

RUBBER RESEARCH IN SRI LANKA

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INTRODUCTION

Research into the production and processing of rubber began in Sri Lanka in 1909, with the appointment of a chemist, by a group of planters in the Kalutara District, to study the process of coagulation of rubber latex and drying the coagulum. This led to the formal acceptance by the Government of the necessity for research on rubber manufactures in 1910, with a first meeting. The Rubber Research Scheme was started in 1913, the Ordinance for the Rubber Research Board was gazetted in 1930 and the Rubber Research Institute of Ceylon was so named in 1951.

This makes the Rubber Research Institute of Sri Lanka (RRISL) the oldest research centre for natural rubber in the world, having completed 70 years of service to the industry in 1980. Therefore, it is a good reference point from which to review the progress of the Institute and evaluate its contribution to the rubber industry.

In the past 70 years, natural rubber (NR) more than any other crop, has had its ups and downs, reaching its nadir, perhaps, in about 1972 when the price of a barrel of crude oil was \$ 3 and synthetic rubber (SR) was actively pushing out the natural product from the world markets. Then, with the support of vigorous research coupled with the energy crisis NR has come back to its own. The contribution of research to this revival can be gauged when one considers natural products such as indigo which could not survive the competition from synthetic dyes and is not heard of any more.

The work of the RRISL can be broadly divided into three sectors: biological research, chemical research and extension. Biological research involves the breeding of new rubber clones which are high yielding, disease and wind resistant and can grow in the varied soil and climatic conditions present in the different rubber growing districts in Sri Lanka. Biologists also study the optimum nursery requirements for rubber seedlings, the growth of plants in the field, bud-grafting methods, tapping systems, yield stimulants, fertilizer requirements of rubber plants at various stages of growth, disease control methods, soil conservation and the biochemistry of latex production. The Rubber Chemists' studies are directed towards the modification of the NR molecule in various ways, so as to increase the value of the product eg. by producing an oil resistant NR or one resistant to oxidative degradation. Therefore, basically, the RRISL, just like all other crop research institutes, is studying methods that will give a higher income from the land area planted

with rubber by increasing yield per acre and manufacturing a more valuable product. It is important to understand this concept that crop research is not an assay in scientific achievement but a mere matter of economics—how to increase the income per unit area under a certain crop.

The RRISL has six research departments viz Genetics and Plant Breeding, Plant Science, Intercropping, Plant Pathology, Soils & Plant Nutrition and Rubber Chemistry & Technology. The research findings from these departments are rapidly conveyed to the industry by the extension services of the Advisory Services Department. At present 70% of the rubber growing land in Sri Lanka is owned by smallholders. Therefore, as appropriate, the Institute lays heavy emphasis on keeping the smallholders abreast of research findings. Rubber Extension Officers are stationed in all villages where rubber growing is a major occupation of the rural population.

Some of the important research findings of each of the Departments will now be described, along with an analysis of the economic importance of the factors established by research.

GENETICS & PLANT BREEDING

Improved Clones. The development of high yielding, disease resistant Hevea clones in Sri Lanka, can be divided into three phases. The first phase comprised early selection and hybridizing of these selections from 1939 to 1945. The second phase, from 1955 to 1969, utilized selections from phase 1 as well as material introduced from other countries. The third phase commenced in 1970 and re-introduced selections from clonal sources in addition to the usual bi-parental artificial pollinations (Fernando, 1973).

The earliest selections consisted of propagations from high-yielding trees in different estates. At about the same time a system of artificial pollination for Hevea was developed and breeding programmes started. Earlier breeding and selection concentrated on yields but later other characters such as growth habit, latex properties, bark characters, disease and wind resistance were included.

This led to the development of the RRIC 100 series clones, with significantly increased vigour, yields, resistance to Oidium leaf disease and Phytophthora bark diseases. The latest clones released for small scale planting like RRIC 117, 121 and 130 are also resistant to South American Leaf Blight, and are the highest yielding clones so far bred anywhere in the world with this characteristic.

Yields. The old seedling rubber trees, planted up to about 1921, gave yields in the order of 350–400 lb per acre per year. The modern clones have a yield potential of 2500–3000 lb per acre per year. This yield increase of

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about seven fold compares well with the best achieved by the scientific breeding of any crop, and is a significant achievement in a tree crop which takes several years to mature.

PLANT SCIENCE

Nurseries. The optimum methods of producing stock plants for bud-grafting have been developed by the RRISL. It is recommended that rubber stock nurseries be planted in areas with a ready supply of water for providing irrigation facilities when necessary as long periods of drought adversely affect young plants. The site should be dug up to the depth of several feet, so as to remove obstructions to root growth, such a large stones and roots of other trees. This operation also helps produce an easily cultivable soil which facilitates the uprooting of budded stumps without excessive root damage, which is very important to ensure rapid field establishment. It is also important to thin out nurseries at regular intervals so that the stock plants ultimately selected for budgrafting are vigorous, as this leads to better establishment and growth of the plants.

Recent studies have shown that the seeds of Clone PB 86 are suitable for producing stocks. This is important as the selection was restricted to Tjir 1 selfed seed until the Institute established this in the late 1970s. Clone Tjir 1 is not recommended for planting now, and there is only a small area of land planted with it at present. Therefore, an alternate clone for seed production was essential for the industry.

Crown Budding. The conventional method of planting rubber in Sri Lanka is to plant bare-root budded stumps. However in order to avoid leaf diseases, a resistant crown of another clone can be crown budded on to a high yielding middle section of a leaf disease susceptible clone. This gives a 3-part tree; the stock, the high yielding though leaf disease susceptible middle section and the disease-resistant crown.

Crown budding experiments have shown that the growth of the trunk is significantly affected by the type of crown used. Therefore, it is necessary to use not only disease resistant, but vigorous crowns for optimum growth and yield of the mid-section. Budding experiments have also shown that high stumped buddings can grow and reach maturity faster than bare-root budded stumps. This can be exploited for bringing replanted areas into bearing in a much shorter time. However, the economics of the preparation and use of stumped buddings have not been fully analysed up to now.

Tapping Systems. The Institute has carried out a large number of field experiments to select the optimum tapping system for each recommended clone as there can be differences between clones, in regard to extraction of latex, due to their genetic yield characteristics. Generally, it has been found that

the alternate day, half spiral system (S/2 d/2 100%) is the best for all clones recommended for planting in Sri Lanka. However, intensive studies are being continued, as extraction of latex is the most costly item in the production of dry rubber, accounting for about 35% of the cost of production (COP). Recent studies have shown that puncture tapping with the use of the yield stimulant Ethrel has some advantages over conventional tapping. The present indications are that trees can be tapped at an earlier age, and yields from conventional tapping can be increased, when the trees are converted to the latter system from puncture tapping when they are young (Waidyanatha, 1981).

Significant increases in yield have also been achieved by tapping virgin bark above the conventional panel in trees approaching their normal useful span of life. Virgin bark at high level is tapped upwards on a 'V' cut with the conventional tapping knife attached to a long handle. The yield of virgin bark at a height of 6-8 ft. (180-240cm) has been found to be comparable to that from bark in the normal panel, and clearly it is important to exploit this vast area of untapped bark if we are to extract the maximum yields from rubber trees.

The normal life span of a rubber tree is about 33 years with about 26-27 years of tapping. The rubber tree coming into bearing in 6-7 years reaches peak yields in about the tenth year when the yield curve flattens out and remains so for several years before it starts dropping. The Institute has shown that yields can be propped up by intensifying tapping at this stage so as to keep yields steady. In the last 4-5 years of the life of the tree it can be "slaughter tapped" i.e. tapped on several conventional and high level cuts so that the tapping intensity is increased from the normal 100% gradually to 150% (2 years), 200% (1 year), and 400% (last year) during the last 4 years of the life of the tree. Yields can be maximised in this manner before the trees are uprooted and replanted (Chandrasekera, 1977).

Yield Stimulants. Over the years it has been found that the application of various chemicals like copper sulphate and 2, 4, 5-Trichlorophenoxyacetic acid on the scraped bark of the rubber tree can increase the yield of latex significantly. The latest yield stimulant for rubber trees is 2-4 Dichloro Ethyl Phosphonic acid, commercially marketed as Ethrel. This material when applied to the scraped bark of the rubber tree can increase yields by as much as 200%. The RRISL has been cautious with regard to the use of Ethrel, because of the physiological effects it can have on the tree on account of the high output of latex. We have been proved correct in our surmise in that other countries that used Ethrel at high concentration have found that yields rapidly dropped on its continued use, and ultimately went below those of control trees. However long-term experiments carried out by us have shown

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that with 2-3 applications of Ethrel at 5% concentration (compared to the usual 10%) during the drier months of the year, yield increases of 25-30% can be obtained without ill-effects from trees in good condition and tapped an renewed bark. Our experiments with the use of Ethrel on virgin bark are continuing, and we will be in a position to give our recommendations on its judicious use in the very near future.

Brown Bast. This is a disorder of the rubber tree which gradually dries out the tapping panel and eventually kills the tree. It has long been considered to be a physiological reaction of the tree to over-extraction of latex. All rubber clones are susceptible to this disorder, which is more common on high yielding clones. In general, anything up to 10% of trees being affected by Brown Bast in any area can be considered to be an acceptable level, but the incidence can be much higher in some clones, particularly those that are high yielding.

The problem of Brown Bast is being studied by a multidisciplinary team because of its ramifications into many disciplines. There are interesting indications that this may at least partly be caused by a nutritional imbalance similar to internal cork of apples. This line of investigation is being followed, as well as those on the possibilities of this disorder being caused by a virus or other sap transmissible disease, or that it is a purely physiological disorder caused entirely by the over-extraction of latex, the classical theory. Whatever the cause of the disorder, we have found that tapping Brown Bast affected trees gives yields high enough to warrant the exploitation of such trees.

INTERCROPPING

Selected Crops. Intercropping is a recent innovation by the RRISL. The rubber tree comes into production in 6-7 years after planting in the field and 70% of rubber growing land in Sri Lanka belongs to smallholders. Therefore, it is important to provide rubber growers with an alternative source of income to tide over the period during which they get no income from the rubber after replanting. The Institute's studies showed that there was sufficient light between rubber tree rows during the first 3-4 years of their growth to produce various cash crops, provided the latter were grown at a distance away from the rubber plants and both crops were adequately fertilized.

The four crops, bananas, passion fruit, pineapple and coffee are promising intercrops for rubber in the early years of the growth of the main crop. The income from these intercrops is so attractive that many estates and smallholders are planting large areas of some of them, particularly bananas. Passion fruit gives a very good return in the first year of growth. However, the Institute foresees a marketing problem when these crops are grown on a large scale and it is important for the local authorities in each area to ensure that a proper marketing system is developed for these products.

PLANT PATHOLOGY

There are three leaf diseases caused by the fungi *Oidium heveae*, *Colletotrichum gleosporioides* and *Phytophthora meadii*, a bark disease (*P. meadii*) and a root disease (*Rigidoporus lignosus*) which are of importance in rubber cultivation in Sri Lanka. The RRISL has developed economic methods of controlling all these diseases, and this has been a major contribution of the Institute to the economy of the industry.

Oidium Leaf Disease. This disease affects young leaves only. It was controlled by regular dusting with sulphur at weekly intervals soon after refoliation of the rubber trees after wintering each year. Generally, about 6-8 rounds of sulphur dust at 8 lb per acre per round were applied costing the industry about 1.5 ct per lb of rubber produced. The Institute carried out detailed studies on the biology of the causal fungus and defined the weather conditions under which it caused epidemics. It was then found that such weather conditions do not occur every year during the refoliating season so that routine control measures against the disease were not warranted under our conditions. Further studies showed that the new clones bred by the Institute were tolerant of the disease and did not require protection unless weather conditions were bad. Our present recommendations are that control measures be adopted only on susceptible clones and if cool, moist weather conditions are prevalent during the period of refoliation (Peries, 1963). Even so, four rounds of sulphur dusting at 6 lb per ac. per round are sufficient for adequate control, if the Superintendent studies the weather conditions carefully and applies the control measures according to our recommendation, which has resulted in the saving of about 1.25 ct per pound on COP.

Colletotrichum Leaf Disease. Here too infection is confined to young leaves so that the disease can occur just after refoliation or on new flushes of leaf throughout the year. Economic damage can be caused by this disease only if epidemics occur during the refoliation period or on young plants where the ratio between infected and mature leaves is high (Peries, 1981). Under such conditions which are rare, control of the disease can be effected by the application of copper based fungicides. This disease caused considerable concern to the industry until the Institute's studies elucidated its economic importance.

Phytophthora Leaf Disease. This disease affects only mature leaves where the site of infection is the leaf stalk. The fungus sporulates profusely on mature pods during the South West Monsoon season in cool wet weather periods, the spores being washed down from the pods on to the leaves below, causing infection and leaf fall. Critical studies of this Institute have shown that this disease can occur only during prolonged periods of cool rainy weather and that hot sunny days occurring during the SW Monsoon season act as

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a natural barrier to the spread of infection (Peries, 1965). It has also been established that the normal weather patterns prevalent in this country are not conducive to the occurrence of this disease in epidemic proportions.

This disease was controlled by dusting with copper fungicides at a cost of about 2.5 ct on COP before the Institute's studies showed that it was not necessary to control it under our conditions. On the basis of these findings the industry effected a considerable saving on control costs of this disease.

Bark Rot. This disease is also caused by the fungus *P. meadii* which causes Phytophthora leaf disease. It affects the bark around the tapping panel, the pathogen gaining entry through the tapping cut. The disease was controlled for many years by the extensive use of tar acid and organomercurial fungicides, costing the industry about 2 ct on COP. Studies carried out by the RRISL in the early 1960s showed that infection occurs mainly through spores washed down the tree from infected pods. Therefore, recommendations were made that the most important factor in controlling the disease was to ensure that wet trees are not tapped (Peries, 1953). At the same time it was shown that fungicides need not be applied on every tapping day right through the year as done previously, and their use can be restricted to the period when mature pods infected by the disease are present on the tree (Peries, 1967). These recommendations reduced control costs by about 1.5 ct on COP.

White Root Disease. This is the most virulent disease of *Hevea* in Sri Lanka at present. The control of White Root (*Rigidoporus*) disease at the lowest cost is the most important commitment of this Department. The planting public has still not recognised the importance of this disease in the economics of rubber production and the ravages it can cause in their plantations. Our studies have shown that the vacant patches caused by this disease can account for 8-15% of the total area of certain estates, and the increase in infection can be as high as 0.4-1.2% annually. When this is converted to hard cash, on the basis of production losses, the figures become astronomical (Liyanage, 1978). Therefore, obviously this is a problem that has to be tackled with military precision. Consequently, we have arranged to train "Root Disease Teams" for all estates.

The critical factor in the control of White Root disease is the removal of the food base, as we have clearly shown that new centres of infection in replanted areas always originate from infected debris left from the previous stand. Therefore effective control should start at the time of uprooting for replanting, when all infected material should be removed ensuring a disease free "seed bed" as far as practicable.

We have pioneered the studies on the biological control of *Rigidoporus* and have shown that soil amendment with sulphur significantly reduces the incidence of the disease. We have now found that soil amendment with urea

too gives good results. We are perfecting a method for the biological control of this disease and in this respect our observation that the roots of clone LCB 1320 are consistently resistant to *Rigidoporus* is significant (Liyanage, 1981). We are confident that with meticulous land clearing, suitable soil amendment, and a resistant root stock we can control this disease and maintain an optimum stand of rubber throughout its economic life span.

The other threat to rubber in South East Asia is South American Leaf Blight (SALB), a devastating leaf disease which has not yet been recorded in this hemisphere. However, we are breeding material resistant to this disease, and 26 clones bred by us were tested for resistance to it in Trinidad. Eight of the clones were found to be resistant, so that we now have high yielding disease resistant varieties (Fernando & Liyanage, 1980), which will be planted out on a small scale in all the rubber growing areas of Sri Lanka. We have bred the highest yielding SALB-resistant clones in the world to date.

SOILS & PLANT NUTRITION

General. The soils of the rubber growing areas have been grouped into six series on the basis of mineralogical studies (Silva, 1968). Suitable fertilizer mixtures have been recommended for each of the soil series. A further refinement in fertilizer usage is the recommendation of specific fertilizer mixtures for different fields in each estate on the basis of soil and foliar analyses thus ensuring that only the mineral nutrients required by the trees are provided to each area rather than applying blanket fertilizer mixtures to all areas of each estate on a general classification of soils in a certain rubber growing district. This has resulted in significant savings in the fertilizer bill, as in many cases certain fertilizer elements may be already available in the soil for optimum production. Phosphorus is a good example, as it is fixed in many soils.

Local Fertilizers. This department has taken a special interest in the use of indigenous or locally manufactured fertilizers for rubber. We have now found from experiments which have gone on for 8 years that urea is as effective as sulphate of ammonia as a nitrogen source in Boralu soils, that Eppawela apatite is as efficient as imported rock phosphate for immature rubber, and that dolomite, although sparingly soluble, can be effectively used for replantings. All three are local or locally manufactured materials, and based on our findings fertilizer recommendations for rubber have been revised to utilize the cheapest sources of fertilizer in our schedules.

Clones. Our most recent studies have shown that certain clones require higher amounts of some fertilizer elements e.g. potassium (PB 86) than the levels recommended earlier for Boralu soils. The nitrogen and potassium requirements of the RRIC 100 series clones appear to be higher than those of PB 86. There are also indications in general of higher yields with higher

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dosages of NPK in other clones. Yield increases of 5-27% over no fertilizer plots have been recorded overall, and in view of the high cost of fertilizers it has been decided to study the long term economics of fertilizer usage.

Soil Classification. We have now found that the rubber soils of Sri Lanka can be placed in three distinct groups of weathering stages: Oxic, Demi-oxic and Inceptic, based on the mineralogy of the sand fractions. The details of the scheme are given in the Departmental reports and the currently recognized soil series placed in the relevant groups (Yogarathnam, 1981).

RUBBER CHEMISTRY & TECHNOLOGY

General. The studies of this Department were expanded and diversified in 1969 with the recruitment of new staff and their rapid training at post graduate level. This has led to significant advances in the industrial uses of rubber in Sri Lanka. The achievements of this department in 1980 alone are described here.

Solar Drying. The high cost of fuels for drying rubber and other produce has made it imperative for us to look for other energy sources. A new system for using solar energy for drying crepe rubber was tested and we now have data on the area of the solar collector required and how to store solar energy for night heating. This is a significant breakthrough in energy conservation and we are carrying out further tests on estate factories to perfect the method.

Bleach. The new bleaching agent for crepe, RRI 7, developed by the Institute and commercially marketed as Nexobleach, has proved completely effective for the manufacture of the highest quality crepe. We have found that the initial problems with this material were due to contamination from their storage cans, and these have now been solved on the basis of our recommendations to the manufacturers.

Structure. A major area of research was on the structural modification of and the applications of NR in diverse uses. Two of the members of our staff worked on a UNIDO sponsored project in the UK in this connection to develop thermoplastic NR. Significant advances have been made in this field by our staff showing the importance of and the long term advantages of the reorientation of the work of the Institute undertaken by the Rubber Research Board in the early 1970s. The current developments achieved by us would have been impossible without such a reorientation of research interests.

Mixes. The use of latex-bitumen and latex-cement mixes as sealants for concrete roofs and for the construction of cheap irrigation channels and tanks has been successful. One large commercial firm is manufacturing large quantities of roof sealant according to our formula and has found it an extremely profitable commercial venture.

Paints. A large quantity of road-marking paint based on cyclised rubber was supplied to the Highways Department Research Unit for further testing. The competition for enamel paints based on alkyd resins made from rubber seed oil became more pronounced during the year. A research student is working full-time to improve the drying characteristics and clarity of rubber seed oil alkyd resins.

DPNR. Our studies on the manufacture and uses of deprotenised natural rubber (DPNR) has created international interest. We have found that rubber prepared from pineapple juice assisted biological coagulation will cyclise readily and completely with p-toluene sulphonic acid.

EXTENSION SERVICES

It is important to ensure that the results of research are rapidly disseminated amongst rubber growers and that innovations are adopted so that the industry gains from the investment in research. The RRISL achieves these objectives through its extension services. The whole rubber growing area of the country is divided into 4 Regions, which are in turn divided in 15 Divisions and 76 Ranges. The ranges are situated in the rubber growing villages, so that Rubber Extension Officers are stationed in those villages and visit rubber holdings on a regular basis to advise and assist growers on all aspects of rubber growing and manufacture, basing their advice on research findings.

This Department will be expanded with World Bank assistance to provide a much more personalized service to smallholders. Steps have been taken to recruit the staff and train them at the Institute, while a new training school and dormitory are under construction at Nivitigalakele Division. In addition to its present function, this Department will arrange to supply fertilizers to smallholders and have several mobile publicity units to carry the message on correct cultivation and manufacturing methods to the remote villages.

CONCLUSION

The RRISL by its research into all aspects of rubber growing has increased yields and reduced cost of production of rubber. The yield increases achieved in this crop, which are about seven fold compared to old seedling rubber, are equal to the best achieved in any crop anywhere in the world. This is all the more spectacular when the small genetic base on which this has been achieved is considered; as all South East Asian rubber clones at present have been bred from the progeny of some 75 plants brought to Sri Lanka in 1876 from seed collected by Sir Henry Wickham in Brazil.

The studies carried out by the Chemists and Technologists at the RRISL have helped increase the price of the raw rubber produced and diversified its uses.

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These innovations have helped the rubber industry to withstand the competition from SR even when the price of oil, the raw material for SR, was very cheap. Rubber represents one of the few natural products that has withstood competition from cheap synthetics, mainly because of the contribution of a virile research effort in all parts of the NR producing world. This shows the importance of research in the survival and progress of any industry.

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