Natural Rubber Research in India: Yesterday, Today and Tomorrow

Dr. N.M. MATHEW

Research and development support is essential for the healthy growth of any industry. With the development of the rubber plantations is South East Asia, research on various aspects of rubber cultivation started in most rubber producing countries, Malaysia and Sri Lanka giving early leadership. Though rubber cultivation on a commercial scale started in India in 1902, R&D activities to support the growing plantation industry were meagre in the early phase of its growth. However, the institutional support provided by the government through the establishment of the Rubber Board under the Rubber Act, 1947 resulted in the spectacular growth of the industry during the second half of the last century. There was phenomenal increase in the area under rubber as well as in production. More importantly productivity increased from a mere 300 kg/ha in the early 1950s to 1576 kg/ha in 2000-01. The contribution of R&D and extension programmes of the Board to this remarkable progress needs no emphasis.

1. History

Ever since the beginning of commercial cultivation of natural rubber (NR) in India during the early 20th century, the planters in Travancore, Cochin and Malabar regions in Southern India had been experiencing the necessity for research on problems of rubber planting and upkeep. Initially, the scientific department of the United Planters' Association of Southern India (UPASI) was largely responsible for the initiative in research on rubber. On their request, the Madras Government appointed a Scientific Officer in 1909 to strengthen research activities on rubber. Subsequently, experiment stations were established in Mundakayam, Thenmalai and Moopley for addressing agronomic and mycological problems concerning rubber. Consequent to the rubber slump and falling revenue of rubber estates, Thenmalai and Moopley experiment stations were closed down in 1926 and the Mundakayam station in 1932. Since then, for over two decades, the Indian rubber plantation industry had been without any organized research support.

When the Indian Rubber Board was established on the 19th April 1947 to look after the rubber plantation industry in the country, its functions as defined under the Rubber Act, 1947 included the development of the NR

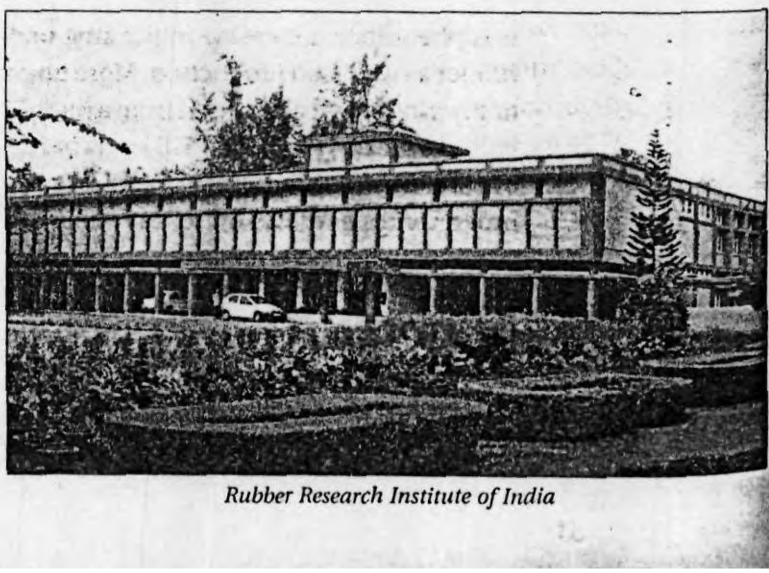
Author is the Director, Rubber Research Institute of India

industry by devising suitable promotional measures, undertaking scientific, technological and economic research etc. Even after the establishment of the Rubber Board, there were only two scientific officers namely, the Rubber Production Commissioner (RPC) and a Field Officer, and their work confined mainly to advisory services and distribution of selected planting materials.

The importance of research on rubber was recognized by the Rubber Board and as early as in 1949, when the Board in its sixth meeting had resolved that it should establish its own research stations at suitable places in the plantation districts of Travancore - Cochin. This meeting approved the appointment of Sri. K.N. Kaimal as the Rubber Production Commissioner. As per the request of the Rubber Board, the Indian Tariff Board which was entrusted by the Government of India in 1950 with the task of examining the cost of production of raw rubber and determining the fair price of various grades, was asked to examine the different aspects of protection necessary for the speedy development of the industry. The Tariff Board in its report dated 28th March 1951 recommended establis-hment of an All India Rubber Research Institute on a scale comparable to the existing research organizations in the main rubber producing countries. The scheme included the appointment of a Director, Rubber Production Commissioner, Rubber Chemist, Botanist, Pathologist, Soil Chemist and a few Assistant Chemists, Assistant Pathologists etc.

On the request of the Government of India, the Indian Council of Agricultural Research (ICAR) examined the recommendations of the Tariff Board and rejected the scheme as out of proportion with the requirements and suggested for a small laboratory and essential staff (Pathologist, Junior Chemist and Junior Botanist) to investigate local problems. ICAR also recommended the establishment of a 100 acre experiment station and also an isolated seed garden of 15 acres for the production of high yielding seeds. The Rubber Board also rejected the Tariff Board's proposals as unsuitable for the requirement and being beyond its resources. The Tariff Commission, in their report dated 27th October 1952 recommended for the implementation of the revised scheme as suggested by the ICAR for the proposed research station.

Meanwhile the Rubber Board on 27 March 1954 approved a research scheme prepared by the Rubber Production Commissioner for the establishment of a Rubber Research Institute with an Experiment Station, with a financial outlay of Rs.10 lakhs and the Government approved the same in June 1954. According to the scheme, the new Institute was to have four research divisions namely, Agronomy, Botany, Pathology and Chemistry. Each Division was to have a research officer and a research assistant and a small experiment station for field experiments. A beginning was made in 1955 by establishing the Institute at the rented premises of Ancheril Buildings of the Rubber Board in Kottayam town with a temporary laboratory. The foundation stone of the Rubber Research Institute of India (RRII) building was laid on 4th February 1956 in the suburbs of Kottayam.



Rubber Research Institute of India

During the early years, RRII had only three Divisions namely, Agronomy, Botany and Pathology. Agronomy and Botany Divisions had senior officers only for short periods. Due to lack of enough laboratory space and supporting staff, the Rubber Research Scheme 1954 could not be implemented fully. The Agronomy and Botany Divisions collected data pertaining to the response of clones to manuring and locations respectively. Subsequently the different Divisions were transferred to the RRI building in 1962, when its construction was completed. The Chemistry and Rubber Technology (C&RT) Division started functioning with the appointment of a Deputy Director on 1st June 1963. Other senior officers of C&RT and Agronomy Divisions were also appointed during June 1963.

The Publicity Section of the Administration Department and the Extension Wing of the Development Department of the Rubber Board were put under the control of the Director in 1964. The Library functioning under the Administration Department since its beginning was also transferred to the administrative control of the Director from 1st June 1964.

The Economic Research unit, which was functioning as part of the RRII since 1968 and later as part of the Rubber Production (RP) and Rubber Processing Departments, became the Agricultural Economics Division of the RRII in September 1986. In 1976, the Biochemistry unit functioning under the C&RT Division was transferred to the Plant Physiology unit of the Botany Division. The full-fledged Plant Physiology and Exploitation Division started functioning in 1978 and the Biotechnology Division in December 1985. The C&RT Division was renamed as Rubber Chemistry, Physics and Technology (RCPT) Division in 1986. The Germplasm Division was established in February 1989 and the posts created in the Botany Division during 1978 for germplasm work were transferred to the new Division.

When the research component of the World Bank Project was implemented in 1994, the organization set up of RRII has been changed with the creation of 28 new posts under the scheme.

2. Achievements

Production and productivity enhancement have been the major goals for research activities. This was achieved through improvements in planting material, estate management practices, pest and disease control, crop harvesting and processing. Additional income generation from the rubber plantation also was given due importance. The major sources of additional income are intercrops, rubber wood, rubber honey and seeds.

From the yield levels of 200-300 kg/ha of original *Hevea* during the early 20th century, systematic plant breeding efforts have raised this to the high levels of about 4000 kg/ha. As a result of conventional breeding programmes with a Judicial use of research data, RRII has been successful in evolving perhaps the highest yielding clone in the world, namely RRII 105.

The development of RRII 105 blending high yield potential with good tolerance to abnormal leaf fall disease, has been instrumental in the significant leap that the country has made in production and productivity. This clone became so popular among rubber growers that it has covered more than 85 percent or the cultivated area in the traditional tract. Rubber Research Institute of India (RRII) developed a few other clones, which were recommended for experimental planting. Though these clones did not perform well in all the agroclimatic zones like RRII 105, some of these have performed extremely well on certain areas. The potential and realized yield of a few of these clones are given in Table 1. Recently RRII has developed another set of eleven improved clones, which are in the final stages of experimentation. As some of these clones have significantly outyielded RRII 105 in experimental fields, limited quantities of budwood of these clones are being supplied to farmers for experimental planting and generation of more data prior to their release.

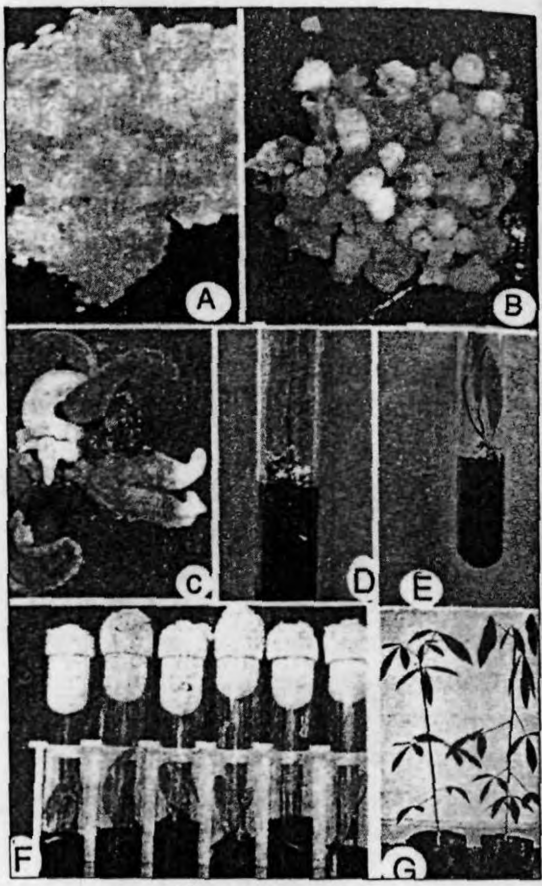
Table 1.
Performance of RRII clones (over 10 years)

Clone	Yield (kg/ha)	
	Potential	Realized (on-farm)
RRII 5*	2797	1299
RRII 105	3146	1710
RRII 109	1699	1361
RRII 116	2102	1490
RRII 118*	2093	1246
RRII 203	3272	1649
RRII 208	3449	1743

* For five years

The gene pool of *Hevea* has been broadened by the IRRDB germplasm collections. RRII has acquired nearly 5000 accessions and these are under evaluation for yield and secondary characters like timber quality, disease and drought tolerance. The accessions with desirable qualities will be included in future breeding programmes. Genetic diversity among these accessions has been under evaluation using molecular techniques. Attempts are also being made for identification of genetic markers for tolerance to diseases, drought and cold.

To supplement conventional crop improvement techniques, biotechnological research was initiated during 1986. Tissue culture protocols were developed for rubber using different explant sources. The tissue culture-derived plants were field-planted and some of these have been brought under tapping. Yield performance of these plants is being monitored. Genetic transformation of *Hevea* was another area in which research has given valuable results. Introgression of genes coding for SOD activity using *Agrobacterium* as vector has been successful. Plants with SOD gene controlled by CaMV35S promoter is under hardening in polybags.



Tissue culture plants

The development of high yielding clones alone would not have brought in the production levels achieved, if it were not matched with appropriate development in agromanagement. The discriminatory fertilizer recommendation evolved by the Institute has helped in need-based fertilizer management for individual fields. Other agronomic strategies like cover-cropping and intercropping, weed control and water and soil conservation also yielded rich dividends by ensuring healthy plant growth. As rubber cultivation has a long gestation period, reduction of immaturity phase was given top priority. By strict adherence to the package of practices recommended, many small growers and some of the large estates could bring the trees to yielding in about five to six years. Further, intercropping schedules have been developed with objective of ensuring returns from the land used for rubber cultivation during the immature stage of the plantation. The results of experiments reveal that apart from the additional income to the farmers, intercropping contributes to better tree growth and early maturity (Table 2).

Table 2.

Girth of rubber (clone RRII 105) under intercropping

Treatment	Girth (cm)	
	One year	Two years
Intercropping with pineapple	16.31	21.27
Intercropping with banana	16.82	20.88
Rubber alone	14.83	19.67

The International Rubber Research and Development Board (IRRDB) has recognized the contributions of RRII in the field of plant physiology by declaring the Institute as a Centre of Excellence in plant physiology. Research in this area concentrated on stress physiology particularly tolerance to drought and cold. This was aimed at development of appropriate agrotechnology for non-traditional rubber growing areas like North Konkan and North Eastern India. It was interesting to observe that with partial irrigation the rubber yield in summer could be increased beyond 100 percent in a drought-prone area like North Konkan, provided soil is deep (Table 3).

Table 3

Summer (January-May) yield of rubber in Dapchari (North Konkan)

Irrigation	Yield (kg/ha)	
	2001	2002
Rainfed	302.7	279.2
Partial irrigation (1/5 ETc)	481.6	561

In the crop protection area, cost reduction was the main concern. Reduction in the cost of high volume spraying by reducing the total spray volume, use of more efficient motorized sprayers and partial replacement of copper sulphate with cheaper zinc sulphate have been attempted (Table 4). For low volume spraying, modification in micron sprayers was carried out to reduce the weight from 65 to 52 kg. For younger plantations smaller micron sprayers with a throw height of up to 10 meters were developed. These achieve-ments were made through the collaborative efforts of RRII with sprayer manufactures. The reduction in cost of pink disease control by prophylactic disease management technique was also successful. A significant reduction in disease incidence could be achieved by spraying the branches with Bordeaux mixture. Treatment schedules have been developed for panel and stem diseases.

Tapping panel dryness (TPD) is a disorder of serious concern in all rubber growing countries. RRII has been coordinating an international research programme in this area under the auspices of IRRDB. A collaborative study with the Indian Agricultural Research Institute (IARI) under this programme has indicated association of low molecular weight RNA (suspected to be a viroid) with most cases of TPD. Further studies are required to establish its causal function, if any. The biochemical changes associated with TPD have also been investigated in detail. Lack of precursors of rubber biosynthesis does not appear to be the cause of panel dryness.

Agrotechnology for North East India was evolved through research programmes initiated in 1978. Clones suitable for rubber growing areas in Tripura and Assam could be identified. Fertilizer requirements for rubber in these states could be identified and recommendations have been given. Tolerance to prolonged winter experienced in these

Table 4
Effect of partial replacement of copper sulphate with zinc sulphate for high volume spraying

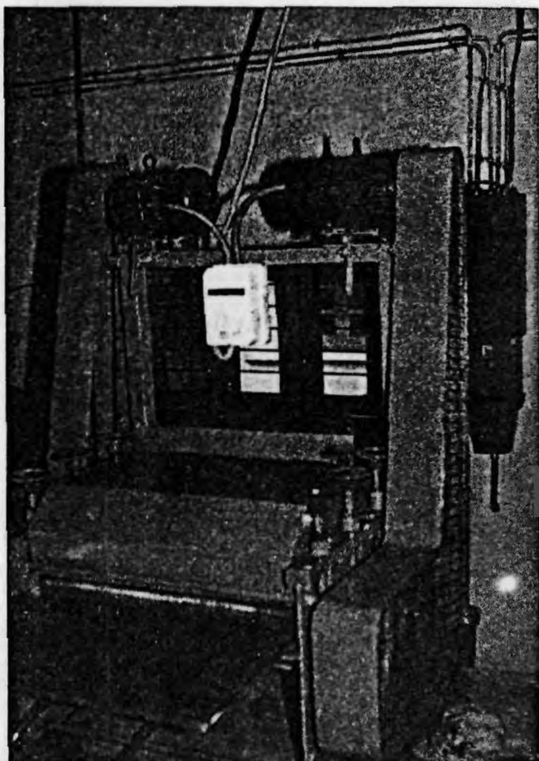
Treatment	Cost (Rs/ha)	Leaf retention (%)			
		Clone RRII 105		Clone RRIM 600	
		1st year	2nd year	1st year	2nd year
Bordeaux mixture 1%	Rs. 1590/-	72.0	70.0	63.0	50.0
Bordeaux mixture 0.5%+ Zinc sulphate 0.5%	Rs. 1200/-	70.0	72.0	62.0	65.0
Unsprayed control		10.0	27.0	-	-

regions gained special attention. The rating of popular clones in NE India is presented in Table 5.

Table 5
Ranking of clones for North East India on the basis of their performance

Tripura	Assam	Meghalaya
PB 235	RRIM 600	RRIM 600
RRIM 600	RRII 105	PB 311
RRII 208	PB 235	RRII 208
RRII 203		RRII 118
RRII 118		RRII 105
SCATC 88/13		

Improvements in processing of natural rubber have been a prime need or addressing quality competitiveness. Reduction in the demand for conventional energy sources was another concern. Modifications in the rubber sheet drying smoke houses for use of alternative energy sources like biogas and solar energy have been experimented. The technology for using biogas to supplement the biomass for smoke houses has been developed and is being adopted at a fast rate. Value addition to rubber through production of modified forms of NR also gained attention. Technology for production for liquid natural rubber (LNR), epoxidised natural rubber (ENR) and constant viscosity (CV) rubber has been evolved. The break through made in developing a sheet-cleaning machine and versatile trolley for use in smoke houses are being patented.



Sheetcleaning Machine

The impact analysis of research and extension services was also attended to. The adoption level of most of the recommendations has been very good especially with the small growers. The productivity of a large number of small growers is much above the national average due to this factor. Some progressive small growers have achieved productivity, which is almost double that of large growers under the same agroclimatic regions.

The impact of globalization consequent to the WTO agreement on the NR sector was studied in detail. The elimination of tariff and non-tariff barriers in rubber trade has left the Indian NR sector exposed to the changes in the world market. The issues confronting our NR industry include uncertainties in market price, increase in input costs and consequent erosion in profit margins.

3. Challenges

The challenges that the NR production sector has to address include increasing the productivity further and reduction in the cost of production. The key to higher productivity being genetic improvement of the cultivated clones, one of the important areas of future research programmes is evolving higher yielding clones through breeding. The new set of improved clones, which have yield potential as high as 46 percent above RRII 105 needs further experimentation in all rubber growing regions.

The gap between the potential and achieved yield levels of the cultivated clones needs to be bridged through appropriate extension strategies. The economic viability of rubber plantations needs improvement. This can be achieved through intercropping, multiple cropping and through other farm businesses like bee keeping, mushroom culture, biogas generation etc. Attempts are being made to identify germplasm materials with desirable traits, which could be incorporated into breeding programmes for developing latex-timber clones.

Productivity can be improved through evolving higher yielding clones with high levels of disease tolerance. Identification of genes imparting desirable characters like yield, disease and drought tolerance and their incorporation in agronomically desirable varieties are now being attempted. Genes, which are likely to impart drought tolerance have been successfully incorporated into the *Hevea* genone. Their expression in the plants needs confirmation. Attempts to identify markers linked to resistance to abnormal leaf fall disease are in progress. Search for desirable characters in the *Hevea* germplasm is being pursued.

Agronomic practices are to be fine-tuned to achieve cost reduction. Conservation of soil and water and reduction in input costs are other areas of active research. In order to optimize fertilizer input, norms have been developed for Diagnosis and Recommendation Integrated System (DRIS) and these are now being evaluated. The use of microorganisms like phosphate-solubilising and nitrogen-fixing bacteria and mycorrhizae are being attempted to reduce fertilizer use. Intercropping and multiple cropping, comprising systems in which even timber-yielding tree species are included, are being experimented with the objective of developing rubber-based sustainable farming systems. Farm mechanization may help in cost reduction in areas like planting operations and weed management.

In crop harvesting, low frequency tapping has proved to be effective in maintaining yield levels with reduction in labour input. The findings of RRII in this area need popularization. Further improvement in tapping and stimulation to optimize the schedules is to be taken up. Associated problems such as ensuring optimum use of available tappers are to be addressed. Stress tolerance of rubber is an important area particularly in the context of extension of rubber cultivation to marginally suitable agroclimates. Research in this direction has to be strengthened to identify factors contributing to stress tolerance.

Tapping panel dryness (TPD) remains as one of the major challenges in improving productivity. It is estimated that nearly

15 percent of the trees are affected by this disorder. More concerted efforts are required to identify the cause of the disease and to evolve control strategies.

As the pressure on cultivable land is very high in the traditional rubber growing tract, extension of cultivation will be possible only in the non-traditional region. The agroclimates in these areas are not very conducive for rubber cultivation. Hence, clones and management techniques suitable for these areas, which are prone to climatic extremes, have to be developed.

The biosynthetic pathway of rubber needs to be studied in detail to identify the missing links. This may help in understanding the factors which limit biosynthesis and aiming at increasing production through appropriate modification in this pathway. Further, this pathway can be utilized for production of pharmaceutical and other products, which may turn rubber plantations into biological factories for multiple production.

In crop protection, the important challenge is to develop resistant clones. Identification of the genes responsible for resistance in cultivated and wild *Hevea* germplasm, their isolation and incorporation into clones which have other agronomically desirable traits, will help in reducing, if not eliminating, the need for expensive crop protection measures. Environment friendly methods of disease and insect control have to be developed to ensure sustainability of the farm ecosystem.

Resistant varieties, which can withstand biotic stresses like diseases and pests, are an essential component in low input farming. The genes responsible for imparting resistance to various stresses have to be identified and incorporated into otherwise desirable clones through genetic engineering. Research in techniques like crown budding, which can reduce the need for fungicide application has to be strengthened to overcome the present hurdles in their adoption. Enhancing the net farm income of rubber holdings is of prime importance. Apart from intercropping, studies related to other sources of income generation such as rubber wood, honey from rubber, rubber seed oil etc. need to be strengthened.

Processed rubber wood and modern rubber wood furniture have excellent scope for raising revenue of the rubber plantation sector. Once the technical and financial feasibility are established at the Model Rubber Wood Factory of the Rubber Board, a number of units will come up and begin to operate.

Quality improvement of rubber with simultaneous reduction in cost of processing is the most important goal in primary processing. Protection of the environment from pollution also is another concern. Quality improvement of sheet rubber can be achieved only if adequate care is taken in processing the crop by the small growers. Group processing and associated issues are to be addressed properly. Lack of uniformity of the raw material remains as a problem at the secondary processing stage. Fixing up quality standards for sheet rubber may have to be attempted. The quality of TSR also requires improvement. TSR production in India is mainly from field coagulum. Adequate care has to be taken in collection and drying of field coagulum to avoid degradation. Sorting and cleaning of field coagulum also may help in reduction in impurities. Introduction of quality standards at the product manufacturing stage necessitates steady supply of standard raw materials.

Value addition of natural rubber through physical and chemical modification is an area of active research. Modified forms of natural rubber will fetch higher returns as they have desirable properties for specific end uses.

In the past, the plantation industry had an inward orientation as there was adequate demand from the domestic manufacturing industry and a protective market environment. With globalization of trade and entry of new competitors who are able to produce rubber at lower costs and offer the produce at lower prices, consolidation of the position of Indian rubber in the internal market and aiming at competition in the world market have emerged as the most important challenges. This can be achieved only by ensuring cost and quality competitiveness. Identification of products with specific locational advantages and their production has to be pursued to consolidate the position of our manufacturing industry in import substitution and export.

Since its genesis, the RRII has been instrumental in perfecting location specific agrotechologies for the traditional rubber growing regions. The research results from non-traditional areas aid in formulating appropriate agrotechnology for those regions where the crop is cultivated under suboptimal conditions. The cumulative efforts of the research programmes of RRII, the highly responsible farmer community and a well co-ordinated extension service of the Rubber Board have contributed in achieving the present enviable position in production and productivity among the major NR producing countries. RRII is now in the process of reorienting its research priorities so as to transform the Indian NR industry globally competitive, which is the need of the hour. ◄

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