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TRENDS IN RUBBER RESEARCH

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India has made remarkable progress in the rubber plantation sector, particularly during the last five decades. In spite of the less favourable agroclimatic conditions prevailing in the country, we could achieve the highest average productivity among the major producing countries. Moreover, rubber cultivation could be extended beyond the traditional regions and latitudes. Today India has become the fourth largest producer and consumer of natural rubber (NR) occupying a very significant position in the global NR scenario. One of the key factors contributing to this remarkable success is the R&D efforts by the Rubber Board ever since its establishment. For any crop, a sustained R&D support is very essential for ensuring steady progress and rubber is no exception. This has become particularly relevant in the globalised scenario where competition has become very severe. Therefore, the Rubber Board of India has been giving maximum priority for continued R&D support to the NR industry in the country (Fig. 1). Some of the recent trends in NR research in India are briefly discussed below.

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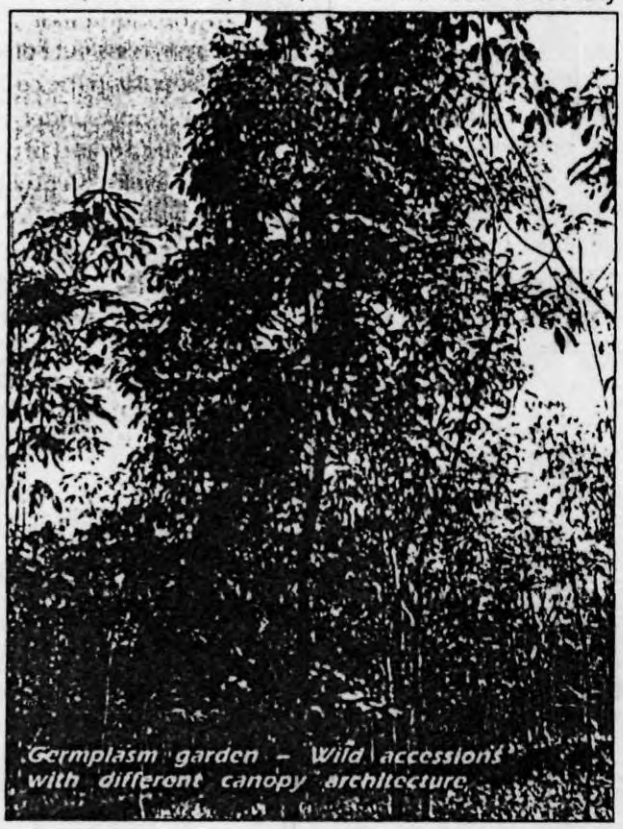
Genetic improvement of the crop

The most important factor contributing to productivity of a rubber plantation is the type of planting material used. The highest productivity that India has achieved can be attributed mainly to the clone RRII 105 evolved by the Rubber Research Institute of India (RRII). This has become so popular in the country that around 85% of the area is now under this single clone, which has become a matter of concern. Though the Institute has developed other clones, which are equally promising, none of these has become as popular as RRII 105, as growers are prepared to plant new clones only if these are much higher yielding than the existing popular clone, RRII 105. In this context, the development of the new RRII 400 series clones is a new landmark with a potential to enhance the average productivity of rubber plantations in India in a significant manner. Four among these clones are now included in the Category III of recommended planting materials and it is believed that within a short period of time at least one or two among these clones could be released for large-scale cultivation. The recent introduction of PB 260, a Malaysian clone, in Category I along with RRII 105, is based on systematic observations in different agroclimatic regions over a long period of time. This clone is as high yielding as RRII 105 with a potential for yielding higher timber volume. Its faster growing characteristics also will be a boon to the growers as they will be able to bring the plantation into tapping in a shorter period compared to RRII 105. Other studies particularly on propagation techniques, anatomy of bark and

wood in relation to rubber yield and cytopalynological investigations have also been undertaken to support the breeding programme.

One of the constraints in evolving higher yielding clones with desirable secondary characteristics such as disease and stress tolerance is the narrow genetic base of *Hevea*. The entire rubber plantation in the South-East Asian countries originated from a few seedlings, which were originally brought from Brazil through the Kew Gardens in the 19th century. Due to successive breeding and selection programme there has been significant erosion in the genetic base of the plant and therefore, the scope for developing new clones with better desirable characteristics has become limited. In order to overcome this problem, the International Rubber Research and Development Board (IRRDB), an association of the research institutes on NR functioning in different producing countries, conducted an expedition to the Amazon valley in 1981 and a large number of wild germplasm have been collected. India has received nearly 5000 from these collections. All these wild materials are being evaluated in various stages for different parameters. A wide variability in various genetic characteristics have been observed among these collections. Once the evaluation is completed these materials are used for breeding along with the existing cultivars. The germplasm collection is, therefore, a great asset for our future crop improvement programme (Fig. 2). Along with conventional evaluation programme, advanced molecular techniques have also been employed to characterize the wild germplasm. The genome analysis laboratory established in RRII could evolve techniques by which the characterization of these *Hevea* germplasm could be made in a more meaningful manner.



Germplasm garden – Wild accessions with different canopy architecture

Confronted with the long breeding / evaluation cycle for a perennial crop like *Hevea*, it has become essential to generate new clones through modern biotechnological interventions. RRII has been sparing no efforts in developing protocols for genetic transformation of *Hevea* using agronomically desirable genes. The work initiated in collaboration with the California University have started yielding results and the genetically transformed plants are already in the green house. These can later be planted in the field observing the various biosafety regulations of the Department of Biotechnology. Investigations on micropropagation systems also have yielded encouraging results. A system based on somatic embryogenesis with a high rate of multiplication has been developed and the plants have already been planted in the field. Using such techniques, it is possible to eliminate stock-scion incompatibility, which is a problem in budgrafted plants. Perhaps the non-uniformity existing in the budgrafted population of *Hevea* can be eliminated by using this new technique.

The Hevea Breeding Stations established by RRII in Karnataka and in Kanyakumari District of Tamil Nadu, have contributed well in the evaluation of various clones in different stages. A breeding orchard and a polyclonal seed garden also have been established in Kanyakumari District aimed at

evolving better planting materials for the future.

Crop management

Various crop management programmes implemented in the field are as important as the planting material. As the agroclimatic conditions prevailing in India are les favourable than those in other major producing countries, development of appropriate management techniques was found very essential to improve the growth and yield

Intercropping – Banana with rubber

performance of rubber. Therefore, research on various crop management techniques has been given maximum priority in RRII. Various cultural practices for rubber have been evolved through years of research and recommendations issued. As drought is a major constraint in India, moisture conservation programmes are very important. Introduction of cover crops, establishment of contour bunds, silt pits etc. have been found to be highly beneficial in ensuring faster growth of rubber trees. Moreover, irrigation, particularly during the summer months, is found to reduce the period of immaturity by 6 – 12 months. The beneficial effects of silt pits in conserving soil have been quantified and 250 pits per hectare have been found to be optimum, particularly in a sloppy area. Experiments on cropping systems have resulted in recommendations on cultivating various annual crops along with rubber. Apart from realising additional income to the growers, cultivation of crops such as banana is found to provide shade, which is beneficial for faster growth and biomass generation in rubber (Fig. 3). Harnessing modern tools such as remote sensing for the benefit of rubber cultivation has been attempted and studies on mapping of rubber leaf diseases from satellite imagery is in progress. Studies on the nutritional aspects of rubber have resulted in fertilizer recommendations suitable for different regions.

Considering the importance of balanced nutrition, RRII has evolved a discriminatory fertilizer recommendation (DFR) system, which has been made available to rubber growers on a nominal charge. The effect of following DFR has been studied in comparison with the general fertilizer recommendation. Based on a survey conducted in smallholdings it was observed that DFR could lead to increased yield of nearly200 kg/ha and a saving in fertilizer cost to the tune of Rs.400/ha. Facilities for offering the services to growers of different regions have been established, which include four mobile soil testing laboratories in the traditional region and one in the north east.

Disease control measures

Unlike in other rubber producing counties, rubber plantations in the traditional rubber growing region in India have been faced with a number of diseases. Many of these diseases are caused by the heavy rainfall during the monsoon period. Therefore, effective control measures are very essential to protect the trees and to ensure sustained yield. Successful efforts have been made by the Institute to evolve control measures for most of the diseases of rubber. Such control measures are being practised in a regular manner in the rubber plantations in India. This adds to the cost of rubber production, but the high productivity of rubber in India is contributed also by the effective control measures adopted by the growers in the country. Although abnormal leaf fall disease caused by *Phytophthora* is the major problem in India, another severe leaf disease caused by *Corynespora cassiicola* has also been observed in the recent past in the North Kerala and South Karnataka areas. For this disease also chemical control measures have been evolved and implemented in a fairly large area and the measures were found very effective and the

incidence of the disease has been brought down significantly (Fig. 4).

Tapping panel dryness (TPD), popularly known as brown bast, has been one of the problems affecting high yielding rubber clones. Although research on this problem has been in progress in many countries, a solution is yet to evolve. While management strategies based on low intensity tapping and tapping rest have been advised, recent studies undertaken by RRII have indicated association of viroids with this disorder. Further studies on this aspect are in progress jointly with the Indian Agricultural Research Institute (IARI), New Delhi.

As chemical control measures are likely to be more expensive and considered environmentally unfriendly, biocontrol measures are also being investigated. Moreover, as the ultimate answer to disease control is development of clones with high level of tolerance to various types of diseases, steps are being initiated to identify high yielding rubber clones having superior resistance to various types of diseases. Fundamental investigations at molecular level on susceptibility / tolerance to various diseases are also being undertaken, which will ultimately lead to development of disease tolerant varieties. Advanced studies in the area of entomology, microbiology and agrometeorology with respect to rubber plantations have also been in progress.

Physiology and biochemistry

Basic studies in plant physiology / biochemistry are necessary to support various crop management programmes and exploitation techniques and also in characterising clones for yield and other characteritics. Studies in the areas of production physiology, environmental stress physiology and basic aspects of ageing and senescence, stock-scion interaction, TPD etc. have yielded useful results. Various environmental issues related to rubber plantations including possibilities for getting monetary compensation for rubber plantations under the Kyoto Protocol, based on their carbon sequestration capacity are also being studied.

Studies on secondary metabolites in rubber latex is another promising area. Presence of significant amount of quebrachitol, a commercially important biomolecule, has been established in NR latex. Attempts are being made to isolate these materials from rubber latex in pure form. As these materials are having importance in many areas including the pharmaceutical industry, it may be possible to cause over production of such materials in latex through genetic transformation of *Hevea*. This will provide opportunities for using rubber tree as a source of new materials in addition to rubber leading to enhanced economic importance of the rubber tree.

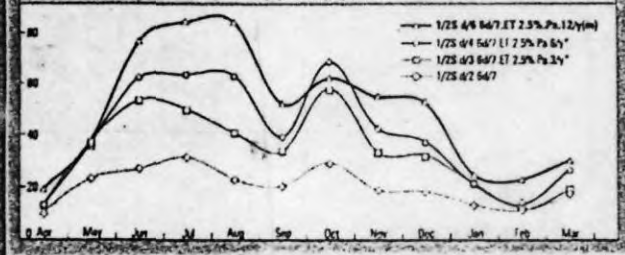
Harvesting techniques

One of the important elements in the cost of production of rubber is the cost of harvesting. Therefore, any attempt to reduce the cost of production has to invariably consider options to reduce the cost of tapping. New techniques of exploitation such as low frequency tapping have been experimented. It has been observed that tapping once in three days, four days and six days, with appropriate levels of chemical stimulation is found to reduce the cost of tapping significantly, while maintaining annual yield levels at the same level as that obtained

Annual dry rubber yield of RRII 105

System of tapping	No. of tappings	Yield (kg/ha/year)
1/2S d/3 6d/7.ET 2.5%.Pa.3/y*	102	2200
1/2S d/4 6d/7.ET 2.5%.Pa.6/y*	71	2172
1/2S d/6 6d/7.ET 2.5%.Pa.12/y(m)	50	2350

Mean monthly per tap yield of RRII 105



Tapping - Low frequency tapping reduces cost of harvesting

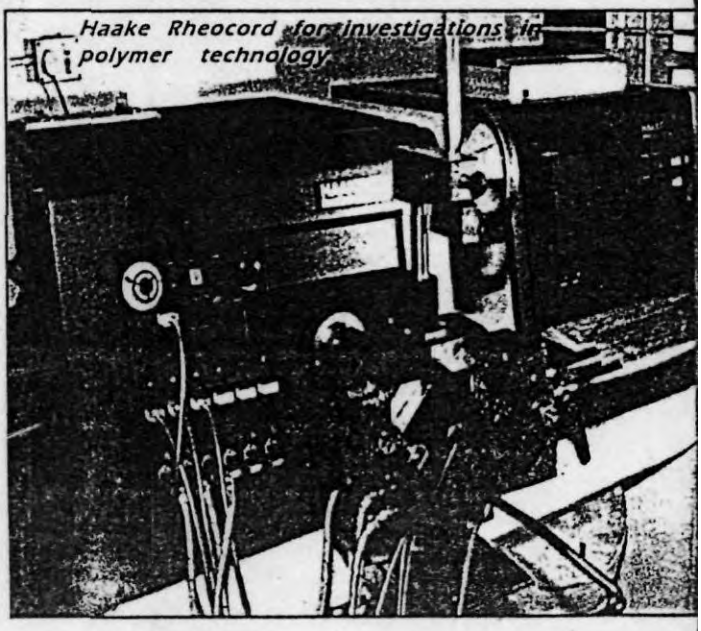
under alternate daily tapping (Fig. 5).

These systems have been recommended and widely accepted in large plantations. However, these cannot be implemented in the smallholdings mainly on account of problems associated with engagement of tappers. Appropriate labour management systems are to be evolved in order to extend low frequency tapping systems in smallholdings. Latex diagnosis using various chemical parameters is found to be a useful technique in optimising exploitation of rubber, particularly in designing clone-wise exploitation techniques and also in characterising new clones.

Processing and technology

In the present context of international competition quality of rubber produced in the country is equally important as its cost of production. Therefore, maximum priority is given for evolving technologies and systems for improving quality of rubber produced in the country and also in minimising cost of processing. Chemical modification of NR is another area of importance as it provides for an avenue for evolving new materials from NR, which could be used in areas where NR is not being used at present. Similarly, blending of NR with other polymers including synthetic rubbers is being focused to design appropriate blends for specific applications. Research efforts aimed at developing rubber products, both from latex and dry forms of rubber, have been given maximum priority aimed at providing technology support to the manufacturing industry. Development of products including quality improvement of existing products has been undertaken based on specific requirements of the rubber industry. Emerging areas such as nanocomposites based on NR are also being given due importance (Fig. 6).

In order to fine tune the research programmes in processing/ technology with the requirements of the rubber manufacturing industry, it is necessary to have frequent interactions between RRII and the industry. A forum for regular interaction has already been established between RRII and Automotive Tyre Manufacturers' Association (ATMA). The sub-groups formed under this programme have been meeting frequently to discuss the problems faced by the industry with respect to quality of different forms of processed rubber and also with respect to the human resource development requirements of the industry. Based on the suggestions from the forum, appropriate R&D programmes have been undertaken and results transferred to the processing sector. The work done in the field of epoxidation of NR has been extended to find new areas of application for the modified rubber, particularly in the areas of blends with other polymers and as a reinforcement modifier in silica filled rubber



Haake Rheocord for investigations in polymer technology

compounds. NR/HDPE/PP blends have been attempted in tyre tread compounds. Based on the encouraging results in the laboratory, field testing of the compounds is being attempted now. Preparation of low protein latex using enzymes such as Anilozym P-10, Papain or by g-radiation and evaluation of the latex in products such as gloves, have also been carried out. Attempts have also been made to identify allergenic latex proteins and to make allergen free latex products. Preliminary attempts have been successful in developing NR based nanocomposites having higher modulus and better barrier properties.

Agricultural economics

Commercial application of any research finding is possible only if the same is found to be economically viable. Therefore, research in the area of agricultural economics assumes importance, particularly in a globalised scenario. A number of research projects on the NR sector in the country have been completed. These include (1) Implications of WTO Agreement on the Indian rubber sector, (2) Dynamics of informal labour market in the context of structural changes, (3) Stock holding behaviour of rubber small growers in Kerala, (4) Timber yield potential of *Hevea* clones in India, (5) Commercial exploitation of honey from rubber plantations, (6) Global trade and tariff policy on rubber and rubber products under the WTO regime, (7) Trends in NR trade in India in the post-reforms phase, (8) Trends in the adoption of low frequency tapping system etc. The study on implications of WTO Agreement yielded a comprehensive assessment of the implications of the WTO Agreement on the Indian NR sector in the larger context of the evolutionary dynamics of GATT and consequent trade policy measures initiated by the Government of India since 1995. The structural and sectoral composition of world exports in rubber and rubber products and intra- NR producer trade in the three major forms of processed NR and six selected rubber products among the five major NR producing countries, *viz.*, Thailand, Indonesia, India, Malaysia and China and three major consuming countries, *viz.*, USA, China and European Union, has been analysed and appropriate conclusions evolved. The study on the adoption of low intensity tapping systems examined the aggregate level of adoption of low intensity tapping system in the estate sector in India. The study indicated that in spite of age profile and clone-wise differences in tapped area, there has been a growing convergence in the shift towards low intensity tapping during the last few years. It was also observed that the trends need to be corroborated with multidisciplinary studies at the disaggregate level so as to understand the underlying factors.

Research support for non-traditional regions

The RRII has been maintaining Regional Research Stations in various rubber producing regions where studies have been in progress to identify location specific agrotechnology for rubber cultivation. It was with this type of research support that India could extend rubber cultivation well beyond the traditional regions and maintaining the economic viability under adverse climatic conditions (Fig. 7).

The NR sector in the country has been immensely benefitted from the R&D programme undertaken by the RRII. The research programmes are being strengthened to support the growth of the sector further.

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