones RRII 105 and RRIC 100, at the age of four and a half years after planting. The hybrids displayed substantial differences in their variability and heterotic responses for different characters (Table-Bot. 4 & 5).

8.2 Estimation of combining ability for parental selection

The trees in 1987 trial, on estimation of combining ability in the juvenile phase were subjected to test tapping after recording girth. The 1990 trial at HBSS, Nettana was maintained properly.

Table-Bot. 4. Range, mean, variance ratio and genetic parameters for yield and yield attributes at $4^1/_2$ years

Parameters	Range	Mean	Variance ratio (clones)	G. C. V.	P. C. V.	Heritability (H^2%)	GA %
Mean annual yield (g tree^{-1} tap^{-1})	04.35 - 19.90	11.41	7.37**	34.56	41.92	67.96	58.72
Peak yield (g tree^{-1} tap^{-1})	7.49 - 40.57	22.51	7.18**	37.42	45.61	67.31	62.95
Summer yield (g tree^{-1} tap^{-1})	1.27 - 5.26	2.88	5.36**	34.20	44.47	59.15	54.17
Ethrel stimulated yield (g tree^{-1} tap^{-1})	8.14 - 61.25	36.68	6.96**	39.36	48.26	67.00	66.61
Initial flow rate (ml min^{-1} cm^{-1})	0.02 - 0.14	0.07	5.31**	37.80	49.49	58.33	58.57
Total volume of latex (ml tap^{-1})	4.42 - 61.83	30.17	2.46**	42.71	74.63	33.00	50.75
Plugging index	2.5 - 13.68	7.03	4.79**	36.82	49.29	56.00	56.76
Girth at opening (cm)	31.34 - 39.88	35.42	2.60**	5.19	8.80	34.77	6.32
Girth increment on tapping (cm)	3.47 - 7.25	5.06	4.73**	18.99	25.25	55.00	28.91
No. of latex vessel rows	3.67 - 8.22	5.57	2.76**	17.03	29.04	37.00	21.38
Bark thickness (mm)	5.09 - 6.34	5.58	2.76**	4.24	6.96	37.00	5.30

**Significant at P=0.01

8.3. Genetic divergence, prepotency and inbreeding depression

The study on genetic divergence was concluded during the period under report. Based on the wintering pattern recorded over two years, the forty clones studied were grouped into early, intermediate and late types. Data pertaining to rubber yield and certain physiological, morphological and structural attributes recorded from the clones were analysed statistically for the components of variance. Employing the 'Mahalanobis' D^2 technique, the forty clones could be grouped into eight genetically divergent clusters (Table-Bot. 6). This study established the existence of considerable genetic diversity among Wickham clones and showed that geographic diversity was not related to genetic diversity.

Data collected from two year old open pollinated progenies and one year old selfed progenies of promising clones raised for the

Table-Bot. 5. Estimates of heterosis (%) over better parent, for yield and yield attributes in hybrid selections

Clones	Mean annual yield (g tree^{-1} tap^{-1})	Initial flow rate/unit length of cut (ml)	Total vol. of latex/ tap (ml)	Girth at opening (cm)	Girth increment on tapping (cm)	No. of latex vessel rows	Bark thickness (mm)
82/3	40.41	14.06	72.07	5.45	—	—	—
82/7	61.32 **	—	48.44	5.45	12.55	—	2.99
82/10	50.46 *	—	—	7.04	10.67	—	—
82/14	83.55 **	85.94**	84.74	18.02 **	—	—	—
82/17	37.56	48.44	21.91	13.11	—	14.64	—
82/22	78.88 **	104.69**	—	—	—	10.04	—
82/27	56.55 **	7.81	78.36	12.34	13.59	—	7.23
82/29	102.03 **	28.13	111.38 *	14.95 *	17.82	—	—
82/30	40.71	112.50**	33.61	—	—	—	—
CD 5%	4.44	0.036	30.30	4.13	1.42	2.04	0.505
CD 1%	5.92	0.048	40.40	5.51	1.89	2.72	0.674

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

Table-Bot. 6. **Distribution of clones in genetically divergent clusters**

Cluster	Clones
I (15)	PR 107, PB 5/139, Ch 32, Lun N, HC 28, PB 5/60, Waring 4, Tjir 16, BD 10, Ch 4, PB 213, HC 55, Mil 3/2, Ch 29, BD 5.
II (11)	Gl 1, PB 206, AVROS 255, AVROS 352, PB 215, PB 5/51, LCB 1320, PB 28/83, PB 230, PB 5/63, PB 5/76.
III (6)	RRII 105, Ch 26, PB 252, PH 242, PB 217, GT 1.
IV (3)	Ch 153, PB 6/50, PB 86.
V (1)	RSY 23.
VI (2)	AVT 73, PB 28/59.
VII (1)	Ch 2.
VIII (1)	PB 235.

Figures in parentheses denote number of clones in each cluster

studies on prepotency and inbreeding depression respectively are under statistical analysis.

9. Cytogenetical investigations

Meiotic studies of normal fertile clone RRII 105, had shown that there were no abnormalities in methaphase I. Eighteen bivalents were seen and the stainability of pollen was 95 per cent. Meiotic studies in a sterile clone of *Hevea brasiliensis* showed that there was a wide spectrum of abnormalities. The normal meiotic behaviour of 18 bivalents was never observed in the sterile clone. There was predominant formation of univalents ranging from 8 to 32 and bivalents from 2 to 14 (Table-Bot. 7). Anaphase I was highly irregular with unequal distribution of chromosomes, absence of active polar movement and presence of varying number of laggards. The distribution of microspores during tetrad stage varied from 3 to 9. After the formation of microspores there was complete degeneration of cytoplasm and nuclei resulting in the formation of sterile pollen grains having varying size and shapes.

Table-Bot. 7. **Chromosome association at metaphase I of sterile clone of *Hevea brasiliensis***

Association	Frequency	Per cent
14 II + 8 I	20	2
13 II + 10 I	90	9
12 II + 12 I	80	8
11 II + 14 I	30	3
10 II + 16 I	150	15
9 II + 18 I	30	3
8 II + 20 I	190	19
7 II + 22 I	30	3
6 II + 24 I	130	13
5 II + 26 I	40	4
4 II + 28 I	30	3
3 II + 30 I	120	12
2 II + 32 I	60	6

10. Floral biology and fruitset

In order to have a deeper insight into the causes of low fruit set in *Hevea*, a new project was initiated with two selected popular clones. Hand pollinations were done and fruits at different developmental stages were sampled.

11. Bark anatomical investigations

11.1 Variabilites, correlations and path coefficient analysis for yield in relation to anatomical characters

In a study on ten clones it was observed that laticifer area index and the latex flow characters such as initial flow rate and plugging index are the major traits governing yield drop during drought period. Variabilities and genetic parameters of the anatomical triats as well as the variations of latex flow characters during drought period were estimated. The data are summarised in Tables-Bot. 8 & 9. Per cent variation on initial flow rate showed the highest variability. This trait has high heritability associated with very high genetic advance and hence the expression of this trait appears to be governed by additive gene action. Very high heritability associated with good genetic advance was recorded for the anatomical traits such as laticifer area index and height

Table-Bot. 8. **Bark anatomical characters of drought tolerant and susceptible groups of clones**

(a) **Laticifer traits**

Source	Total number of latex vessel rows	Proportion** of latex vessel rows in the soft bast (%)	Diameter of latex vessels (um)	Total thickness of bark (%)	Proportion** of soft bast thickness (%)
Drought tolerant	32.55	41.77	20.71	6.17	28.13
Drought susceptible	32.33	52.38	21.30	5.27	39.42

(b) **Phloem ray characters**

Source	Height of phloem rays (mm)	Width of ** phloem rays (mm)	H/W ratio of phloem rays
Drought tolerant	237.15	41.19	10.58
Drought susceptible	373.96	47.81	8.52

** Significant at 1% level

width ratio of phloem rays indicating high involvement of additive gene action for the expression of those traits. For the variation in plugging index heritability was comparatively low.

11.2 Studies on bark renewal

Processing of bark samples and microscopic observations are under progress.

11.3 Estimation of anatomical parameters of clones under evaluation

As a part of the clone evaluation programme latex vessel rows were assessed in 20 clones, ten each in two evaluation trials.

Table-Bot. 9. **Vairabilities and genetic parameters of certain anatomical traits and variations of initial flow rate and plugging index during drought period**

Characters	G.C.V.	P.C.V.	Herita-bility %	Genetic advance %
Rise in plugging index (%)	31.10	48.86	41.49	41.67
Drop in initial flow rate (%)	57.99	74.53	60.54	92.95
Lacticifer area index	24.01	30.60	61.57	38.81
Height/width ratio of phloem rays	17.88	19.61	83.09	33.57

For bark study, sample collection from four cytotypes in an evaluation trial, has been done. Clones (66 numbers) in the garden of Wickham germplasm were evaluated for the number of latex vessel rows in the virgin bark at the time of opening. Parental clones for breeding programmes were identified based on anatomical parameters.

Comparative bark anatomy of drought tolerant and susceptible clones were studied. Four anatomical traits (pholem rays width, height/width ratio of phloem rays, proportion of soft bast and proportion of latex vessel rows in the softbast) showed significant differences between the two groups. For the height/width ratio of phloem rays within group differences were not significant.

12. Wood anatomical investigations

To study the effect of ethrel application on rubber wood quality two popular clones (RRII 105 and RRIM 600) were selected and stimulant applications were continued as per the schedule.

13. Propagation techniques

Girth and other secondary characters of the trees in the trial on depth of planting were recorded. As in the previous years control plants (bag plants) showed maximum vigour.

Girth and other secondary characters of the trees in the experiment on benchgrafting were recorded. Growth characters at the nursery stage recorded from these plants were summarised. Benchgrafted plants generally showed more vigorous growth than normally budded plants. Vacancies were filled in the trial on deep planting of bag plants.

14. Genetic basis of stock-scion combinations

The experiment with 14 different

stock-scion combinations at CES, Chethackal was opened for tapping and monthly yield recording was commenced. Among the different stock-scion combinations, RRII 203 budgrafted on clonal root stocks of RRII 203 as well as on assorted stock continued to record the highest girth at the age of seven years. Casualties were replaced in the new trial laid out with nine different treatments during 1990.

15. Horticultural manipulations

Planting of bag plants, budded stumps and seeds in the trial on comparative study of twinstocks and single stocks was completed. Seed at stake plants were twin-grafted. The growth characters of the plants in the trial on crown budding of bag plants were recorded.

16. Studies on early evaluation

Performance indices of the 13 clones included in the experiment were computed considering the variables girth and juvenile yield at the age of two and four years. Values higher than the general mean were recorded from RRII 6 (9.89), RRII 118 (9.82), RRII 105 (9.16), RRIM 600 (9.00) and PB 311 (8.98) in the descending order, at two years growth (Table-Bot. 10). At four years' growth in addition to these clones, GT 1 also came under this group. All these clones except RRII 118 are high yielders in the mature phase as well.

A multiple correlation coefficient of r = 0.7383 between juvenile yield and three yield components viz., panel length, plugging index and DRC at three years, suggest that 54.51per cent of the total variability for juvenile yield could be accounted for by the three independent variables. Correlations worked out between girth and yield at two and four years revealed highly significant positive correlations for girth (0.7580) and yield (0.4560) suggesting that these characters at two years are sufficient for screening the populations. Observations on number of latex vessel rows and bark thickness were collected from six clones. Relatively higher number of latex vessel rows were recorded in the high yielding clones RRII 105 and RRIM 600 in comparison to that in the low yielders. A similar trend, however, was not observed for bark thickness.

Ten selected clones coming under high, medium and low yield groups were multiplied and established in a polybag nursery for laying out a new field experiment during 1992 season.

Table-Bot. 10. Performance indices of clones at two growth phases

Clone	1st year	4th year
RRII 105	9.16	1.57
RRIM 600	9.00	1.35
PB 311	8.98	1.37
RRII 6	9.89	1.81
GT 1	8.11	1.36
RRII 300	8.07	1.22
RRII 208	7.73	1.18
RRII 118	9.82	1.74
Tjir 1	7.55	1.17
RRIM 501	7.20	0.98
RRIM 612	7.56	1.22
RRII 38	6.29	1.01
HP 20	6.74	0.91
Mean	8.16	1.30

GERMPLASM DIVISION

The Germplasm Division continued its activities on introduction, collection, conservation and evaluation of *Hevea* germplasm. The Division involved in a successful operation of a bilateral clone exchange programme with Institute de Recherches sur le Caoutchoue, Ivory Coast.

1. Introduction, collection and conservation of germplasm

1.1 Wickham materials from the secondary diversity centres

A clone museum comprising of 174 older cultivars and elite clones of exotic and indigenous origin is being maintained. Nucleus budwood and specimens for various field and laboratory experiments were supplied from this collection.

Five promising IRCA clones were introduced from Ivory Coast. Ten metres budwood of each clone were received and the number of budgrafts established ranged from 168 to 207 (Table-Gplm1). In reciprocation 10 meters budwood each of the clones RRII 5, RRII 105, RRII 118, RRII 208 and RRII 300 were sent to IRCA.

Table-Gplm. 1. IRCA clones introduced

Clones	Parentage	No. of plants raised
IRCA 18	PB5/51 x RRIM 605	171
IRCA 109	PB5/51 x RRIM 600	188
IRCA 111	PB5/51 x RRIM 605	168
IRCA 130	PB5/51 x IR 22	201
IRCA 230	GT 1 x PB 5/51	207

1.2 Wild germplasm from 1981 IRRDB explorations

Introduction of wild germplasm from the source bush nursery in Malaysia was discontinued, as the remaining plants were reported to be unhealthy. 530 genotypes of the 1989 introduction and 206 genotypes of the 1990, were planted in the source bush nursery. A total collection of 4709 genotypes were received at RRII and are being maintained in the nursery at the Central Experiment Station. RRII now has a rich genetic resource of *Hevea* from its centre of origin (Table-Gplm. 2).

Table-Gplm. 2. Total accession of wild germplasm

Provenance/source in Brazil	No. introduced
Acre	2148
Rondonia	1833
Mato Grosso	564
Ortets	126
Mixed seedlings	38
Total	4709

2. Evaluation of germplasm

2.1 *In situ* conservation gardens

Characterisation and evaluation of the Wickham materials conserved in three germplasm gardens were continued. Monthly yield and annual girth were recorded. Observations on clones in garden II have been initiated to study the genetic divergence among these clones.

The average girth of the 51 clones in germplasm garden I was 76.35cm. The control clone RRII 105 had a girth of 79.32cm, while ten clones showed a higher girth than that of RRII 105. The garden average for yield was 47.92 g per tree per tap. RRII 105 had an average yield of 76.58g while 3 clones (PB 215, PB 217, PB 235) gave higher yields than RRII 105.

In garden II, RRII 105 was the highest yielder. A total of 7 trees belonging to different clones were severely affected by wind

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

Traits	Wild genotypes			Controls	
	Maximum	Minimum	Mean	GT 1	RRII 105
Girth (cm)	18.3 (AC655)	12.4 (RO343)	15.1	17.3	16.2
Height (cm)	766.0 (AC697)	424.2 (MT1005)	570.9	561.0	538.0
Bark thickness (mm)	3.1 (AC685)	1.8 (AC668)	2.4	2.9	2.9
Yield (g tree^{-1} tap^{-1})	2.9 (MT1020)	0.1 (RO319)	0.6	6.3	6.5
Single leaf area (cm^2)	236.3 (AC667)	72.2 (RO368)	120.7	77.0	69.6
TLVR	7.0 (MT999)	2.0 (AC714)	3.7	4.7	4.0
DLV	23.8 (MT999)	11.8 (RO319)	19.4	18.3	19.2

TLVR = Total number of latex vessel rings DLV = Density of latex vessels per ring

and 18 trees showed symptoms of dryness, clone RRIM 617 being badly affected by this syndrome. Data on yield and girth of the 17 clones in garden III showed that five clones had higher girth than the garden average. RRII 203 was the highest yielder, followed by PB 311 and RRII 105.

2.2 Nursery evaluation, juvenile characterisation and cataloguing

Preliminary evaluation of 100 genotypes belonging to the Acre, Rondonia and Mato Grosso provenances was carried out. Parameters studied were girth, total height, bark thickness, test tap yield, single leaf area, total number of latex vessel rings and density of latex vessels per ring per 2 mm circumference. General mean values of the wild germplasm for all the characters except height, single leaf area and density of latex vessels per ring were found to be lower than that of the controls (Table-Gplm. 3).

The test tap yield of the wild genotypes was very low compared to that of the controls. Among the three provenances - Acre, Rondonia and Mato Grosso - the genotypes from Mato Grosso showed a general superiority for all characters except girth, height and single leaf area (Table-Gplm. 4). Higher estimates of GCV along with H^2 and GA were shown by the characters test tap yield, single leaf area and total number of latex vessel rings. This study revealed that (1) chances for direct selection is very remote, (2) wide variability exists for secondary characters and (3) bark thickness, number of latex vessel rings and density of latex vessels per ring have got higher heritability values which indicates their significance in breeding programmes.

2.3 Field evaluation of Brazilian germplasm

Growth performance and other morphological observations of 300 genotypes in the further evaluation trial (1990) were recorded. Girth, total height, total number of flushes and total number of leaves per flush at three month intervals were recorded. Characterisation is being continued.

193 selected genotypes, including 50 ortets were multiplied and are being raised in polybags for the envisaged further evaluation in 1992.

Table-Gplm. 4. **Comparison between the three provenances**

Characters	Provenances		
	AC	MT	RO
Girth (cm)	15.43	14.95	14.66
Height (cm)	598.78	525.21	576.90
Bark thickness (mm)	2.29	2.62	2.32
Yield (g)	0.38	1.07	0.38
Single leaf area (cm^2)	141.84	93.74	118.89
TLVR	3.52	4.06	3.60
DLV	19.35	20.09	18.78

MYCOLOGY AND PLANT PATHOLOGY DIVISION

The Plant Pathology and Entomology Sections under the Division concentrate on experiments in crop protection aspects of rubber. Basic studies of pathogens are carried out by Mycology Section. Research on improvement of soil fertility and biological control of pollution are being done by Microbiology Section.

1. Abnormal leaf-fall disease

This most important disease of rubber caused by *Phytophthora* spp. is largely confined to high rainfall areas. But recently this disease appeared in four consecutive years in Kanyakumari district of Tamil Nadu also. The disease was severe in the high rainfall areas and some plantations in Kanyakumari district during the year.

The experiment to evolve regionwise recommendation for different clones initiated in clone RRII 105 during last year was extended to clone RRIM 600 also in the high rainfall area. The dosages included are 4, 6, 8 and 10 kg copper oxychloride (COC)/ ha in 40 l spray oil. The leaf retention recorded is given in Table-Path. 1.

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

Treatments	RRII 105		RRIM 600
	High rainfall	Low rainfall	High rainfall
COC 56% ODP 2 kg ha^{-1}	-	84.75	-
" 4 kg ha^{-1}	31.6 (27.5)	76.50	25.0
" 6 kg ha^{-1}	34.8 (32.9)	85.71	40.3
" 8 kg ha^{-1}	46.4 (52.4)	76.31	40.3
" 10 kg ha^{-1}	65.9 (83.1)	-	42.3
Unsprayed	17.3 (9.4)	80.92	-
CD (P = 0.05) 9.11	NS	NS	

Figures in parentheses represent arc sine transformed values

While no significant difference is observed between the treatments in RRII 105 in low rainfall area only the highest dose tried gave satisfactory protection in high rainfall area. In RRIM 600, even the highest dose tried did not give satisfactory protection in high rainfall area.

A survey on the incidence of this disease in the clone RRII 105 was conducted covering all the rubber growing districts of South India. The leaf fall ranged from 40 to 50 per cent in almost all the districts except Idukki, Wynad, Trivandrum and Kanyakumari. No leaf fall was noticed in 30.25 per cent of the 1005 holdings surveyed. A judicious spraying recommendation based on earlier experience on disease incidence in each holding is required. As the disease cause considerable crop loss and debilitate the trees in majority of the rubber growing areas prophylactic spraying in the clone RRII 105 is essential in the disease prone areas.

Two formulated products of 56% oil based COC were subjected to large scale screening in two locations. As the results were not satisfactory, the products were not recommended. One new formulation of COC 56% Oil dispersible powder was subjected to small scale screening and approved for large scale field testing.

2. High volume spraying

Efforts are on to reduce the cost of high volume spraying and improve the results to benefit the small holders among whom it is popular.

In continuation of last year's high volume experiment in clone RRII 105 (tolerant clone) the experiment was extended to clone RRIM 600 (susceptible clone) in

high rainfall area. The percentage leaf retention recorded in different treatments is given in Table-Path 2.

Table-Path. 2. Percentage leaf retention in high volume spraying

RRII 105		RRIM 600	
Dosage l ha^{-1}	% leaf retention	Dosage l ha^{-1}	% leaf retention
1000	21	3000	63
2000	36	4000	72
3000	72	5000	75
Control	9	—	—

The experiment to compare Zinc Bordeaux (0.5% Bordeaux mixture + 0.5 % Zinc sulphate) with Bordeaux mixture (1%) was continued in RRII 105 and was extented to RRIM 600. The percentage leaf retention was on par in both the treatments (Table-Path 3).

Table-Path. 3. Leaf retention in the high volume spraying

Treatments	RRII 105	RRIM 600
1% Bordeaux mixture	72.0	63.0
0.5% Bordeaux mixture + 0.5% Zinc sulphate	70.0	62.0

3. Evaluation of panel protectant/ wound dressing compounds

In heavy rainfall areas, when tapping is continued during rainy days, bark rot disease caused by *Phytophthora* occurs. An experiment to compare furnace oil as panel protectant with the approved compound sopkot was concluded.

A new panel protectant compound 'Tew coat' was approved for use after large scale screening in two seasons. The petroleum compounds 'Bituchem' and 'Treekote' were also found suitable as panel protectants in large scale screening trial. Two more petroleum products were subjected to small scale screening and approved for field testing.

4. Pink disease

This most important stem disease is found to be very serious in recent years in the plantings of the highly susceptible clones RRII 105 and PB 217. Severe incidence of the disease is being noticed in plantations where the mature trees of these clones are found adjacent to the immature areas.

A new experiment was initiated to evaluate prophylactic spray protection of young rubber from pink disease incidence in a 1990 replanting of RRII 105 at Mundakayam. The treatments included are Tridemorph (0.1%), T.M.T.D. (0.2%), Cobox.L. (1%), and Bordeaux mixture (1%), Bordeaux paste application and detection and treatment with Bordeaux paste as controls. The disease incidence in the first year was less. The experiment will be continued in the second year also.

5. Powdery mildew disease

A definite negative relation is found on the incidence of powdery mildew disease and abnormal leaf fall disease, as powdery mildew disease can considerably reduce the pod formation due to attack on inflorescence and reduce inoculum for abnormal leaf-fall disease.

An experiment to evaluate integrated schedule involving systemic and non systemic dust fungicides for the control of powdery mildew was initiated. The experimental plots were laid out in the disease-prone areas of Kanyakumari and Wynad districts. The treatments include 1.5 per cent dust formulations of carbendazim and tridemorph alone and in integration with 70 per cent sulphur dust. Three rounds of dusting were done in both the locations.

Table-Path. 4. **Comparative yield (g^1 t^1 t^1) and disease incidence (percentage)**

Year	Treatments	RRIM 600		RRII 105		GT 1		RRII 118	
		Y	D	Y	D	Y	D	Y	D
* 1988-89	S	63	—	80	—	36	—	40	—
	US	55	—	80	—	38	—	37	—
1989-90	S	64	77.76	73	—	35	—	44	—
	US	50 (34.21)	10.84	56 [23.28]	—	36	—	42	—
1990-91	S	80	69.96	101	88.97	59	—	57	—
	US	54 (56.84)	38.86	118	79.62	61	—	45 [14.03]	—

* In 1988 all plots in the four clones were sprayed

S = Sprayed, US = Unsprayed, Y = Yield, D = Disease, — = Not recorded.

Figures in paranthesis are percentage yield loss based on pretreatment yield during 84-85 ( ) or 88-89 [ ].

6. Yield loss due to diseases

The experiment to assess crop loss due to powdery mildew disease was concluded. The data collected indicated that in the clone PB 86, 7.7 to 11.8 per cent more disease in unprotected plots caused 21.1 to 31.8 per cent crop loss. Similarly 7.5 to 18.4 per cent more disease in clone RRIM 600 caused 13.5 to 28.5 per cent crop loss.

The crop loss due to abnormal leaf fall disease was assessed in four clones at Central Experiment Station. The data obtained are presented in Table-Path 4.

The data indicate considerable crop loss in RRIM 600, moderate loss in RRII 118 mixed results in RRII 105 and no loss in GT 1. The experiment is being continued.

7. High pressure injection for disease control

For wood preservation, the technique of pre-felling pressure injection of copper sulphate is being tried. For the past 2 years, even in 30 year old trees, there is only very mild attack of insect borers and moderate attack of fungi. In the injected wood pieces 56.8 mg copper was estimated compared to 0.92 mg in the case of uninjected wood.

8. Biological control of rubber diseases

The modern trend of organic and sustainable agriculture requires considerable reduction in use of chemical fungicides for the control of diseases. Biological control is a means to achieve this objective. A rhizosphere isolate of *Trichoderma harzianum* when multiplied and introduced in the root zone of rubber seedling in polybags protected them from infection by *Phellinus noxius* and increased the growth of seedlings (Table-Path. 5).

9. Host parasite interrelationship

The total phenol content in the healthy leaves of clones tolerant to abnormal leaf fall disease like RRII 33, RRII 105, Fx 516, F 4542 and susceptible clones like RRIM 600 and RRIM 701 were estimated. Phenol content was found to be comparatively more in tolerant clones than in susceptible clones.

Table-Path. 5. **Effect of introduction of antagonists in rhizosphere of rubber seedlings planted in *P. noxius* infested soil**

Treatments	Girth at 2.5 cm from collar (mm)	Height (cm)
T. hamatum	10.62	61.88
T. harzianum	9.43	59.13
T. koningi	10.21	56.13
T. viride	9.83	65.63
S4 F1 (*T. harzianum*)	11.40	56.25
R1 F2 (*Trichoderma* sp)	9.43	51.75
Uninoculated control	8.64	53.75
Inoculated control	6.69	42.63
CD	1.85	7.75

Attempts were made to study ethylene production by the fungi *Corynespora cassiicola* and *Phytophthora meadii* in culture. Among the different sources tested for ethylene production methionine was found to favour ethylene production by both the fungi. An increase in the production of ethylene was observed with increase in the concentration of methionine. Effect of light and temperature on ethylene production was also studied.

10. Minor leaf spot diseases and their control

In order to study comparative morphology of the fungus *Collectotrichum gloeosporoids* the diseased specimens were collected from 6 different regions and the pathogen isolated and pure cultures are being maintained.

11. Comparative morphological studies on *Phytophthora*

Growth, sporangial characters and pairing habit of 9 isolates were studied. Oospores produced by pairing were induced to germinate.

12. Oversummering of *Phytophthora*

Lesions were produced on petioles kept as bait in soil samples collected from the field during the off season due to infection of *Phytophthora*. Artificially produced oospores were buried in soil to study their survival.

13. Root diseases

Artificial inoculation was carried out on young potted seedlings using the fungal isolate obtained from purple root disease affected rubber plants and it was proved to be pathogenic. The pathogen was reisolated. Basidiospores were observed on the fruiting body formed at the collar region of the infected plants.

14. Multidisciplinary evaluation of clones

Observations were recorded on the incidence of *Gloeosporium*, shoot rot and pink disease. Powdery mildew incidence was also observed. A general observation on leaf fall due to *Phytophtora* was made.

15. Screening of germplasm material/ HP seedlings

Natural incidence of *Gloeosporium* and shoot rot was recorded in the clones planted in 1984. Observation on pink disease was also recorded.

16. Microbiology of leguminous cover crops

Large scale on-farm trials on the effect of *Bradyrhizobium* inoculation in *Pueraria phaseoloides* were continued. In addition to augmenting nodulation, biomass production and spread, bacterization resulted in comparatively more drought tolerance in *P phaseoloides*. A field trial was initiated to find out the actual contribution on nitrogen by *Bradyrhizobium* in inoculated *P. phaseoloides* with the aim of saving nitrogenous fertilizer applied to rubber.

Two isolates of *Bradyrhizobium* ie., Rh 2 and Rh 5 increased biomass as well as total nitrogen in tissues when estimated 30 months after inoculation in a field experiment at Pudukkad Estate. However, there was not much difference with regard to total nitrogen in soils of different Rhizobium treatments. (Table-Path. 6).

Table-Path. 6. **Effect of Bradyrhizobium on biomass of *P. phaseoloides* and soil nitrogen (30 months)**

Treatments	Biomass (t ha^{-1})	Total N_2 in biomass (kg ha^{-1})	Total N_2 in soil (%)	
			0-15 cm	15-30 cm
Control	4.95	135.43	0.746	0.249
Rh. 1	4.87	135.40	0.760	0.251
Rh. 2	5.37	147.58	0.762	0.258
Rh. 3	5.12	137.73	0.766	0.247
Rh. 4	4.76	132.90	0.754	0.250
Rh. 5	5.41	146.80	0.761	0.256
Rh. 6	5.02	136.65	0.779	0.248
CD (P=0.05)	0.27	7.45	NS	NS

Bradyrhizobium inoculation on the leaves of *P. phaseoloides* showed traces of nitrogenase activity. In a laboratory study Zn and Mn were observed to favour the growth of *Bradyrhizobium*.

Soil samples collected from fields of *Mucuna bracteata* and *P. phaseoloides* at 0.15 cm and 15-30 cm were examined for the population of *Beijerinckia* a non-symboitic N_2 fixing bacteria and nitrogenase activity. In both the cases, top soil registered a higher population of *Beijerinckia* and nitrogenase activity when compared to bottom soil. However, soil from *M. bracteata* was superior with respect to the population of *Beijerinckia* and nitrogenase activity.

A field experiment was initiated to study the effect of dual inoculation with *Rhizobium* sp. and *Beijerenkia* sp. in *P. phaseoloides*. Soil physicochemical and biological properties and the growth, nodulation, spread etc., of the cover crop are being studied. Observations made during the initial stages of establishment indicated that dual inoculation was superior with respect to nodulation, biomass and spread of *P. phaseoloides*.

Two field experiments, one for fixing optimum planting density of Mucuna plants and the other to study the effect of different covers on soil moisture and temperature laid out in Palghat region were continued. Periodical observations on the establishment of cover crops and the growth of weeds were made.

Cuscuta sp. collected from *P. phaseoloides* was inoculated on several cover crops and weeds. It established on all plants including rubber plants. This parasite not only suppressed the growth of *P. phaseoloides* but also considerably reduced the nitrogenase activity.

17. Mushroom culture

Detailed investigations on the possibility of using saw dust used for mushroom cultivation as spawn for subsequent mushroom cultivation were carried out. Mixing equal quantity of used saw dust and freshly prepared saw dust favoured mushroom growth. However, the yield is not comparable with the one cultivated using fresh spawn.

In another experiment it has been observed that tray type of mushroom cultivation was superior over pillow type of mushroom cultivation with respect to mushroom yield when saw dust was used as substrate.

Dried vines of *M. bracteata* and *P. phaseoloides* were tested as substrates for

the cultivation of oyster mushroom. Though they supported the growth of mushroom the yield was not comparable with that from substrates like saw dust. Frequent contamination was also noticed.

Tenai grains were tested as alternate medium for spawn production and was found to favour the growth of oyster mushroom. The yield of mushroom from beds prepared from tenai and cholam are comparable.

With a view to reduce cost of mushroom production chemical sterilization of saw dust using formaldehyde 500 ppm and Bavistin 75 ppm separately and in combination were tested. The mushroom yield is very poor in chemical treated mushroom beds.

Biochemical changes of saw dust during the course of mushroom production was studied. Cellulose and lignin content reduced considerably throughout the period of mushroom production.

18. Pollution studies

Investigations on biogas production from solid waste of crumb rubber processing factory were carried out. Slurry of solid waste of crumb rubber processing factory was prepared at 5, 8 and 10 per cent (w/v) and charged into 2.5l capacity amber coloured bottle sealed airtight inoculated with biodigested slurry and incubated at 27 ± 2°C for 7 weeks was used as inoculum. Biogas collected upto 8 weeks was measured, tested and recorded. Maximum gas production was recorded in 8 per cent solid waste (Table-Path. 7).

Liquid wastes from latex centrifuge and crumb rubber processing as well as sheet serum were also tried as diluent. Solid waste of crumb rubber processing at 8 per cent was added to each of the above liquid waste. Among these sheet serum was found to promote gas generation.

Table-Path. 7. Biogas production at different levels of solid waste of crumb rubber processing

Levels of substrate	Period (weeks)								Total gas production (ml l^{-1})
	1	2	3	4	5	6	7	8	
5%	35	180	210	240	225	165	145	120	1320
8%	50	200	250	310	750	540	310	210	2620
10%	65	260	280	275	225	180	112	95	1492

The effect of irrigation with liquid waste from crumb rubber processing on the growth of rubber seedlings was studied. The treatment consisted of effluent without dilution and dilution with water in the ratios of 25 : 75, 50 : 50 and 75 : 25. Control plants were irrigated with water. Rubber seedlings were established in 30 cm pots and irrigated as per the above treatments. The growth of the seedlings was assessed every month upto 10 months. Rhizosphere microbial population in each treatment was also estimated. Maximum growth of rubber seedlings was observed in treatment receiving 75 per cent effluent. Corresponding to the growth of seedlings there was an increase in the rihizosphere microbial population.

19. Rhizosphere studies

Phosphobacteria was inoculated to Pikovskaya's broth with 0.5 per cent rock phosphate from six different sources. The phosphates solubilised by this bacteria were estimated after 15 days of inoculation (Table-Path. 8).

The effect of phosphobacterial inoculation at different levels of rock phosphate application, on growth of *Pueraria phaseoloides* in sterile condition was studied. The results showed that the parameters like nodule number, nodule weight, root weight

Table-Path. 8. **Phosphates solublised by phosphobacteria (mg in 150 ml broth)**

Source of rock phosphate	Inoculated	Control
Puerulia	16.00	2.55
Imported (Jordan)	20.00	6.20
Partially acidified Maton	14.00	2.26
Udaipur	8.56	2.20
Maton	16.35	4.60
Mussoorie	14.00	0.60

and shoot weight, nitrogenase activity etc. were increased on phosphobacterial application at 50per cent level of rock phosphate. The effect of inoculation of phosphobacteria on growth of rubber seedlings in polybags applied with different levels of phosphate is also being studied.

From soil samples of Dapchari, CES, Chethackal, RRII, Canannore and Calicut mycorrhizal spore count was taken. Spores of of *Glomus* sp. were found to be more in all the soil samples.

20. Antagonistic micro-organisms

An experiment on the effect of mycorrhizae on root pathogen (*Phellinus* sp.) infection in rubber was initiated. Treatments included pathogen inoculated and uninoculated controls as well as *Glomus* and *Gigaspora* inoculated alone and together with the pathogen. Periodic observations on height, girth and infection of roots by mycrorrhizae were recorded.

21. Biological control of white grubs

Comparative evaluation of biological and chemical control treatments against white grubs revealed that all the biological and chemical treatments proved to be superior to the untreated check in protecting rubber seedlings (Table-Path 9). Among the entomopathogens tested, *Beauveria brongniartii* proved to be the best treatment in giving the highest plant survival and lowest grub population. The next effective treatments were the applications of the fungus, *B. bassiana* and the bacterium, *Bacillus popilliae*. among the treated plots HCH (100 kg ha^{-1}) was least effective and recorded the lowest percentage survival of plants. The untreated check plots recorded the lowest plant survival and highest grub population.

Population sampling revealed the incidence of three species of *Anomala* (white grubs) in regional rubber nurseries viz., *A. varians*, *A. polita* and *A. bengalensis*.

22. Vertebrate and non-insect pests

In block trials, baits of brodifacoum and bromadiolone (0,005%) and Zn_3P_2 (2%) were evaluated for the control of *Bandicota bengalensis* infesting rubber seedlings. Post-control population counts showed 96.10, 94.90 and 67.50 per cent reduction respectively.

Severe incidence of *B. bengalensis* infesting rubber seedlings at the Regional Nursery, Perumpulickal was effectively controlled by the applications of aldicarb (0.01%) and bromadiolone (0.005%) baits.

23. Beekeeping in rubber plantations

Albizzia lebbek, *Strobilanthus* spp., *Knoxia* spp. and *Cassia* spp. were indentified as major sources of nectar and pollen for off-seasonal bee management in rubber plantation-based apiaries.

Beehives were screened for the incidence and intensity of bacterial and viral bee diseases in the affected areas.

24. Minor pests

Crickets damaging plastic rainguards was effectively controlled by the applications of carbaryl 50per cent WP and HCH 50per cent WP inside the rainguards at 0.1 per cent concentrations.

Table-Path. 9. **Comparative evaluation of different biological and insecticidal formulations for the control of *H. serrata***

Treatments	Dose + (kg ha^{-1})	Mean percentage survival of plants/plot*	Grub population/30 cm^3
Beauveria brongniartii	1x10^8 spores/g of soil	93.90 (75.67) a	0.02
Beauveria bassiana	1x10^8 spores/g of soil	89.60 (71.17) b	0.05
Doom dust *Bacillus popilliae*	2g/9.30m^2 plot	88.80 (70.45) b	0.05
Isofenphos 5G	25 kg ha^{-1}	82.90 (65.57) c	0.15
Phorate 10G	25 kg ha^{-1}	82.50 (65.27) c	0.20
Carbaryl + lindane (sevidol) 4:4G	25 kg ha^{-1}	82.30 (65.12) c	0.25
Carbofuran SRII 3G	25 kg ha^{-1}	62.95 (52.77) d	0.30
Carbofuran 3G	25 kg ha^{-1}	36.07 (36.54) e	0.40
Carbaryl 5D	100 kg ha^{-1}	35.22 (36.19) e	0.40
Carbaryl 4G	25 kg ha^{-1}	39.88 (39.11) e	0.45
BBHC HCH 10D	100 kg ha^{-1}	21.20 (27.10) f	0.80
Untreated check	—	9.88 (18.32) g	3.00
F test	—	Significant	—
SE of X	—	1.26	—

\+ For insecticides. * Mean of four replications, at eleven months after treatment. Figures in parenthesis are arc sine values. Mean values followed by the same letter do not differ significantly p = 0.05 (DMRT)

25. Nematodes infesting rubber seedlings

Root-knot nematodes accounted for 15.20 to 18.80 per cent and 12 to 12.6 per cent loss of rubber seedlings in areas of high infestation in regional nurseries at Kadackamon and Perumpulickal respectively.

26. Slugs and snails

Aldicarb at 0.01 per cent in a slurry form with maida was superior to snail kill baits at 2.5 per cent concentration for the control of slugs and snails infesting young rubber plants.

27. Rubber wood preservation

Studies revealed that boric acid + borax + sodium pentachloropenoxide combination and copper sulphate + sodium penta chlorophenoxide + borax mixture are effective against insect borers and fungi attacking rubber wood.

PLANT PHYSIOLOGY AND EXPLOITATION DIVISION

The Plant Physiology and Exploitation Division undertakes research on biochemistry, crop physiology, stress physiology, exploitation, shade tolerance of medicinal plants for intercropping etc. The Division also evaluates commercial products used in tapping, rainguarding and stimulation. Controlled upward tapping (CUT) was recommended during the period.

1. Physiological and biochemical subcomponents of yield

Latex diagnosis parameters (plugging index, dry rubber content, sucrose, thiols, inorganic phosphorus and magnesium) were analysed in nine clones. The data showed that eventhough sucrose, thiols and phosphate were generally high in high yielders and low in low yielders, exceptions were not uncommon.

2. Early prediction of yield and stress tolerance

To study the relation between leaf fatty acid composition and tolerance to cold, the fatty acid composition of 12 clones were estimated and the double bond index was calculated (Table-Phy. 1). Maximum double bond index was noticed in RRIM 703 followed by Haiken 1, RRII 118 and RRIM 600 in order and least in RRII 105. Increased unsaturation of membrane lipid is considered as a necessary adaptation to cold stress. Further studies are in progress.

3. Lipid metabolism and latex production

Lipid analysis in the rubber cream and bottom fraction was continued in more high yielding and low yielding clones. Bursting index, plugging index and DRC were also recorded. It was observed that the content of phospholipids was significantly high in the high yielders compared to that in the low yielders (Table-Phy. 2). Phospholipid content of bottom fraction was negatively correlated with bursting index. No correlation was observed between the triglyceride content of rubber cream and plugging index or DRC.

Table-Phy. 1. Double bond index of polar lipids in leaves of young plants

Clones	Double bond index
RRIM 703	1.02
Haiken 1	1.01
RRII 118	1.00
RRIM 600	0.99
RRII 5	0.99
RRII 208	0.99
PCK 1	0.98
SCATC 93-114	0.96
RRII 308	0.96
SCATC 88-113	0.90
PCK 2	0.90
RRII 105	0.89

4. Clone' identification by protein mapping/isoenzymes

Isoenzyme and membrane protein variability studies of different clones were continued and the results are being analysed.

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

Latex diagnosis parameters were analysed at monthly intervals in clones RRII 105, RRII 203, RRII 118 and GT 1 under different intensities of tapping. The parameters analysed were sugars, thiols, inorganic phosphorus and magnesium. The results are being analysed.

Table-Phy. 2. **Bursting index and phospholipid content in the bottom fraction of latices**

Clone	Bursting index	Phospholipids mg g^{-1} dry wt
Ch 4	21.05	4.425
Pil B 84	22.66	4.115
Tjir 16	43.39	0.575
Ch 29	33.90	3.035
PB 215	12.55	8.510
PB 235	11.27	7.420
PB 217	11.65	12.070
RRII 105	7.45	6.550
GT 1	9.64	8.490
CD (0.01)	8.00	3.380

Phospholipids x Bursting index r = -0.769**

6. Yield constraint analysis

The major conclusions of the five year study are (1) annual dry rubber yield was maximum in Kulasekharam, while it was 20 per cent less in Central Kerala and 30 per cent less in Calicut, (2) soil moisture status was more favourable in Kulasekharam due to better rainfall distribution, which was reflected by higher bark water potential and turgor pressure and (3) sugars, thiols and inorganic phosphates were higher in latices of trees at Kulasekharam compared to Calicut.

Soil moisture stress adversely affects carbohydrate availability, thiol content and leads to lower membrane stability. This may be one of the reasons for higher plugging index at Calicut. In addition to soil moisture stress, excess rainfall and low sunshine hours during the south west monsoon can also be factors for lower annual yield in Calicut region. Soil pH and nutrient status are comparable in different locations. Major differences are not there in leaf nutrient status also. Unlilke yield, girth increment was low in Kulasekharam and this may be due to higher dry rubber yield.

7. Photosynthesis and partitioning of assimilates

Recording of physiological attributes of *Hevea* clones in three seasons (Nov., Jan. & March) was carried out in 13 clones of 1988 planting. Girth, photosynthetic rate, water use efficiency and stomatal resistance were recorded.

Significant differences were observed among the clones and the seasons. In November, when the soil moisture was adequate, photosynthetic rate varied from 4.53 in clone HP 20 to 12.62 μ mole m^{-2} sec^{-1} in clone RRIM 600. Clones RRIM 600, GI 1, Tjir 1, RRIM 623 and RRII 105 maintained higher photosynthetic rate while the values in HP 20, RRII 300, PB 311 and GT 1 were low. In the summer month of March when the soil moisture was low there was general decline in photosynthetic rate and it ranged from 1.14 to 5.71 μ mole m^{-2} sec^{-1}. Very low rates were observed in clones HP 20, RRIM 623, RRII 105 and RRII 300 (Table-Phy. 3). However, high girth was attained by clone RRII 118 inspite of medium photosynthetic rate. During January-March period, signifcant girth increment was not noticed in any of the clones. The data given in 1989-90 report is that of 1989 planting.

8. Physiological evaluation of clones

Data on girth of different clones at Central Experiment Station (traditional region), Regional Research Station at Dapchari, Maharashtra (non-traditional region with prolonged dry season) and at Mudigere in Karnataka (non-traditional tropical high elevation) are presented in Table-Phy. 4. Observations on dry rubber yield at Central Experiment Station (CES) and at RRS, Dapchari are presented in Table Phy-5.

Table-Phy. 3. Photosynthetic rate (A), water use efficiency (WUE) and stomatal resistance (rs) in different clones (1988 planting) in different seasons of 1991-92

Clone	A(μ mole m^{-2} sec^{-1})			WUE (A/E)*			rs (sec^{-1} cm^{-1})		
	November	January	March	November	January	March	November	January	March
GI 1	11.25	6.54	4.35	0.501	0.926	0.765	1.26	5.01	6.52
RRII 43	8.26	3.54	3.33	0.509	0.560	0.624	1.41	6.72	7.95
RRIM 623	11.25	6.50	1.18	0.408	0.950	0.577	0.98	4.96	16.92
RRII 105	11.22	5.27	1.52	0.488	0.974	0.447	1.13	7.14	17.85
RRII 38	8.25	4.03	2.22	0.324	0.767	0.635	1.68	10.10	15.22
RRII 308	8.52	7.83	5.71	0.429	1.180	1.301	2.06	4.38	7.71
GT 1	7.16	4.30	4.29	0.444	0.533	0.707	2.85	6.16	7.35
RRII 118	8.66	5.52	3.52	0.529	1.000	0.903	2.87	9.61	11.34
Tjir 1	11.22	6.23	2.93	0.489	1.320	0.712	1.13	7.92	9.93
RRII 300	6.50	3.75	1.74	0.456	1.613	0.524	3.25	3.01	12.67
PB 311	6.97	4.34	2.85	0.469	0.733	0.849	3.03	8.69	15.44
RRIM 600	12.62	9.69	5.04	0.470	1.424	0.942	1.12	2.46	7.92
HP 20	4.53	1.49	1.14	0.298	0.286	0.529	3.02	10.77	11.55
Mean	8.95	5.31	3.06	0.447	0.943	0.735	1.98	6.68	11.41
CD (0.05)									
Clone (C)		0.327			0.045			0.478	
Season (S)		0.544			0.107			1.067	
C x S		0.943			0.187			1.849	

* Transpiration rate (E)

Table-Phy. 4. Girth (9th year) of clones at different agroclimatic regions (cm)

Clones	CES	Dapchari	Mudigere
RRII 300	60.1	49.1	40.9
PB 235	58.8	47.3	39.1
RRII 105	59.4	—	36.7
RRIM 600	55.5	59.3	42.2
GT 1	56.9	49.3	41.9
PR 107	48.3	51.2	35.4
GI 1	56.1	50.5	31.6
RRIM 501	52.7	48.1	35.7
RRII 118	65.1	—	42.8
RRIM 703	57.6	—	41.3
Tjir 1	60.6	54.8	36.2
RRIM 612	59.6	57.9	44.0
Mean	57.6	51.9	39.0

Table-Phy. 5. Yield of different *Hevea* clones at two agroclimatic regions

Clone	Yield (kg $tree^{-200}$ $year^{-1}$)	
	CES	Dapchari
RRII 300	1,246	864
PB 235	1,858	1,354
RRII 105	1,650	—
RRIM 600	1,500	1,053
GT 1	1,098	832
PR 107	1,071	860
GI 1	1,116	936
RRIM 501	1,147	994
RRII 118	1,039	—
RRIM 703	1,696	—
Tjir 1	1,264	846
RRIM 612	697	469

All clones except RRIM 600, RRIM 501 and PR 107 attained higher girth at CES when compared to Dapchari. General growth performance at Mudigere was poor and hence tapping could not be started. Clones RRIM 612, RRII 118, RRIM 600, GT 1, RRIM 703 and RRII 300 showed better growth performance compared to the other clones. Clone Gl 1 was severely affected by high elevation conditions. At Mudigere, incidence of powdery mildew was high in clones RRII 300, RRIM 501, medium in RRIM 600, PR 107, PB 235 and low in RRII 118, GT 1, Tjir 1, RRII 105 and Gl 1. No incidence of this disease was noticed in clones RRIM 703 and RRIM 612 upto late February. In these clones wintering was also late. From the data it appears that better growth performance can be achieved in clones PB 235, RRII 300, RRIM 600 and RRII 105 by adopting better control measures against powdery mildew. All the clones showed lower yield at Dapchari when compared to their respective yield in CES. At Dapchari among the nine clones, PB 235 and RRIM 600 showed better yield performance. Clone RRIM 612 gave very low yield.

9. Performance of clones at high elevation

Monitoring of growth was continued at Mullenkolly (Wynad). Clones RRII 118, RRII 203 and RRIM 612 contiuned to record higher girth (Table-Phy. 6). Experimental tapping was started in all the clones.

Table-Phy. 6. Girth (1992) of *Hevea* clones at high altitude (Wynad)

Clone	Girth (cm)
PB 28/59	45.76
RRII 203	50.33
PB 6/9	32.33
RRII 105	42.60
RRIM 612	49.56
RRIM 501	43.93
RRIM 605	40.18
Gl 1	41.46
PB 5/51	42.40
PR 107	43.76
GT 1	45.38
RRIM 600	44.90
RRIM 623	44.96
Tjir 1	41.03
LCB 1320	47.45
RRII 118	52.16
Mean	44.27

10. Soil moisture stress, growth and yield

Pot culture study was conducted with three clones (RRII 105, RRIM 600 and GT 1), where different soil moisture regimes were imposed by watering six month old plants at two (control), six and nine day intervals. The diurnal photosynthetic rate was recorded in plants watered at two and nine day intervals. Highest rate of photosynthesis was observed at 09.00 hrs in all the three clones in control while it occured at 08.00 hrs in all clones under stress treatment. (Table-Phy. 11). Photosynthetic rate decreased in all the clones with decrease of vapour pressure deficit at midday in both the treatments. The decrease was maximum in RRII 105 and reached near to zero under stress from 12.00 to 14.00 hrs. The calculated value of daily photosynthesis per plant showed 80 per cent inhibition in RRII 105, 74 per cent in RRIM 600 and 67 per cent in GT 1.

In another pot experiment, six month old plants of clones RRII 105, RRIM 600 and GT 1 were subjected to extreme water stress by withholding watering. Visual injury was observed at 16 per cent soil moisture in clones RRIM 600 and GT 1 and at 18 per cent in clone RRII 105. By 25th day casualiy

Table-Phy. 7. Diurnal variation of photosynthetic rate of 6 month old plants under 35 per cent (control) and 18 per cent (stressed) soil moisture conditions

Time of day	Photosynthetic rate (μ mole m^{-2} sec^{-1})					
	RRII 105		RRIM 600		GT 1	
	Control	Stressed	Control	Stressed	Control	Stressed
08.00	9.65	6.64	10.38	6.15	10.13	6.90
09.00	11.58	3.56	13.26	5.94	11.54	5.60
10.00	10.43	2.59	11.37	4.36	7.77	2.28
11.00	6.31	1.32	10.52	3.83	6.69	2.49
12.00	4.28	0.91	9.75	3.39	6.19	2.60
13.00	4.67	0.59	7.05	2.44	6.43	1.37
14.00	5.67	0.30	7.28	1.60	6.84	1.13
15.00	5.94	1.78	8.44	1.58	7.68	1..87
16.00	6.45	1.71	6.19	2.70	7.29	2.18

was 75 per cent in RRII 105, 30 per cent in RRIM 600 and 25 per cent in GT 1. While there was defoliation in RRIM 600 and GT 1 no defoliation was observed in RRII 105.

Photosynthetic rate at different time of day and soil moisture percentage in different depth are presented in Table-Phy. 8. The observations were taken from irrigation experiment at Konkan region on clone RRII 105.

11. Exploitation systems and yield

The trial started in 1985 to evaluate the effect of exploitation systems on the yield of modern *Hevea* clones was continued. Economic analysis of production

Table-Phy. 8. Soil moisture percentage and photosynthetic rate (A) of clone RRII 105

Treatments	Soil depth (cm)			A (μ mole m^{-2} sec^{-1})		
	0-30	30-60	60-90	8.00 hr	12.00 hr	15.00 hr
Control (unirrigated)	24.3	22.5	21.9	5.56	0.87	0.49
0.50 ETc Basin	31.0	31.8	22.3	9.12	3.55	6.47
0.75 ETc Basin	34.3	36.5	31.4	10.20	9.34	6.66
1.00 ETc Basin	36.4	36.2	41..7	13.70	11.95	6.98
0.25 ETc Drip	30.8	28.3	28.9	12.30	0.91	0.91
0.50 ETc Drip	34.9	37.8	38.0	13.68	8.67	3.64
0.75 ETc Drip	38.9	43.1	46.0	13.55	8.33	9.06
Mean	32.9	33.7	32.8	11.16	6.23	4.89
CD (0.05) Irrigation (I)		8.1		Irrigation (I)	4.38	
Depth (D)		ns		Time (T)	3.17	
I x D		ns		I x T	8.39	

during the first six years was carried out and presented in Table-Phy. 9. Inspite of higher incidence of tapping panel dryness, total income was higher from $^1/_2$ S d/2 6d/7 system when compared to $^1/_2$ S d/3 6d/7. In the block trial being conducted at State Farming Corporation of Kerala (Table-Phy. 10) maximum yield was obtained from $^1/_2$ S d/2 6d/7 system. In high yielding clones $^1/_3$ S d/2 6d/7 appears to be promising. Incidence of brown bast is also less in trees under this system of tapping.

Studies on the effect of different exploitation systems on biomass reduction and harvest index were continued. A new trial was started to evaluate the effects of different rest periods on yield and incidence of TPD in clone RRII 105.

Table-Phy. 9. Effect of different intensities of tapping on discounted farm business income (Rs/ ha) from clone RRII 105

Year of tapping	$^1/_2$S d/2 6d/7	$^1/_2$S d/3 6d/7	$2x^1/_4$ s↓↑6d/7(t.i)
1	13947	11404	9183
2	17571	15314	14574
3	22065	19636	13932
4	33957	27529	20887
5	18895	19777	11168
6	14328	15830	8182
Total	120763	109490	77926

12. Tapping system for small growers

The trial is being continued during the third year (1991-92) and the dry rubber yield and other details are presented in Table-Phy. 11. Preliminary estimates indicate $^1/_3$ S d/1 system to be promising wherein 23 per cent additional income is possible in comparsion to $^1/_2$ S d/2 system. Growth was found to be better and incidence of tapping panel dryness was low in this system. In the systems involving double cut, though returns are high, bark consumption and incidence of TPD are also high. Upward tapping from the very beginning (30 cm from bud union) gave 12 per cent less yield than control and bark consumption was 39 per cent more. Trees tapped under $^1/_2$ S d/2 system with opening at 90 cm height did not show any difference from control in terms of yield, growth and TPD.

13. Controlled upward tapping (CUT)

The large scale trial on CUT was continued during the period. The yield obtained under various systems of tapping are presented in Table-Phy. 12. The trees were stimulated twice (Lam). Introduction of a second support cut by keeping a band of virgin bark of 2 cm width enabled to reduce the requirement of polythene for rainguarding the high panel. Optimum width of polythene sheet was found to be

Table-Phy. 10. Dry rubber yield and incidence of TPD (%) under various tapping systems in clone RRII 105

Treatments	Yield (kg block^{-1})			TPD (%)		
	1989	1990	1991	1990	1991	1992
1/2 S d/2 6 d/7	741.23	1495.72	1931.66	8.33	13.67	15.72
1/2 S d/3 6 d/7	456.97	999.44	1500.49	4.78	7.6	8.78
1/3 S d/2 6 d/7	536.64	1178.51	1730.58	4.61	7.94	8.72
1/3 S d/3 6 d/7 + ET 1.25%	377.76	861.96	1082.13	2.22	6.17	6.67
1/2 S d/7 + ET 2.5%	253.73	420.73	665.89	2.17	2.94	3.61

Table-Phy. 11. Dry rubber yield, bark consumption, girth and TPD% in clone RRII 203

Treatments	Mean annual yield kg tree^{-1}	Cumulative yield kg/ha-1 year^{-3}	Number of tapping days year^{-1}	Annual bark consumption (cm)	Mean girth (cm)	TPD%	variation in net income (%)
1/2 S d/2 6 d/7 (control)	6.26	6573 (100)	150	31.3	74.9	4	100
1/2 S d/2 6 d/7 (90 cm opening)	6.33	6646 (101)	150	30.4	74.3	4	101
1/2 S ↑d/2 6 d/7 (30 cm opening)	6.20	6510 (99)	150	42.7	74.7	6	99
1/3 S d/1 6 d/7	8.32	8736	300	48.0	79.0	5	123
2 x 1/2 S d/1 6 d/7 (t, t) (90 cm opening on BO-1) (130 cm opening on BO-2)	9.59	10069 (153)	300	50.4*	72.7	10	144
2 x 1/S ↑↓ d/1 5 d/7 (t, t) (90 cm opening)	9.12	9567 (146)	250	53.0*	74.0	10	140
CD (0.05)	1.25						

Figures in paranthesis indicate percentage. *Total of 2 cuts.

Table-Phy. 12. Annual dry yield (kg) under CUT in Clone RRIM 600

Tapping systems	Yield kg 300 trees^{-1}
1/2 S d/2 6 d/7	2520 (100)
1/3 S ↑, 1/2 S d/2 6 d/7 (9 m, 3 m)	2721 (108)
2 x 1/2 S ↑↓ d/2 6 d/7	4283 (170)
1/4 S ↑ + 1/2 S d/2 6 d/7	3774 (150)
1/3 S ↑ + 1/2 S d/2 6 d/7	4051 (161)
2 x 1/2 S ↑↓ d/3 6 d/7	3243 (129)
1/3 S ↑ + 1/2 S d/3 6 d/7	2989 (119)
CD (0.05)	1082

Figures in parantheses indicate percentage.

60 cm. Substantial saving of polythene was also possible by horizontal fixing of the polythene on the exterior side of the back end of the panel. If tapping in a panel commences during March-April, rainguarded tapping in the first year can be done without using a lifting device.

14. Studies on shade tolerance of medicinal plants potentially useful for intercropping

Light requirement studies were conducted for five species of medicinal plants by giving six light regimes. Data were collected for growth analysis and economic yield. Changes in morphology, photosynthetic rates, pigment composition etc. were also recorded. An experiment was also conducted to study shade-nutrient interaction. The data are being processed.

Table-Phy. 13. Growth and RGR during wet and dry period of 1990-91

Treatments	Wet season girth (cm)				Dry season girth (cm)			
	Initial June 1990	Final October 1990	Increment	RGR	Initial January 1991	Final May 1991	Increment	RGR
Control (unirrigated)	14.83	18.65	3.82	638	19.39	19.72	0.33	44
0.5 ETc Basin	17.29	22.36	5.07	715	23.18	26.28	3.09	347
0.75 ETc Basin	18.05	22.88	4.84	660	23.78	27.35	3.57	389
1.00 ETc Basin	17.72	21.92	4.20	592	22.62	26.67	4.05	458
0.25 ETc Drip	15.84	20.30	4.50	690	21.17	24.26	3.08	376
0.50 ETc Drip	15.66	20.10	4.43	695	21.00	24.17	3.17	391
0.75 ETc Drip	15.47	19.89	4.42	699	20.59	24.74	4.15	515

15. Effects of irrigation on growth performance

The irrigation experiment in clone RRII 105 was continued at RRS, Dapchari. Growth data collected from trees receiving different quantities of water under basin and drip irrigation systems during 1990-1991 period is presented in Table-Phy. 13. The data shows that basin irrigation at the rate of 0.5 ETc and drip irrigation at the rate of 0.25 ETc are comparable and result in substantial growth increment. Further increase in the quantity of water under both systems of irrigation results only in marginal increase in growth.

RUBBER CHEMISTRY, PHYSICS AND TECHNOLOGY DIVISION

The Rubber Chemistry, Physics and Technology Division concentrated on quality improvement of raw natural rubber and products made therefrom. The broad areas of research were primary processing, chemical modification, rubber technology and product development.

1. Solar drier for sheet rubber

The blower of the 800 kg capacity solar drier was replaced with a new one suitable for continuous operation and for starting automatically as and when sufficient sunlight is available. Trials carried out by partial loading of sheet rubber showed that sheets could be dried in 5-6 days with solar energy alone. The construction of the 200 kg drier in collaboration with the Agency for Non-conventional Energy and Rural Technology, Trivandrum has been in progress.

2. Sulphuric acid as alternative latex coagulant

Studies on the corrosion aspects of using sulphuric acid for making sheet

rubber have been continued. Trials conducted in selected small holdings showed that weight loss of aluminium coagulation pans was negligible as in the case of formic acid. Use of excess sulphuric acid for making sheet rubber has a slightly adverse effect on the ageing characteristics of vulcanizates. This aspect is being examined further.

3. Epoxidation of NR

Equipments for the pilot plant have been procured. Construction of the building was in progress. Studies to improve the PRI of ENR were continued. Addition of polymerised 2, 2, 4-trimethyl-1, 2-dihydro quinoline was found to improve PRI significantly. But batch to batch variation in PRI was observed. Moreover, use of this antioxidant led to discolouration.

4. Development of chemical resistant NR compounds

Ageing studies revealed that NR vulcanizates can withstand phosphoric acid, sodium hydroxide and sulphuric acid solutions having concentrations of 90, 75 and 50 per cent respectively. Ageing properties were found to be better and water absorption less in electrolyte media than in distilled water.

5. Degradation of NR

Studies on the effect of tensile strain on the ageing of NR vulcanizates showed that the rate of degradation of the strained samples was faster, the cause being predominantly main chain scission. The extent of degradation was relatively higher in the case of conventional vulcanizates.

6. Effect of storage on properties of latex

During storage of preserved NR latex concentrate many complex chemical reactions take place leading to changes in some of its quality parameters. A study was hence taken up to investigate the effect of storage on properties of latex and vulcanizates prepared therefrom. Field latex was processed into high ammonia and low ammonia preserved centrifuged latex. The properties of the two latices and their vulcanizates have been evaluated at different intervals. Preliminary data indicate that strength properties of the vulcanizates are influenced by the period of storage.

7. Development of NR based adhesives

The effect of different solvents and degradative agencies like heat and moisture on bond strength of NR based adhesives was evaluated. Among the solvents tried, solvent naphtha was found to be the best. Chemically modified rubbers like ENR-25, ENR-50 and methyl methacrylate graft NR were also tried for preparing adhesives.

8. Studies on EPDM-SP rubber blends

Studies were carried out on blends of EPDM and SP rubber in different ratios. The effects of fillers and surface modifying agents were also studied. Using blends of EPDM and SP rubber compounds with high ozone resistance, better extrusion characteristics and moderate mechanical properties were developed. The die swell of the 30:70 EPDM: SP rubber blend filled with FEF black and china clay was measured at different shear rates in a capillary rheometer. The results, as given in Table-Chem. 1, indicate the usefulness of blending SP rubber with EPDM in the manufacture of extruded

Table-Chem. 1. **Die swell (%) at different shear rates**

Shear rate	FEF black		China clay	
S^{-1}	Blend	EPDM	Blend	EPDM
30	11	19	16	20
300	13	21	20	23
3000	18	26	22	24

products. A blend of EPDM and SP rubber in the ratio of 30:70 showed optimum mechanical properties.

9. Blends of NR and ethylene vinyl acetate copolymer

The rheological behaviour and dynamic mechanical properties of NR-EVA blends were studied. The flow behaviour of the blends was found to be dependent upon the morphology of the blends and shear rate. The dynamic mechanical and X-ray diffraction studies indicated that the type of crosslink system affects the properties of the blends to a great extent. Reinforcing silica was found to affect the mechanical properties of the blends adversely. A standard formulation for making hawai soles meeting BIS specifications was developed from NR-EVA blend. The formulation and the properties of the sole are given in Tables-Chem. 2 and Chem. 3 respectively.

Table-Chem. 2. **Formulation for hawai sheets to meet BIS specifications**

Polymer (blend consisting of 40 % NR and 60% EVA)	100.0
Zinc oxide	3.5
Stearic acid	1.0
Zinc stearate	2.0
Styrenated phenol type of antioxidant	1.0
Dicumyl peroxide (40% active)	4.0
Precipitated calcium carbonate	90.0
Paraffinic oil	3.6
Azodicarbonamide	4.0

10. Heat transfer and vulcanization of NR compounds

Preliminary studies on heat transfer in natural rubber compounds indicated that use of carbon black or metal powders increases heat transfer in rubber compounds to a significant extent.

11. Short sisal fibre-rubber composites

Rheological studies of short sisal fibre-NR composites have shown that fibre breakdown occurs during shearing and the extent of breakdown was proportional to rate of shear. Stress relaxation studies indicated two types of relaxation phenomena in the composites corresponding to fibre-matrix adhesion and network structure.

Table-Chem. 3. **Physical properties of hawai sole**

	NR-EVA compound	BIS specifications limit
Relative density	0.45	0.4 to 0.5
Hardness (Shore A)	46	45 ± 5
Change in hardness after ageing at 100°C for 24 hours	+2	+5
Split tear strength (N)	53	50
Shrinkage, 100 ± 1°C, 1 h (%)	2.9	3.0
Flex resistance : Kilocycles to crack initiation	400	60
DIN abrasion loss 5N load (mm^3)	440	—
Compression set (%)	23	25
Room temperature shrinkage at 27°C after 2 weeks (%)	1.3	1.5

12. Chemical modification of rubber seed oil

Attempts were made to prepare epoxidised rubber seed oil with a view to make the latter suitable for specific applications. The reaction conditions for the above were standardised.

13. UNIDO Project on NR based precured tyre retreads

Evaluation of the 180 precured retreaded tyres received from MRPRA, UK has been completed. Report on the performance of the tyres was communicated to MRPRA. It was observed that the control compound made of SBR/BR blend performed better than the NR based compounds. Among the NR based compounds, those from NR/BR blend performed better than

that from NR/SBR blend. However, under high severity conditions, the difference in performance of the NR based compounds was only marginal.

14. Development of 'flex seal' compound for VSSC

The rubber compound developed for use in large rocket boosters as 'flex seal', was tested for its critical properties at the Vikram Sarabhai Space Centre (VSSC), Trivandrum and was found to meet the specifications. The final report on this was furnished to VSSC.

15. Development work

Other product development activities during the period under review included (i) "rubber membrane component" of imported water immercible pumps, (ii) general purpose solution adhesive and (iii) trial production of rubber bungs for use in electrolytic capacitors.

AGRICULTURAL ECONOMICS DIVISION

The Agricultural Economics Division undertakes studies relating to economic aspects of natural rubber cultivation, processing, marketing and end uses. Studies are also undertaken to work out the economics of ancillary products. The problems pertaining to smallgrowers are given utmost priority. The Division evaluates the response to and performance of different development schemes of the Rubber Board and analyses economic viability of the findings of other research divisions. The Division monitors the position of natural rubber in the light of the developments in Indian economy.

1. Commercial evaluation of planting materials

The third report on the study was published in 1990. During the reporting period the yield estimates of RRII 105 had been revised. The first 5 year average yield came to 1450 kg ha^{-1} and the average yield of the first 10 years was found to be 1586 kg ha^{-1}. The other planting materials with better commercial yield were PB 28/59, GT 1, RRIM 600 and PB 217.

A large scale survey covering 105 estates, on the pattern of the use of planting materials revealed that contrary to the small holding sector, the share of a single variety did not exceed 20 per cent of the total area in the estate sector. While materials of PB origin accounted for 20.3 per cent and RRIM varieties claimed 19.4 per cent, RRII varieties occupied only 10.6 per cent of the gross planting material stock. The single major planting material used in the last decade was RRII 105 (41.6 per cent of the area). PB 311 was introduced during mid 1980's. Most of the stocks of old planting materials were mainly found in the estates in Tamil Nadu and Karnataka. While Travancore-Cochin region showed a higher percentage of RRIM 600 and RRII 105, the Malabar region had altogether planted 25 per cent of its area with GT 1. A size groupwise analysis showed that while RRIM 600 had been preferred by all size groups, small estates preferred RRII 105. The share of RRII 105 in estates above 400 ha was only 7.7 per cent but it was 16.9 and 29.7 per cent respectively in medium (200-400 ha) and small estates (below 200 ha). A sectorwise comparison showed that while planting in private sector is spread over a large number of planting materials, the public sector had concentrated mainly on a few varieties.

2. Production and utilization of rubber wood

The estimated rubber wood production in India during the year 1991-92 is 1.27 million m^3. The branch wood accounting for about 40 per cent of the rubber wood production is exclusively used for factory and household firewood requirements. The remaining 60 per cent of the production is constituted by stem wood which is consumed for various industrial applications as shown in Table-Age. 1.

There are 14 rubber wood processing units with vacuum and pressure impregnation facilities. A few rubber wood processing factories and a number of other independent units are manufacturing furniture and building materials from treated rubber wood. A small quantity of rubber wood is used for the production of compressed wood while pilot level attempts are made for the production of polymer composite. Non-pressure treatment is followed by a large number of small scale plywood manufacturing units. Rubber wood saw dust is used for the manufacture of particle boards and briquets. The price of sawn planks ranges from Rs. 850 to Rs. 1050 per m^3 while the price of treated rubber wood ranges from Rs. 6400 to 8800 per m^3. But the growers realised only around Rs. 500 per m^3 as the trees are sold before felling. As a result of the constant efforts of the RRII the Bureau of India Standards has included rubber wood in the standards prescribed for the manufacture of doors and windows.

3. Production and utilization of rubber seed oil

It is estimated that 150 kg useful rubber seeds are available from 1 ha of mature plantation. Around 10 per cent of the seeds is used for raising stock seedlings.

Table-Age. 1. **Consumption pattern of rubber wood**

Industrial application	Quantity consumed (million m^3)	Relative share (%)
Packing cases	0.49	64.50
Safety matches	0.13	17.10
Plywood	0.10	13.10
Treated wood	0.03	3.90
Others	0.01	1.40
Total	0.76	100.00

Under commercial conditions, the oil recovery is around 12 to 16 per cent of the total weight of the seed. During 1991-92 the production of rubber seed oil was 1600 MT (1991-92 was the worst year for rubber seed production). Rubber seeds were being procured at the rate of around Re. 1.00 to 1.50 per kg. The production of rubber seed oil is concentrated in Virudhunagar in Tamil Nadu due to favourable weather conditions during the seed fall season and the idle capacity available in groundnut oil mills. Rubber seed oil is mainly used for manufacturing inferior quality washing soaps. A small quantity is also used in paint, varnish and leather tanning industries. The seed cake production estimated for the period was 4,250 MT, the lowest for many years.

4. Commercial production of honey

The rubber tree is a prolific producer of honey. Around 45 per cent of the honey produced in India originates from rubber plantations. About half the rubber honey is consumed by ayurvedic and allopathic pharmaceutical firms, the rest being consumed in various sectors like confectionary, tobacco manufacturing, bakery, dairy and other food products.

5. Adoption of improved methods by small growers

The study attempted to assess the extent of awareness and adoption of new tech-

nologies by the growers and media preference. A random sample survey was conducted in Kottayam district covering 480 units. Though 97 per cent of the growers had adopted high yielding variety of planting materials, only 10 per cent followed the spacing recommendations. Almost all the sample growers applied fertilizer in varying quantities but 30 per cent was not aware of the recommended dose. Though only 69 per cent adopted the correct method of application of fertilizers, 88 per cent was aware of the correct method. The percentage of growers who applied mixtures, straight fertilizers and complex fertilizers were 32, 40 and 28 respectively. Around 84 per cent of the growers had grown cover crops. Awareness of spraying against abnormal leaf fall is near universal (96 per cent) but adoption rate is very low in RRII 105 planted holdings.

Around half of the growers practised 1/2 S d/1 tapping system. Though 69 per cent was aware of rainguarding, only 37 per cent had adopted it and 4 per cent had discontinued the practice mainly due to managerial difficulties. Around 22 per cent used only plastic cups for latex collection while 45 per cent had used both plastic cups and coconut shells. The study revealed that around 86 per cent of the growers was not aware of scientific processing techniques. Only 4 per cent had constructed separate smoke houses.

Though almost all the growers read newspapers regularly, only 54 per cent had made it a practice to go through the agriculture page. Around 94 per cent had radio sets, but only 6 per cent had reported regular listening. Out of the 74 per cent of growers who had TV sets, 54 per cent had been attending programmes related to agriculture. Around 32 per cent of the growers had attended seminars. It was also seen that 23 to 35 per cent of the growers had obtained information on technical aspects from other growers.

6. Profit/utility maximisation of rubber growers

The study analysed the nature of farm families in two districts. One location was Taliparamba in North Kerala and the other Kanjirappally in Central Kerala. While in Taliparamba the growers acquired land mainly through purchase and Land Reforms Act, in Kanjirappally the growers acquired land mainly through purchase and inheritance.

Extent of rubber cultivation in Kanjirappally was 93 per cent compared to around half of the area in Taliparamba. The Gini concentration ratios worked out showed that the concentration of land holdings was similar in both regions. In Kanjirappally 24 per cent of the growers had not planted intercrops mainly due to lack of managerial inputs and possible influence of non-agricultural income. In Taliparamba 48 per cent depended on agricultural income alone. In Kanjirappally 66 per cent had other sources of income. The main source of non-agricultural income in Taliparamba was employment while in Kanjirappally it was business.

7. Study on brown bast

The study was conducted in Kottayam, Palghat and Malappuram regions of Kerala pertaining to the period 1989-90 and 1990-91. In Kottayam region the total incidence of panel dryness for RRII 105 varied from 1.98 to 15.09 per cent in 1st to 12th year of tapping. For the same clone in Palghat region it varied from 1.03 to 11.17 per cent in 1st to 7th year of tapping and in Malappuram region it varied from 1.73 to 6.77 per cent in 1st to 5th year of tapping.

8. Reclaimed rubber industry

The study covered 22 units out of the 25 units producing reclaimed rubber in India. The data required for the study were collected by visiting the units. In the late eighties there were 32 reclaimed rubber production units in India. The industry is beset with many problems, the most important being the excess capacity. The installed capacity of the 25 units was 85000 tonnes in 1991, while the estimated production was 60000 tonnes. The capacity utilisation was 71 per cent. Reclaimed rubber has been classified mainly into four grades (super fine, fine, medium and coarse), though some units have a few more grades. The percentage of production for the industry as a whole was worked out as 25, 25, 30 and 15 respectively. The balance of 5 per cent accounted for other grades.

The main industrial use of reclaimed rubber was in battery boxes, followed by auto tyres, moulded articles, cycle tyres, tread rubber, hoses, soles and micro cellular sheets in the descending order of importance. The maximum price for the superfine quality in 1990 was Rs. 8.60 per kg. The maximum price of raw material (old tyres) was Rs. 1,500/- per tonne during the same period. Small quantities of reclaimed rubber were being exported.

9. Other studies

Studies on transportation of rubber, natural damage to rubber plantations, structure of rubber market in India, impact of RPS on productivity and income of small growers, capacity utilization, processing cost and profitability of centrifuged latex industry in India and a census of planting materials used by small holdings in India during 1989 are under progress.

CENTRAL EXPERIMENT STATION

The Central Experiment Station of the Rubber Research Institute of India established in 1966 at Chethackal, Ranni in Pathanamthitta District is about 50 km away from the Institute. The station covers an area of 254.8 hectares. Long term field experiments dealing with clone evaluation, exploitations studies, evaluation of germplasm, pests and diseases, intercropping of medicinal and other cash crops, etc., have been laid out in the station by the Botany, Germplasm, Plant Physiology and Exploitation, Mycology and Plant Pathology and the Agronomy and Soils Divisions of the RRII. Over 4,000 genotypes of wild Brazilian germplasm received from the Malaysian centre and 102 clones of Wickham materials have been established and maintained in the station for evaluation.

Table-Ces. 1. Rainfall (1991-92) distribution at CES

Month	Rainfall (mm)
April	254.9
May	327.3
June	1137.6
July	639.1
August	397.2
September	33.6
October	354.5
November	165.2
December	15.1
January	—
February	31.3
March	—
Total	3355.8

During 1991-92 period an area of about 5 ha was planted for different experimental purposes. Different blocks planted under very high yielding materials were surveyed for evaluation of tapping panel dryness and the incidence was found to be very high with high yielding clones. The total crop production during the period was 1, 97, 260.76 kg. The total rainfall received during the period under report was 3355.8 mm (Table-Ces. 1.) compared to 3132.7 mm during 1990-91.

There were 210 permanent workers and 202 casual workers in the rolls during the period. The total mandays engaged for different operations in the station was 69481. The medical unit attached to CES extended medical facilities to 13,093 patients from CES and Central Nursery, Karikkattoor.

Training in controlled upward tapping was arranged to 11 participants from New Ambadi Estate, Tamil Nadu.

REGIONAL RESEARCH STATION, ASSAM

The Regional Research Station, Assam, concentrated on location specific research in agro-management of rubber as well as investigations on biotechnology, meteorology and germplasm evaluation.

1. Multidisciplinary evaluation of clones

In the 1985 trial maximum average girth was recorded in the clone PB 235 (46.6 cm) followed by RRIM 600 (45.8 cm) and minimum in clone PB 5/51 (37.6 cm). In the 1986 trial RRII 118 attained maximum girth (43.1 cm) folowed by RRIC 105 (41.4 cm) and RRII 105 (38.8 cm) the minimum.

As in the earlier two years severe *Oidium* leaf fall disease was recorded in the 1985 trial with repeated defoliation from March to July, 1991, which affected grith increment adversely. *Oidium* leaf fall was mild in the trial laid out in 1986.

2. Nutritional studies - immature phase

In the two trials on nutritional requirement of young rubber with clone RRII 105 at Nayekgaon and RRIM 600 at Mendipather, the response trend remained same as that of the previous year with high doses of N influencing the girth positively and P having no influence on girth increment. No trend could be obtained in case of K.

Although two trials were initiated in Borgaon Rubber Plantation at Sonitpur, one to evaluate the efficacy of different cover crops and the other to develop an ad-hoc fertilizer recommendation, both were attacked by wild elephants and cattle and no observations could be recorded.

3. Interaction between potassium and magnesium

The two trials (one each at Sarutari and Nayekgaon) to study the interaction of potassium and magnesium and their effect on growth and yield of rubber were continued. Observation on girth was recorded from both the experiments.

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

The girth recorded druing the period in the trial in clone RRIM 600 at Sarutari farm is summarised in the Table-Nea. 1.

Table-Nea. 1. Effect of sources of P on girth and girth increment during immature phase

Forms of P	Girth (cm)		Girth increment	
	June	November	cm	%
Water insoluble	36.28	40.14	3.86	10.64
50% water soluble & 50% water insoluble	37.96	41.06	3.10	8.17
Water soluble	35.91	39.53	3.62	10.08
No P	35.81	38.82	3.01	8.41

The higher girth increment in water insoluble P might be due to the residual effect of rock phosphate mineralized and made available over a longer period.

In the trial at Nayekgaon, maximum girth increment (17.53%) was recorded in treatment with water insoluble P (20 kg $P_2O_5 ha^{-1}$). However, increasing the doses of phosphorus either in water soluble or insoluble form did not show marked difference in girth increment during the period.

5. Anther culture and plantlet regeneration

Anther derived calli were obtained from five clones of *Hevea*. However, only the anther derived calli of PB 5/51 were able to produce embryos as well as plantlets. Anther callus of RRII 105 also regenerated embryos but these embryos failed to develop afterwards. Four media which favoured development of embryos were identified. Plantlets with well developed root system were transferred to soil vermiculite mixture, watered with Hoagland's solution and sprayed with GA 3 solution every alternate day and allowed to harden slowly.

6. Culture of mature and immature zygotic embryo

Immature embryos, 10-14 weeks old, were successfully cultured on eleven media of varying constitution. The germinated embryos were subcultured in appropriate media to induce rooting. Plantlets with well developed root systems were transferred to pots at 3 - 6 leaves stage and subjected to hardening process.

7. Plant regeneration from tissues of cover crops

Stem, leaf and root explants from *Pueraria* and *Mucuna* were cultured. Although calli were obtained from all the explants in both cases, stem derived calli were found suitable for regeneration purpose. Root development could be induced only in *Pueraria*.

Complete plantlets of *Pueraria* were transferred to pots containing sand and soil (1 : 1), at 6 - 9 leaves stage. Healthy plantlets grew well upto 6 weeks after transfer to soil.

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

Virulence of eight strains of *A. tumefaciens*, was tested by infecting the stem of clones from the Brazilian and Wickham germplasm. It was noticed that all the eight strains were more or less virulent. The degree of virulence was evaluated visually by the size of crown gall on the inoculated plants. It was noticed that virulence of the strain of *A. tumefaciens* is genotype specific.

9. Survey of diseases and pests

A survey on diseases and pests of rubber was carried out in different agro-climatic zones of this region. High intensity

of *Oidium* infection causing die back of twigs was noticed in April - May in Assam and Meghalaya. It affected growth and development of rubber plants to a considerable extent. Flowers were also found to be infected with *Oidium*, thus affecting pod formation. The pathogen causing a leaf blight disease was isolated and identified. The incidence of leaf spot (*Corynespora cassiicola*) and bird's eye spot (*Drechesleria heveae*) was mild. *Gloeosporium* leaf disease was observed during July-September, in nursery plants. Intensity of pink, brown root rot and bark rot diseases was mild.

Intensity of infestation of termites, slugs, snails and caterpillars was mild in this region. Severe infestation of scale insects was noticed in most of the plantations. Spraying of Malathion 50 EC was carried out for the control of scale insects. The pest was subsequently controlled naturally by parasitization of entomogenous fungi.

10. Isolation, identification and maintenance of pathogens

Thrity five fungal isolates associated with various diseases of rubber plants in North Eastern region have been isolated and maintained as stock cultures. Studies on virulence of strains of major fungal pathogens isolated from rubber are in progress.

11. Nursery trials

11. 1 Effect of mulch on frequency of irrigation

A new trial was taken up at Sarutari to monitor the influence of different mulch materials on frequency of irrigation and related aspects in a seedling nursery. It is noticed that black polyethylene mulch favoured maximum girthing of seedlings.

11. 2 Effect of shade and frequency of irrigation

A trial was taken up to study the influence of shade and frequency of irrigation on the growth of *Hevea* seedlings. It is observed that under partial shade (approximately 40 per cent light cut) the frequency of irrigation could be reduced. The girth of seedlings was more under shade than in open condition.

12. Multiple cropping and mixed farming

A new trial on intercropping in the immaturity phase of rubber has been taken up during 1992 at Sarutari farm, with banana, pineapple, cover crop and ginger as intercrops.

REGIONAL RESEARCH STATION, TRIPURA

The Office and Laboratory of the Regional Research Station, Tripura were shifted to the Rubber Board Complex situated at Bhalluika Tilla, Agartala in November 1991. The research farm located at Taranagar, Mohanpur, about 20 km away from Agartala town was properly maintained. The entire area at the farm has been planted and there are 21 blocks currently under tapping. Research in the disciplines of Agronomy, Soil Science, Plant Physiology and Plant Breeding are undertaken. The station has a mobile soil and tissue testing laboratory and a full-fledged meteorological observatory.

1. Nutritional studies

1.1 Mature phase

The fertilizer trial, started in 1980 in a three factorial design with clone RRIM 600 was under tapping. The treatments were three levels each of N (0, 30 and 60 kg ha^{-1}), P_2O_5 (0, 30 and 60 kg ha^{-1}) and K_2O (0, 20 and 40 kg ha^{-1}). It has been observed that the higher doses of N, P and K could give a positive response on girth and yield of trees.

1.2 Immature phase (polybag plants)

The trial was laid out in 1986 at Tulakona, NRETC farm with a view to monitor the response of *Hevea* plants to higher doses of nutrients. The effect of water soluble P on growth of plants was also studied. The data on girth and girth increment during the period under report are presented in Table-Net. 1.

Table-Net. 1. Effect of nutrients on girth

Treatments N : P_2O_5 : K_2O (kg ha^{-1})	Mean girth (cm)		Girth increment (%)
	July '91	February '92	
T_1-30 : 30 : 30	34.93	38.52	10.28
T_2-30 : 30 (15) : 30	35.22	39.21	11.33
T_3-60 : 60 : 60	36.55	40.94	12.01
T_4-60 : 60 (30) : 60	36.04	40.46	12.26
T_5-90 : 90 : 90	33.83	38.69	14.37
T_6-90 : 90 (45) : 90	36.19	40.07	10.72

Figures in parentheses show water soluble from of P.

2. Density-cum-nutritional trial

The trial, started in 1987 at RRS farm Taranagar with clones RRII 105 and RRII 118, having three densities (420, 606 and 824 plants ha^{-1}) and three leves of N, P_2O_5 and K_2O (40 : 40 : 20, 60 : 60 : 30 and 80 : 80 : 40), was properly maintained. The data on girth increment for the period June '91 to March '92 were recorded.

3. Multiple cropping and mixed farming

Interplanting of coffee and pepper with rubber, as an observational trial to monitor the effect of perennial crops on the growth of rubber, was undertaken at RRS farm Taranagar. Observation on the growth of rubber is being recorded.

4. Studies on planting techniques

The trial, started in 1981 with five treatments and five replications in clone RRIM 600, to compare the growth of rubber when different types of planting materials are used, was maintained. Highest girth was continued to be recorded in the treatment in which 14 months old green budded polybag plants were used.

A trial was laid out during 1990 with 72 treatments in a split- plot design having two replications, with period of transplanting budded stumps in polybags as main plot and the clones RRII 105, RRIM 600 and GT 1 as sub plots. Two agromanagement

practices, (with and without shade) were included in each sub plot treatments. The study is an attempt to find out the sprouting pattern of budded stumps poly bagged in various months and to monitor the influence of shade on the rate of sprouting. The clonal variation of sprouting is also being studied.

5. Forms and placement of fertilizers

5. 1. Phosphatic fertilizers (immature phase)

This experiment was started in 1986 with a view to compare the efficiency of different sources and combination of phosphatic fertilizers being used in rubber. The girth data recorded during June 1991 and February 1992 revealed that treatment with water soluble P for the first two years and then water insoluble P for the remaining period has a positive influence.

5. 2. Mode of fertilizer application (Mg)

The experiment was laid out as an on-farm trial in Mohanpur in 1988 with RRII 105. Three methods of application (band placement, 15 cm deep pocket placement and 30 cm deep pocket placement) are compared with magnesium treatment being superimposed. The girth data recorded indicated positive response of deep placement and magnesium application.

5.3 Mode of fertilizer application (N and P)

Data are being regularly collected to monitor growth of the immature rubber plants from the on-farm trial at Tulakona planted with budded stumps of clone RRIM 600.

6. Soil test crop response studies

Investigation on standardisation of soil extractants was continued and the extractant Bray II was observed to give better correlation. The project is being continued for further confirmation of the results.

7. Evaluation of planting materials

7. 1. Clone trial (1979)

The data on girth increment during the early growth phase of the clones were analysed for stratifying the genotype and genotype x environment interaction (winter and summer). The results revealed significant interaction between clones and the two uncontrollable environments confirming that clones RRIM 600, PB 86 and GT 1 as widely adapted and RRII 105 and Harbel 1 as specifically adapted. All the fifteen clones were found representing independent clusters during both winter and summer. The relative positions of the clones in the clusters suggest that RRIM 600 and PB 86 are better adapted to the present agroclimatic zone and these clones can be used as a better paradigm for evaluating the relative performance of other clones in this region.

Studies on yield and yield components are being continued and two years data show a peak yielding period in November.

7. 2. Clone trials (1987 a and 1987 b)

Observations on performance of the clones in both the trails during their early growth phase, by girth data, revealed that three different groups exist based on their significant mean differences at 5 per cent level (Table-Net. 2).

8. Mother tree selection

Bud grafted plants from the selected mother tree were field planted and their performance is being evaluated.

9. Performance of polyclonal seedlings

The study initiated for assessing the suitability of polyclonal seedlings in Tripura was continued and growth is being monitored.

10. Flowering and fruit development

Leaf fall pattern during the wintering period was recorded based on an evaluation scale from the fifteen clones at an interval of 7 - 10 days.

Table-Net 2. Performance of clones in two evaluation triats

Clones	Mean girth (cm)	
	1987 a	1987 b
RRII 105	20.66 k *	18.90 ha
RRII 118	24.69 bc	23.73 a
RRIM 600	23.43 fg	21.33 e
PB 5/51	20.89 k	20.57 g
PB 86	24.10 cd	22.69 b
PR 107	20.55 k	17.58 j
GT 1	23.98 de	20.85 f
Gl 1	22.26 i	18.54 i
RRII 203	23.69 def	-
RRII 208	-	21.61 d
RRII 300	22.06 i	-
RRIM 501	22.92 h	-
RRIM 612	25.90 a	-
RRIM 703	25.40 a	-
RRIM 605	23.24 fgh	-
PB 235	24.26 bc	-
Tjir 1	20.44 kg	-
SCATC 93 - 114	-	21.93 c
SCATC 88 - 13	-	20.91 f
Haiken 1	-	21.63 d

* Clones followed by same alphbets in a column are not significant at P = 0.05 in DMRT

11. Recombination breeding and selection

11. 1. Half-sib progeny evaluation

Seedlings raised from open pollinated seeds of ten clones were evaluated for their morphological and physiological parameters. The data generated from the initial growth phase are being analysed.

11.2. Full-sib progeny evaluation

A total number of 1251 hand pollinations involving 21 cross combinations were undertaken during the flowering season of 1991. Sixty seeds were derived from these crosses. Seeds were germinated in seed beds and after germination, they were transplanted to nursery beds. Only fifteen plants belonging to eight cross combinations survived in the nursery beds which are being closely monitored.

12. Germplasm conservation, evaluation and maintenance

There are three gene pool gardens maintained at the Agartala subcentre. The first garden consists of 29 clones of Wickham origin, the second with 158 wild Brazilian clones from 1981 IRRDB expedition, established in 1987 and the third garden has 209 wild genotypes from the 1981 IRRDB expedition planted in 1989. In addition, 67 wild Brazilian clones were transferred from NERC, Guwahati. Efforts are being continued to strengthen the gene pool through exchange of materials with base centre and other subcentres. Morphological performance of these genotypes is being studied.

13. Relationship between girth and biomass

This experiment, laid out in 1987 with two clones (RRIM 600 and RRII 118) to derive regression equations for calculation of biomass from girth and height measurements at different ages, revealed positive relationship between girth and above ground biomass. No differences were observed between the regression equations of (a) between clones in the same year, (b) between the years after the second year and (c) between clones over years (after the second year).

14. Environmental and physiological parameters and growth

This experiment was started in 1987 with 5 clones (RRII 105, RRII 118, RRIM 600, PB 235 and GT 1) to study the interaction between various agrometeorological factors and growth of *Hevea*. Girth data were recorded during different seasons and physiological parameters were recorded during April '91. RRIM 600 showed highest photosynthetic efficiency followed by PB 235 while the girth increment was highest in RRII 118 during August to November.

15. Exploitation systems

This experiment was started with two clones (RRII 105 and RRIM 600) during November 1990 to find out a suitable exploitation system along with different periods of rest in winter. As the tapping was done only for one year under the two (1/2 S d/2 and 1/2 S d/3) systems, it is too early to draw conclusions. The experiment is being continued.

REGIONAL RESEARCH STATION, MEGHALAYA

The Regional Research Station, Tura concentrated on field experiments in Ganolgre (600 m) and Darechikgre (1100 m) farms and at NRETC, Jenggitchakgiri.

1. Field experiments at Ganolgre farm

1.1. Multidisciplinary evaluation of clones

Among the ten clones included in 1985 trial RRII 118 (40.98 cm) and RRIM 600 (40.02 cm) have attained the maximum girth while PB 5/51 (32.93 cm) has shown the minimum girth. In the 1986 clone trial, RRII 208, RRIC 105 and PB 311 have attained the maximum girth among the ten clones while least girth was recorded in PCK 1 and RRII 5. It has been observed that the girth increment was maximum during the period June to August in all clones. The adverse effect of low temperature affected growth of plants during winter.

1.2. Assessment of potential intercrops

The intercrops have been removed completely and the trial is discontinued. The rubber trees (RRIM 600) in the trial area have attained a maximum girth of 22.79 cm.

1.3. Rubber based cropping system

The growth of tea and orange was satisfactory. Wintering of rubber did not affect tea while orange showed retarded growth during the period. During the year 167 kg green tea leaves were harvested.

2. Field experiments at Darechikgre farm

2.1 Multidisciplinary evaluation of clones

All the ten clones included in this trial were adversely affected by the high elevation. Although a total of 65 plants are surviving, their growth is retarded.

2.2 Intercropping with perennial crops

Tea and orange are growing well but all polyclonal stumps planted have dried up. It appears from the results that rubber cannot be grown at such a high elevation.

2.3. Intercropping trial, NRETC

The intercrop trial initiated during 1990 at D. D. C., Jengitchakgre, to increase the sources of income for rubber growers in West Garo Hills during the immature phase of rubber was continued. Budgrafts of RRII 105 were planted along with pineapple, banana and cover crops (50% area with *Pueraria*). After the establishment of cover crops, the growth of rubber (RRII 105) was observed to be satisfactory under the intercropping system irrespective of the two intercrops viz., banana and pineapple. Rabbit rearing has been introduced in the year 1991 as a component of the farming system. The rabbits fed on cover crops are found to grow well. The banana harvested from the trial has fetched Rs. 1,351/-. The growth of pineapple and cover crops was quite satisfactory.

3. Research programmes in plant pathology

3.1. Mushroom culture

Cultivation of mushroom was carried out on paddy straw, as substrate. Around 12 kg of mushroom was produced.

3.2. Plant diseases

During the year a regular survey was carried out at monthly intervals on rubber diseases in the Ganolgre research farm. Only leaf-spot and powdery mildew diseases were noticed. The highest disease index was recorded during the months of May-June and subsequently their intensity decreased sharply.

3.3. Microflora studies

A comparative study of microflora of different rubber growing soils of Garo Hills indicated that there existed very little difference in the composition of fungal taxa of different soils under rubber.

4. Research programmes in plant physiology

4.1. Flowering and fruiting

Percentage of tree flowered, fruited and number of pods per tree were recorded in ten clones during the years 1990 and 1991. In 1990, percentage of tree flowered was maximum in Gl 1 (21.42%) and minimum in RRIM 600 (2.22%) while in 1991, clone RRII 203 (87.50%) and RRIM 600 (28.57%) showed maximum and minimum respectively. Maximum pods per tree was recorded in PB 86 (38.21) followed by Gl 1 (37.06) and least in RRII 118 (8.83). It has been observed that flowering and fruiting were affected by high wind velocity, higher rainfall and number of rainy days during the onset of flowering and fruiting.

4.2. Leaf expansion

Leaf expansion was recorded at different time intervals in ten clones of *Hevea*. Maximum leaf expansion was recorded during the months of June/July and August and minimum during March/April in all the clones. In all the seasons maximum leaf expansion was recorded in RRIM 605 and RRII 118. Leaf expansion was least in clone PB 5/51.

4.3. Effect of winter

It has been noticed that during the year minimum air temperature of 5°C upto 5 hr was recorded during the winter. The low temperature adversely affected all the clones.

REGIONAL RESEARCH STATION, MIZORAM

The Regional Research Station, Mizoram, concentrated on trials on clone evaluation and physiographic features on growth of rubber. Observations on weed management, planting etc were also in progress.

1. Multidisciplinary evaluation of clones

This trial was started in the year 1985 with 10 clones. The observation on girth shows that although RRII 118 has the highest absolute girth (41.57 cm) the highest girth increment during the period was attained by clone RRIM 600 (6.28 cm).

2. Polyclonal seed garden

The polyclonal seed garden, established in 1988-89 with seven clones (RRII 105, RRII 118, RRII 300, RRIM 600, GT 1, PB 235 and SCATC 93-114) was maintained well.

One of the hillocks in the seed garden was selected to study the effect of slopes on the performance of different clones. It was observed that clone SCATC 93-114 grows well in all the positions (top, middle and foot) of the hill. Performance of the clone RRII 118 has also been satisfactory.

3. Influence of physiographic features on growth

This trial was started in 1987 to study the influence of physiographic features on growth of *Hevea*. The average girth of rubber plants in four aspects as on January 1992 is given in Table-Nez. 1. It can be observed that rubber plants grew most vigorously when planted on eastern slopes.

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

Aspect	Girth (cm) at 150 cm
North	12.04
South	11.68
East	13.95
West	11.83

4. Weed management

The experiment to investigate the efficacy of paraquat and glyphosate in controlling *Imperata cylindrica* (Lalang) in Mizoram laid out in 1990 was continued in 1991 also. The results are being summarised.

5. Field planting of budded stumps

A trial to find out the appropriate period for direct field planting of budded stumps under Mizoram conditions was laid out with four treatments replicated five times. The results show that June is the most appropriate month for field planting.

6. Nursery management

A new observational trial was laid with two clones (RRII 105 and RRIM 600) in the polybag nursery, to identify the best period of planting and also to study the effect of shading on sprouting of buds.

REGIONAL RESEARCH STATION, WEST BENGAL

At the Regional Research Station at Nagrakata, trials on nutritional requirement of *Hevea*, evaluation of clones, intercropping and exploitation systems were in progress. The station has a small area under seedling and budwood nurseries.

1. Nutritional studies

The trial was started in the year 1989 with four doses of nitrogen (0, 20, 40 and 60 kg ha^{-1} and three doses of phosphorus and potassium (0, 20 and 40 kg ha^{-1} each) in a randomised block design with a view to find out the optimum dose of N, P and K for rubber under West Bengal conditions.

The girth (at 150 cm) after 30 months from planting clearly indicated that application of nitrogen significantly influenced girth increment. The highest girth recorded (14.26 cm) was at 60 kg N ha^{-1}. Response to phosphorus was not significant though the maximum (13.93 cm) was recorded at 40 kg P ha^{-1}. In the case of potassium, a trend similar to that of phosphorus was observed. The highest girth (13.94 cm) was recorded at 40 kg K ha^{-1} level. The interaction of fertilizers was not significant.

2. Multidisciplinary evaluation of clones

2.1 Clone trial 1990

Two clone trials, one with eleven and the other with seven clones, were laid out during 1990. Among the first set of clones it was observed that the maximum girth was attained by RRII 203 (10.67 cm) followed by GT 1 (10.06 cm) and the minimum girth was recorded in PB 5/51 (9.0 cm). Wide variations were noticed with regard to plant height, number of flushes and number of leaves from clone to clone. In the second trial, maximum girth was recorded in PB 86 (9.0 cm) followed by RRII 105 (8.77 cm).

2.2 Clonal trial 1991

Under this trial, 11 clones were planted during 1991. Observations will be recorded from the next year.

3. Exploitation systems

A new trial has been laid out in the year 1991 covering an area of 3.5 ha to study different systems of exploitation under local conditions.

REGIONAL RESEARCH STATION, MAHARASHTRA

The Regional Research Station, located at Dapchari concentrated on research in plant physiology, irrigation, clone evaluation and intercropping.

1. Irrigation systems

The irrigation experiment was continued. At the end of the dry season (May '91) basin irrigation at 1.00 ETc had registered 70% growth of 1990 wet season growth while 0.75 ETc drip registered a recovery of 75%, which indicates more efficient water use in the drip irrigation. Control plants (unirrigated) did not register any growth.

The moisture stress in the control plots resulted in reduction in number (18%) and size (16%) of leaves during 1991 compared to those in 1990. Under irrigation the leaf size was maintained while number increased in both basin (30%) and drip (37%) treatments.

Seven year old plants (RRII 105 and RRII 118) are being given hose and sprinkler irrigation at 0.50, 0.75 and 1.00 ETc at 600 l tree^{-1}. The growth of the trees as reflected in girth increment is given in Table-Dap. 1.

Table-Dap. 1. **Growth of *Hevea* under irrigation**

Treatments	Girth increment (cm) January'91 - May'91	
	RRII 105	RRII 108
No irrigation	0.23	0.13
0.50 ETc irrigation	2.42	2.30
0.75 ETc irrigation	2.80	3.04
1.00 ETc irrigation	3.37	3.83

2. Physiological evaluation of clones

Among the clones included in this trial PB 235 and RRIM 600 have recorded high yield during the year 1991-'92, their projected annual yield being 1290 kg ha^{-1} and 1020 kg ha^{-1} respectively. The clone RRIM 612 gave the lowest yield, which was 57 per cent less than that of RRIM 600. Yield in all the clones started declining from February 1992. Tapping rest was given from the middle of March 1992.

3. Mulching

A mulching experiment was laid out during January 1992. Organic mulch at the rates of 4 t ha^{-1} and 8 t ha^{-1} and no mulch (control), with or without irrigation formed the treatments. Growth in terms of girth and soil temperature were recorded regularly. During March both the mulch treatments lowered soil temperatures at 5 cm depth (11 to 13°C) and at 20 cm depth (3 to 4°C) under both irrigated and unirrigated conditions. Mulched plants with irrigation recorded significant growth, while plants without irrigation even under mulch did not show any growth.

4. Clone trial

The clone trial established during 1985, consisting of fifteen clones, was continued and girth data were collected monthly. The girth increment from April 1991 to March 1992 showed that the clones RRII 208, RRIC 52 and RRIC 100 were growing better than other clones included in this trial.

5. Polyclonal trees for selection

Twenty six polyclonal trees of the 1985 plantation were opened for tapping during June 1991. The average yield of the polyclonal trees was comparable to that of PB 235 the highest yielding clone. The trees continued to yield high even after the onset of drought.

6. Cost evaluation

The trial laid out in 1987 to estimate the cost of cultivation of *Hevea* plants under irrigated and non-irrigated conditions was continued. The plants were provided water at 220, 400 and 412.5 l irrigation ha^{-1} during the dry periods of 1990, 1991 and 1992 respectively. Another block of 250 plants are maintained without irrigation for comparison. Observations are being recorded.

7. Intercropping

The trial was undertaken to study the benefits of raising pineapple as an intercrop in immature rubber plantation. The experiment includes two plots each of 50 trees and in one of the plots 140 pineapple suckers were planted. The pineapple plants were given irrigation during drought period. This has resulted in the promotion of growth of rubber plants also in this plot (20%), compared to the other. An estimated income of Rs. 3,400 ha^{-1} was obtained from pineapple.

REGIONAL RESEARCH STATION, ORISSA

The Regional Research Station, Orissa continued its research activities on agromanagement techniques and clone evaluation specific to the drought prone areas of eastern India.

1. Nurseries

Stock seedlings and budwood nurseries were maintained properly for the production of the planting materials required for planting experimental area.

2. Experimental planting

Growth of plants in all the experimental area has been satisfactory. In a trial on comparsion of different types of organic matter it was found that the combination of farm yard manure and cake-o-meal, an organic matter supplement, is superior to other treatments.

Three trials on the evaluation of clones were in progress. In one of the trials planted in 1990, PB 310 recorded maximum girth (11.9 cm) closely followed by RRIM 600 (11.8 cm). In another trial with a different set of clones planted in 1991, RRII 5 attained maximum girth (8.0 cm) followed by RRIC 102 (7.7 cm). In order to assess the performance of three popular clones (RRII 105, RRII 600 and GT 1) a field trial was laid out in 1987. Early growth did not reveal any appreciable variation.

An area of three ha was planted in 1988 with polyclonal seedlings in order to study its suitability under stress situations. It was observed that most of the trees attained a girth of 25 to 30 cm in 1992 which reveals that polyclonal seedlings are more adaptive to stress situations.

3. On-farm trials

The performance of the plants in the on-farm trial was not satisfactory since irrigation could not be continued from the third year as envisaged in the original technical programme. Therefore, the trial was discontinued.

REGIONAL RESEARCH STATION, MADHYA PRADESH

A Regional Research Station with 47 ha farm was established in Sukma, Bastar Dist., Madhya Pradesh. Stock seedlings and budwood nurseries were established in 1990. During 1991-92 an area of 2.5 ha was planted with polyclonal seedlings and RRII 105. Permission to clear fell 5.4 ha of land was obtained which will facilitate laying out of field experiments.

HEVEA BREEDING SUB-STATION, KARNATAKA

The following field trials were in progress at the Hevea Breeding Sub-Station, located at Nettana (Dakshina Kannada Dt), Karnataka State.

1. Trial on growth, yield and exploitation systems

The two trials with five clones each, one laid out in 1987 and the other in 1988, were maintained. Girth recording was done at quarterly intervals.

2. Trial of ortet clones

Girth recording was carried out at quarterly intervals. Wind damage in the

trial was 0.85 per cent and there were no casualties due to drought.

3. Clone trials

One round of girth recording was done in the trial laid out in 1989 with 14 clones. Casualties due to wind in the area was 3.15 per cent and those due to drought 0.66 per cent.

The trial on second selections from 1954 hand pollination programme and popular clones was under proper care. Life saving irrigation was given in the trial using sub-soil injector. Casualties in the trial were replaced with polybag plants.

Three field trials, covering an area of 2.5 ha, were laid out in July 1991 for small scale evaluation of indigenous and exotic clones.

4. Estimation of genetic parameters

Gap filling was done wherever casualties were noted and the plants were given life saving irrigation using sub-soil injector.

5. General

The power fence erected in 1990 was maintained properly and has been working satisfactorily.

The station recorded a total rainfall of 4544.85 mm during 1991 with the highest rainfall of 1427.7 mm during the month of July. The maximum temperature recorded was 39.5°C in the month of March and the minimum, 6.4°C in January 1992.

HEVEA BREEDING SUB-STATION, TAMIL NADU

The station is located at Paraliar, about 40 km from Nagercoil. In the two breeding orchards established during 1987 and 1988, branches were induced at low levels.

The large scale trial using 15 clones, laid out during 1991, was maintained. Irrigation was given whenever necessary but heavy casualty was observed. Test tapping of seedlings, for identifying potential ortets, was attempted. Identification of promising ortet trees from holdings in the locality was initiated. A source bush nursery was under maintenance.

HIGH ALTITUDE RESEARCH STATION

The high altitude research station is temporarily functioning at Kalpetta, Wynad. Efforts were made to locate suitable area for establishment of a research station in the high elevation area. On-farm trials under progress included physiological evaluation of clones initiated by the Plant Physiology and Exploitation Division during 1981 covering an area of 5 ha at Mullenkolly, fertilizer and intercropping trials initiated by the Agronomy and Soils Division during 1991 covering an area of 15 ha at Mananthavady and powdery mildew disease control using systemic fungicide dusts initiated by the Mycology and Pathology Division during 1992 at Panamaram covering an area of 6 ha.

The Botany Division has proposed to initiate a clone evaluation trial at Mangalam Carp estate for which the planting materials have been raised in polybags in the site itself.

Advisory assistance for rubber growers was also provided whenever called for.

AGROMETEOROLOGY UNIT

Weather conditions at Experiment Stations

Agrometeorological parameters were regularly recorded at five locations, during the year 1991 also and summarised in Table-Agromet. 1. The total rainfall varied from 2294.9 mm at Keeriparai (Kanyakumari Dt.) to 4,665.2 mm at Nettana, Karnataka. Both the SW and NE monsoons were vigorous in Kottayam, Ranni, Kanyakumari, Mangalore and Tripura areas. In Kanyakumari area, the NE monsoon was very active only during October and satisfactory during November. The rainfall received in Agartala was very favourable for rubber throughout the year, except inthe month of November. In other places, short spell of drought occured during the months of January and December. The minimum temperature recorded was 9.9°C at Agartala during the month of January and the maximum temperature was at Keeriparai, (35.5°C) in the month of April. High temperature conditions prevailed in Nettana during the months of February to May, but its bad effect was off-set due to the moderate rainfall received during these months. Low temperature detrimental to the photosynthetic activity and growth of rubber prevailed in Agartala in the months of January and December, offsetting the effect of favourable moisture conditions.

Table-Agromet. 1. Meteorological conditions recorded in different rubber growing regions during 1991

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
a. Rainfall (mm)												
Agartala	23.2	40.6	83.6	163.9	812.7	263.5	153.8	282.9	280.2	278.2	0.0	137.2
Nettana	0.0	118.6	1.4	157.0	168.0	929.5	1427.7	1134.8	244.5	386.7	97.0	0.0
Kottayam	2.0	7.2	58.5	215.1	171.9	1373.4	648.6	438.4	38.3	416.4	171.9	22.9
Chethackal	32.5	14.5	—	254.9	327.3	1137.6	639.1	397.2	31.4	354.5	165.2	25.7
Keeriparai	42.2	51.2	70.6	195.7	75.4	799.8	340.8	—	1.0	551.4	159.0	7.8
b. Maximum temperature (°C)												
Agartala	25.0	29.0	33.0	33.6	31.5	32.0	32.5	32.6	30.7	31.3	29.3	25.5
Nettana	33.8	35.3	35.4	35.1	34.3	29.0	27.0	27.1	30.4	30.9	31.2	31.9
Kottayam	32.7	34.0	34.4	34.1	33.6	29.3	30.2	29.2	31.1	30.7	31.7	32.2
Chethackal	33.2	34.8	34.2	33.5	33.4	29.0	28.5	28.1	31.0	30.2	31.6	32.4
Keeriparai	31.6	33.1	35.0	35.5	35.3	32.0	33.2	32.8	32.3	33.2	30.0	32.1
c. Minimum temperature (°C)												
Agartala	9.9	15.3	19.5	22.1	21.8	25.0	25.4	24.9	24.4	22.3	14.9	11.0
Nettana	14.7	14.9	20.2	23.3	23.3	23.4	22.2	22.2	22.3	21.9	19.7	16.0
Kottayam	23.6	23.8	25.0	23.8	24.9	23.3	22.5	22.8	23.4	22.8	22.6	21.2
Chethackal	20.1	19.4	21.1	22.8	23.5	24.4	22.6	22.3	23.1	22.2	21.8	20.6
Keeriparai	20.8	20.3	22.6	22.8	24.2	23.6	23.4	23.3	23.4	22.3	20.8	18.2

LIBRARY AND DOCUMENTATION CENTRE

The total collection of books and bound periodicals in the RRII library was 20589 and 17023 respectively. The library subscribed to 254 journals and nine dailies. About 150 other journals were also received in the library, either as gift or as exchange to our publications.

Two issues of the Documentation List containing abstracts of articles on natural rubber (NR) and two issues of Rubber Alert containing indexes on NR publications were complied and circulated. A list of current periodicals in the library was compiled and distributed among the scientists.

The library made 32 requests for scientific articles from overseas and local institutions' scientists. Thirty requests for photocopies of articles of RRII scientists received from local/overseas were supplied. As part of information dissemination, about 1.75 lakh photocopies of different information materials were made by the reprographic section. As part of the database development 4000 documents have been indexed during this year.

The library is actively participating in the sales promotion of Indian Journal of Natural Rubber Research, Rubber Wood : Production and Utilization and Plant and Soil Analysis. The library also actively participated in the production and distribution of circulars, abstracts of papers, souvenir, etc. for the International Natural Rubber Conference (5-8 February, Bangalore).

The facilities and services of the library were also extended to planters, manufacturers and others connected with the natural rubber industry. Research scholars and students from several universities and colleges also utilized these services. Scientists from other national research institutions also visited the library for consultation and reference.

CONFERENCES, SEMINARS AND SYMPOSIA

NATIONAL SEMINAR ON BIOLOGICAL CONTROL IN PLANTATION CROPS, 27-28 JUNE 1991, KOTTAYAM, INDIA

A two day national seminar on biological control in plantation crops was organised by the Pathology and Agronomy divisions of the RRII on 27th and 28th June 1991 at RRII. The seminar aimed at discussing the achievements in the use of biological agents in plant protection of plantation crops and formulating future research startegies in biological control so as to reduce or avoid the use of toxic chemicals which affect the environment adversely. One hundred and thirty scientists from all over the country participated.

Eight lead talks and thirtythree research papers were included in the seminar. Attention was focused on biological control of insect pests, diseases and weeds of plantation crops like rubber, coconut, cardamom, tea coffee and cocoa and cash crops like pepper, ginger and toabcco. The subjects covered included selection, introduction and evaluation of parasites and predators of insect pests and weeds and antagonists of plant pathogens. The need for mass multiplication of biological agents for large scale introduction and efforts to popularise biological method as a viable alternative to chemical control were stressed.

The seminar was co-sponsored by the Kerala Agricultural University, North Eastern Hill University and the Indian Cardamom Research Institute.

NATIONAL SYMPOSIUM ON RECENT ADVANCES IN DROUGHT RESEARCH, 10 - 13 DECEMBER 1991, KOTTAYAM, INDIA

A national symposium on Recent Advances in Drought Research was jointly organised by Plant Physiology and Exploitation Divisions of the RRII and the Society for Plant Physiology and Biochemistry, New Delhi from 10th - 13th December 1991. An orientation programme for young scientists on modern methods and usage of equipments for drought research was organised on the first day. The symposium was attended by over 200 delegates. The symposium had separate sessions on (1) Agroclimatology and crop modelling, (2) Screening for drought resistance, (3) Genetic and molecular basis of drought resistance traits, (4) Relevance of drought avoidance mechanisms in crop improvement, (5) Physiological approaches for drought management and (6) Interaction between drought and other stresses.

One hundred contributory papers were presented in the seminar. Twelve invited talks of leading scientists were also arranged. The plenary session provided an ideal forum for the interaction of scientists and experts working on various crops. The importance of drought research in crops and also the role of plant physiologists were emphasised.

INTERNATIONAL NATURAL RUBBER CONFERENCE, 5-8 FEBRUARY 1992, BANGALORE, INDIA

The Rubber Research Institute of India organised an International Conference on Natural Rubber, INRC 92, during 5-8 February at Hotel Ashok, Bangalore, to review the recent developments in the field of natural rubber research and to identify future thrust areas. The conference comprised oral and poster presentations of research papers, guest lectures, group meetings and a panel discussion. A total number of 104 research papers was accepted for presentation in the conference of which 84 were presented.

The conference was inaugurated by Mr. Salman Khursheed, the Hon'ble Union Deputy Minister of Commerce. The function was presided over by Mr. Eti Shambunath, Hon'ble Minister for Forest, Government of Karnataka.

The keynote address delivered by Tan Sri Dr. B. C. Sekhar, Secretary General, International Rubber Study Group (IRSG), reviewed the developments in the NR industry and projected the shape of things to emerge during the next century. Guest lectures on different aspects of natural rubber were delivered by Prof. Richard Litz (USA), Dr. C.S.L. Baker (UK), Dr. B. Sripathi Rao (Malayasia), Prof. J.M. Vergnaud (France), Prof. Mike Hall (UK), Dr. L. Mulins (UK), Dr. S. P. Raychaudhuri (India), Dr. Padmanabha S. Pillai (USA) and Dr. A Vidal (France).

The research papers in biology and technology were presented in concurrent sessions.

The biology programme consisted of sessions on agronomy and crop management, genetic improvement and germplasm resources, biochemistry, physiology and exploitation, diseases and pests management, economics and planning and molecular biology and biotechnology. The papers presented emphasised the need to introduce improved techniques of crop management for cost reduction and maximum exploitation of available genetic resources. The discussions pointed out that biotechnology and molecular biology will be useful tools for achieving this. Metabolic and biochemical aspects of latex regeneration, investigations on possible causes of tapping panel dryness and new concepts in

exploitation systems were also discussed. Effect of major rubber diseases and pests and new strategies for their management were presented. The impact of new agrotechnology in rubber plantations was evaluated and improvements suggested.

The technology programme consisted of sessions on primary processing, standardisation and quality control, modified forms of natrual rubber, compounding, industrial and engineering applications, rubber - rubber and rubber - plastics blends and rubber wood. The interesting papers presented in the various sessions indicated the latest developments in these imporant fields. Chemical modification of NR continues to be an active field of research as indicated by the number of papers presented on this aspect and the very lively discussion followed. Polymer blends also continued to attract attention of scientists and ten papers were presented on this aspect. The presentations also highlighted the importance of standardisation and quality control of raw rubber and latex, latest development in compounding, industrial applications and utilisation of rubber wood.

The group meetings specially introduced in this conference, provided a forum for close interaction among scientists in their respective fields and focused on identification of future avenues of research. Five of the group meetings were on biological aspects and two on technology. A panel of seven eminent scientists interacted with the audience during the panel discussion with Tan Sri. Dr. B. C. Sekhar acting as the moderator. The discussion covered a broad spectrum of subjects from biotechnology to engineering applications of NR.

The concluding session was presided over by Mrs. J. Lalithambika IAS, in which Mr. L.H.A. Rego, IFS, delivered the valedictory address. Over 500 delegates participated in the conference of whom 64 were from abroad representing Malaysia, Indonesia, China, Thailand, Singapore, France, Sri Lanka, Nigeria, Papua New Guinea, USA and UK. An exhibition on natural rubber, NR vision 92, was also organised along with the conference.

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SCIENTIFIC AND SENIOR SUPPORTING PERSONNEL

Director of Research

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

Joint Director (Germplasm & Regional Stations)

S Narayanan Potty, M.Sc. (Ag.), Ph.D.

Joint Director (Research & Training)

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Agronomy and Soils Division

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Annie Philip, M.Sc.	Junior Scientist
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C K Thankamony, M.Sc. (Ag.) (Resigned on 7-6-91)	Junior Scientist
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M D Jessy, M.Sc. (Ag.)	Junior Scientist
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C P Mary, B.Sc.	Senior Scientific Assistant
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Biotechnology Division

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R G Kala, M.Sc. (From 29-4-91)	Junior Scientist

Botany Division

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D Premakumari, M.Sc.	Anatomist
Y Annamma Varghese, M.Sc., Dr. Sc. (Ag.)	Botanist
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Kavitha K Mydin, M.Sc. (Ag.)	Junior Scientist
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Mycology and Plant Pathology Division

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L Thankamma, M.Sc.	Mycologist
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S Thankamony, M.Sc.	Entomologist
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Molly Thomas, M.Sc., Ph.D.	Assistant Biochemist
K U Thomas, M.Sc., Ph.D.	Assistant Plant Physiologist
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Rubber Chemistry, Physics and Technology Division

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Baby Kuriakose, M.Sc., L. P. R. I., Ph.D.	Deputy Director
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K T Thomas, M.Sc., L. P. R. I., M. Tech.	Rubber Technologist
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N Radhakrishnan Nair, M.Sc., M. Tech.	Junior Scientist
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Leelamma Varghese, M.Sc.	Junior Scientist
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Agricultural Economics Division

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Toms Joseph, M. A.	Junior Scientist

Central Experiment Station

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D Bhuvanendran Nair, M.Sc., Ph.D.	Junior Scientist
Jacob Abraham, B.Sc., M. B. B. S.	Medical Officer
R Harikrishnan, B.Sc., A. C. A.	Assistant Accounts Officer
P J Joseph	Assistant Estate Superintendent
G Gopinathan Nair	Assistant Farm Superintendent
K Somanatha Pillai	Assistant Section Officer
Annamma Andrews	Nurse (Higher Grade)

Experiment Station at RRII

M D Issac	Assistant Farm Superintendent

Regional Research Station, Assam

Radha Raman Sinha, M.Sc. (Ag.), Ph.D.	Deputy Director
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Krishna Das, M.Sc., Ph.D.	Junior Scientist
Debasis Mandal, M.Sc.	Junior Scientist
Chandra Gupta, M.Sc. (Ag.)	Junior Scientist

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P Eswari Amma	Assistant Section Officer
Regional Research Station, Tripura	
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Y A Nanja Reddy, M.Sc. (Ag.)	Junior Scientist
Mary Varghese, M.Sc. (Ag.)	Junior Scientist
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Regional Research Station, Mizoram	
Ram Phool Singh, M.Sc. (Ag.)	Junior Scientist
Regional Research Station, West Bengal	
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Regional Research Station, Maharashtra	
T Mohankrishna Tadikonda, M.Sc., Ph.D.	Plant Physiologist
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P Subramanian, M.Sc.	Junior Scientist
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M J Augustine	Assistant Farm Superintendent

Hevea Breeding Sub-station, Karnataka

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N Bhargavan	Assistant Farm Superintendent

Hevea Breeding Sub-station, Tamil Nadu

T A Soman, M.Sc., M. Phil.	Junior Scientist
S Suma, M.Sc.	Junior Scientist
V Vijayan	Assistant Farm Superintendent

High Altitude Research Station, Wynad

N Raghunathan Nair, B.Sc. (Ag.)	Senior Superintendent
Mathew Joseph, M.Sc. (From 29-4-91)	Junior Scientist

Regional Laboratory, Nagercoil

A Ulaganathan, M.Sc.	Junior Scientist

Regional Laboratory, Muvattupuzha

Siby Varghese, M.Sc.	Junior Scientist

Regional Laboratory, Calicut

Joyce Cyriac, M.Sc.	Junior Scientist
P K Madhusudhanan, B.Sc.	Senior Scientific Assistant

Statistics Section

G Subharayalu, M.Sc.	Statistician
A Malathy, M.Sc.	Assistant Statistician

Library and Documentation Centre

Mercy Jose, B.Sc., M. L. I. Sc.	Documentation Officer
Accamma C Korah, B. Sc., M. L. I. Sc.	Librarian (Documentation)
Kurian K Thomas, B.Sc., M. L. I. Sc.	Junior Publication Officer

Instrumentation Section

S Najmul Hussain, B.Sc., M. Tech., A. M. I. E. T. E.	Instrumentation Officer
Thomas Baby, M.Sc., M. Phil.	Assistant Instrumentation Officer

Art/Photography Section

K P Sreeranganathan	Senior Artist/Photographer

Maintenance Wing	
S Mohanachandran Nair, B.Sc. (Engg.)	Electrical Engineer
T K Somanatha Pillai	Assistant Estate Officer
Sheela A John, B.Tech.	Assistant Engineer (Civil)
Administration Section	
R Soman, B. A.	Assistant Secretary
Josy D'Cruz	Administrative Officer
E K Thankamma	Section Officer
J Kamaladevi, B.Sc. (Upto 26-7-91)	Assistant Section Officer
B Leela Devi, B.Sc. (Upto 1-12-91)	Assistant Section Officer
V Mary Philipose, B. Sc. (From 2-12-91)	Assistant Section Officer
R Babu	Assistant Section Officer
Accounts Section	
M G Gopi, M.Com.	Assistant Director (Finance)
Manu P Sam, B.Sc., A. C. A. (From 25-2-91)	Assistant Accounts Officer
N Vijayamma (Upto 19-2-91)	Section Officer
P Vasanthakumari Amma (Upto 12-7-91)	Section Officer
K Vijayamma (Upto 7-1-92)	Assistant Section Officer
T Thanka (From 6-2-92)	Administrative Officer
Security Wing	
A K Ramakrishna Pillai	Assistant Security Officer

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Research divisions and functions

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

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

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

Central Experiment Station

The 255 ha Central Experiment Station at Chethackal (Ranni), 50 km away from Kottayam, was started in 1966. Field trials laid out by the research divisions cover almost the entire area.

Regional Research Stations

The RRII has established a Regional Research Complex for North East India with headquarters at Guwahati, having regional research stations at Agartala in Tripura, Guwahati in Assam, Tura and Darechikgre in Meghalaya and Kolasib in Mizoram. The RRII has also set up regional research establishments at Dapchari (Maharashtra), Kamakhyanagar (Orissa) Nagrakata (West Bengal), Sukma (Madhya Pradesh), Paraliar (Tamil Nadu) and Nettana (Karnataka).

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

Staff

The staff strength of RRII has been 391 during the period under review. This inculdes 170 scientists and senior supporting personnel.

National/International Collaboration

The RRII is a member of the International Rubber Research and Development Board (IRRDB), an association of national organizations devoted to research and development on natural rubber. The Rubber Board is a member of the Association of Natural Rubber Producing Countries (ANRPC) and the International Rubber Study Group (IRSG).

The RRII has research/academic linkages with the Banaras Hindu University (Varanasi), Kerala Agricultural University (Trichur), Kerala University (Trivandrum), Mahathma Gandhi University (Kottayam), Cochin University of Science and Technology (Cochin), Indian Institute of Technology (Kharagpur), National Chemical Laboratory (Pune) and Indian Institute of Science (Bangalore).

Publications

Books

Handbook of Natural Rubber Production in India ◆ Rubber Wood : Production and Utilization ◆ Plant and Soil Analysis.

Serials

Indian Journal of Natural Rubber Research
RRII Annual Report

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