Success and Trends in Tea Research

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The Tea Research Institute: *Raison d'Être*

The Tea Research Institute of Sri Lanka (TRI) has a distinguished record of achievement going back over the last 75 years, to its establishment in 1925. The efforts of its scientists in devising and adapting agricultural and technological practices, and the co-operation of growers and plantation management in carrying out TRI recommendations for preparing the land, nurturing the bushes and working the factories, have given a consistent increase in made tea production and exports over the years, and ensured at the same time that the name of the country would continue to be synonymous with tea of the best quality.

The TRI's raison d'être is to raise the productivity of tea smallholdings, estates and factories, to contain costs of production, to enhance the quality of the product and add more value to it, and in general to ensure the production potential of the Sri Lankan tea industry for posterity. To these ends, the TRI seeks to recommend appropriate technologies and forward-looking human and resource management practices. Apart from primary research aimed at tea-related issues, it also pursues the strategy of culling findings from up-stream, generic research (as in new fields such as biotechnology, and computer and information technology) and adapting them to tea.

Planning for Research and Development

As set out in the TRI's first-ever Corporate Plan, 1999-2003, research planning is done along trans-disciplinary lines, and in concordance with growers' needs and not only with scientists' perceptions. It takes into account both the goals of the growers (profitability) and national goals (growth, equity and the rational use of resources).

Arising from tea industry problems and our own experience of industry needs, we have formulated research objectives and applied research projects to fulfill these objectives, and made estimations of project success and their time-frames, benefits, costs and levels of priority. Concurrent with the applied projects are basic and supporting projects, designed to supply information and give an understanding of the principles governing the applied research.

Developmental Strategies for the Tea Industry

We believe that higher productivity and profitability of the Sri Lankan tea industry can only come from a combination of strategies for development. These are:

- Conservation of soil and restoration of soil fertility;
- Replanting and infilling with vegetatively propagated (VP) and seedling tea in order to get higher yields, resistance to drought, pests and diseases, and better made-tea quality;
- More profitable land use*;
- Making employment in the tea industry an attractive career option;
- Computerisation and automation of factories; and
- Foreseeing the changing requirements of the global marketplace.

The last mentioned, market research, is outside the TRI's mandate, but the others are being addressed by redoubled efforts in our biological and technological research, as well as in new sociological research. Aspects of these research efforts are outlined here.

Fertility and Organic Amendments

Heavy rainfall and sloping terrain in the Sri Lankan tea lands cause soil erosion, and some years ago the TRI introduced Sloping Agricultural Land Technology (SALT) for reducing it. Tea is planted, not down slopes, but along contour ridges between rows of nitrogen-fixing trees, whose loppings are used as mulch or incorporated into the soil for building up its organic matter content. Artificial fertiliser, imported at a high cost in foreign exchange, does not necessarily improve soil fertility since it quickly leaches out of soil which is characterised by or has sunk to low levels of organic content. Rather, fertiliser applied irrationally and in excess pollutes land, waterways and reservoirs and may cause eutrophication.

For attaining soil fertility, the TRI recommends, in addition to judicious mixtures of artificial fertilisers, biorational organic amendments and composting and, prior to replanting or infilling land with tea, the growing of rehabilitation grasses for a minimum period of one and a half to two years. Recycling of prunings, and addition of tea wastes and earthworm casts are also being recommended to maintain and improve soil fertility.

Organic interventions are more beneficial than artificial fertiliser because, besides being cheaper, they encourage the growth of organisms that make soil fertile, and foster natural biological control agents which serve to reduce the incidence of pests and diseases. As with artificial fertilisers, other expensive agro-chemicals, namely synthetic herbicides and pesticides, lead to a reduction in fertility by interfering with soil biological activity, in addition to polluting land and water, disrupting the natural food web, and constituting a health hazard to humans and animals.

Organic Tea

Sri Lanka pioneered the production of organically-grown tea (or 'bio-tea') in the 1980s. The TRI was involved and continues to be involved in these efforts. Progress has been modest and bio-tea comprises barely 0.1 per cent of national tea production. Owing to poorer yields, the production costs of bio-tea are relatively high, al-

though importers in health-conscious western countries pay premium prices for it.

The TRI is dedicating tea plots at its St Coombs estate for more research into organic production. With the growing global, consumer demand for organically produced food, the market for bio-tea is enlarging, and the TRI is in the process of researching and formulating recommendations for Sri Lankan producers who may be interested in bio-tea production. In any case, expanded research into organics is necessary for economic and environmental reasons.

The Need to Balance Seedling and VP Teas

Seedling teas (STs), now existing as 75- to 100-year old bushes in about 45 per cent of the Sri Lankan tea lands, exhibit a desirable bio-diversity, or genetic variability, as a result of natural hybridisation over the years. However, their yields are low (less than 1,000 kg made tea (mt)/ha/year) compared to that of the VP or clonal teas that the TRI began to produce in the 1950s (yield potentials: 2,500 kg at least at high elevations, and considerably more at low elevations). In order to increase yields, it has been national policy since 1958 to progressively replace STs by TRI series VPs and other VPs.

While yields have indeed increased over the years, concern has been expressed more recently about a gradual decline in the flavour and aroma of Ceylon teas, thought to be associated with the replacement of STs with VPs. In order to address this concern and maintain our made-tea quality, the TRI is now mooting the idea of using a mixture of VP and ST leaf in manufacture. This would entail having in estates and fields a healthy mix of VP and ST bushes, and not merely a small number of VPs chosen primarily for yield potential.

A further downside to the policy of replacement with VPs is the environmental risk to about 95 per cent of the country's VP teas which derive from a single, high-yielding Assamese seed stock, ASM 4/10. As a result, the TRI 2000 series and their hybrid progeny, the TRI 3000 and 4000 series, have a dangerously narrow genetic base. This puts nearly 55 per cent of Sri Lanka's tea fields at risk from unforeseen biotic and abiotic stresses, for instance those that might arise from climate change.

In view of this, our present tea improvement programmes centre on

- conserving good seedling stocks still available in old seedling fields, but now in danger of being lost as a result of uprooting prior to replanting with VPs;
- broadening the genetic base of future planting material by complementing conventional crop improvement with modern biotechnology; and
- developing a long-term policy on conservation and germplasm usage as a safeguard against genetic vulnerability.

"Golden Clones" and Biotechnology

For attaining a broadened genetic base, the TRI has begun selecting parents for breeding new VPs and seed cultivars of higher genetic variability, and for producing bi- and polyclonal seed stocks for commercial cultivation. To this end, we have embarked on identifying and preserving, at diverse locations in the tea country, STs destined for up-rooting but whose genotypes will improve the gene pool of our breeding stocks.

Our objectives over the next several years will be the development of all-purpose, elite or "golden clones" for the different agro-ecologies. These VPs will have a combination of about 8-10 desirable traits (high yields, made-tea quality, tolerance to drought, pests and diseases, and suitability for mechanised harvesting), and not just the four or five traits present in existing VPs.

The conventional field-plot protocols for VP development and release are slow and reiterative, and an improved VP takes about 15-20 years to produce. Together with new biotechnology for improving genotypes such as another culture and somatic hybridisation, rapid laboratory and greenhouse screening for desirable traits are being developed. Laboratory assessments include isozyme characterisation and DNA fingerprinting. Marker-assisted selection would allow an early evaluation of breeding lines and reduce the number of plants to be screened.

DNA markers are being used for molecular characterisation of VPs, the main objective being the detection of genetic diversity. (Molecular characterisation by DNA markers can also be used to tag tea cultivars for patenting purposes.)

Increased ploidy in plants, above the usual mono- and diploid levels, impart vigour and hardiness and, in tea, could also give higher productivity. The development of tea tri- and tetraploids are being pursued using hybridisation, tissue culture, the chemical agent colchicine, and mutagenesis. Mutagenesis and tissue culture have not been successful to any great extent elsewhere for tailoring the tea plant but, with improved facilities, attempts will be made to produce wide crosses, polyploidy, somatic mutations and cell culture lines for producing mutants.

None of these procedures will, however, entail the insertion of extraneous DNA, and the TRI does not intend to produce genetically modified (GM) or transgenic tea.

Sri Lankan Tea: "The Cleanest in the World"

The TRI success of 1936-1939 in controlling a serious insect pest, the tea tortrix moth Homona coffearia, with a braconid wasp Macrocentrus homonae, introduced from Java, that parasitises and destroys the tortrix caterpillars, is a famous, text-book example of classical biological control. However, the use of chlorinated hydrocarbons, in the 1950s and 1960s, to control other tea pests very nearly upset the delicate balance between the tortrix pest and the introduced wasp, as well as between other caterpillar pests and their indigenous natural enemies. This is now a well-

understood phenomenon. Elimination of a non-target organism, an introduced control agent or an indigenous natural enemy, by a pesticide allows the pest that was being kept in check by the control agent or natural enemy to get out of hand. These sorts of ecological dangers from synthetic pesticides were not widely realised at the time.

Following a tacit and welcome change of TRI policy in the 1960s regarding the control of all tea pests and diseases, the TRI has gone on to earn international recognition for its development of integrated pest management (IPM) systems. These employ minimal quantities of non-persistent and less hazardous pesticides, in combination with resistant VPs and cultural methods that may include agronomic operations timed to avoid or reduce pest damage. While the use of synthetic pesticides would still be necessary to keep pest outbreaks in check, IPM and minimisation of synthetic chemicals will continue to be the guiding principle at the TRI.

We now routinely screen exotic, and indigenous, candidate biological control agents, and natural pesticide preparations from plants like neem, in order to allow tea growers to stop relying on the usual synthetic pesticides which leave dangerous or unwelcome residues in made tea. Consumers and the international trade are becoming increasingly sensitive to additives and chemical residues, and the marketing of tea as a natural health beverage demands that it be free of chemical residues and added chemicals.

At the International Standards Organization (ISO) Technical Committee on Tea in February 1977, a pronouncement was made from the Chair that, on the basis of ongoing, routine analyses of made tea from all the major tea-producing countries, Sri Lankan tea was found to be "the cleanest in the world" as far as pesticide residues are concerned. This accolade was reiterated at the next ISO Conference in November 1999. The credit for this goes to the TRI and its de-emphasis of hazardous agro-chemicals, and to the Sri Lankan tea growers who adopt TRI recommendations.

Workers and Mechanisation

A shortage of field and factory workers is threatening the tea industry in the low country which produces almost 60 per cent of the nation's tea, and more recently in the up-country where resident communities have sustained our plantations for a century and a half. The labour force in the plantation sector overall is said to have reduced by about 25 per cent over the last decade, mostly owing to migration by a newly-educated younger generation to what is seen as better working conditions and a more fulfilling life away from the plantations. As a result, plucking, pruning, fertiliser and dolomite application, weeding, and other field operations, have often to be curtailed to the detriment of the plantation economy.

Plantation companies are now rightly concerned in improving the quality of life of their workers. In order to retain workers in the industry, it is necessary to foster in them a sense of professionalism and a pride in their work.

A total mechanisation of a highly labour-intensive agricultural production system is obviously impossible, but even a partial mechanisation of field operations would improve worker productivity and reduce drudgery, and this is what TRI research is aiming at.

The Gold Medal-Winning TRI Selective Tea Harvester

I give one example of partial mechanisation here: that of the plucking operation. The production of high-quality Sri Lankan tea by the so-called orthodox process requires that the green leaf supplied to factories be in the form of tender shoots comprising two or three leaves and the bud (the "flush"). This standard of shoots is attained by virtuoso Sri Lankan pluckers, the backbone of the industry, whose image is instantly recognised all over the world, wherever good Ceylon tea is enjoyed.

It is estimated that selective plucking by hand in Sri Lankan conditions requires, on average, 10-12 pluckers/ha/day. The daily intake (or "plucking norm") is 15-25 kg green leaf/day. The cost of hand plucking to the industry works out to about Rs 20 to 25 per kg of made tea, which is about 30 to 40 per cent of the total cost of production.

To maintain the current level of Sri Lankan made tea production (305.8 million kg in 2000), at least 1,200 million kg of green leaf needs to be harvested every year (about 300 working days), or four million kg every working day. Assuming an average plucker intake of 20 kg/day, the industry requires about 200,000 workers a day for the harvesting of leaf alone.

The TRI has developed and in 1998 patented, with a local fabricating company, a light-weight, all-terrain harvester which is selective in that it harvests only the flush, gives a 50 to 100 per cent increase in plucker output, reduces plucking costs, and maintains made-tea quality. A worker using the TSTH earns considerably more than a manual plucker. At the same time, estates stand to gain. Estates presently using the invention have recorded savings in plucking costs of more than Rs 2 per kg of made tea.

This TRI selective tea harvester (TSTH), when used in conjunction with an innovative plucking basket and leaf conveyance system developed in a joint project with a commercial estate and the TRI, allows the delivery of green leaf to the factory in pristine condition. If the TSTH is used widely and properly, together with these other innovations, the productivity of estate and smallholder tea lands, and our hallmark tea quality would be further enhanced.

At the 28th International Exhibition of Inventions held in Geneva, Switzerland, in April 2000, the TSTH won the first prize of a Gold Medal in the Agriculture, Agricultural Machinery and Gardening Section. In 1998 the TSTH had already been selected to

receive a Sri Lankan Presidential Award.

The TSTH does not require fuel and its environmental rating is therefore good.

Factory Modernisation and Processing Research

TRI research in factory technology and development is aimed at moving away from the image of the traditional tea factory, and to the organisation of the factory as a modern, cost-effective food factory. Specifically, it is for upgrading quality and hygienic standards, controlling costs, and adding value to the product.

Reducing the costs of manufacture is approached by more effective energy use and cheaper means of energy production, and by identifying and testing cheaper packing materials.

Wood for furnaces and air heaters is becoming increasingly scarce. As a result, more liquid fuel is being used. TRI research is concerned with environmentally-friendly, energy-efficient, renewable alternatives, such as solar energy, for drying tea. A solar field consisting of 200 flat plate collectors has been installed at the TRI's St Joachim factory for pre-heating the air entering the furnace-cum-heat exchanger. Only pre-heating is possible: large volumes of air cannot be heated to operational levels (about 95°C). Data collected over a preliminary period of three months indicate a saving of about 32 per cent on fuel used for drying.

Paper sacks, as a replacement for wooden tea chests, have been tested and recommended for packing leafy grade teas. Tea chest linings made of cheap kraft paper with aluminium have been recommended as a replacement for the more expensive tissue paper with aluminium.

Changes are being initiated in the placement of machinery according to ergonomic principles and for making the factory floor more worker friendly.

At a more fundamental level, it is also necessary to review the concept and design of factory machines, and the materials that are used in their fabrication, with a view to making them more effective and more manageable. Many of the difficulties in attaining the required made-tea quality standards, particularly from VP leaf, seem to lie in this area.

Future advances in process technology will be aimed at optimising manufacture by the introduction of electronic temperature, humidity & pressure sensors into the manufacturing sequence, under an automated PC-based monitoring, command & control system.

A bringing together of mechanical, chemical, electronic and computer engineers, and materials experts, is needed and this requires extensive inter-institutional collaborations between engineering firms, other research institutions and universities. Collaborations are being sought in this as in other areas of research.

New Tea-Based Products

The TRI has pioneered research into new tea-based, value-added products.

These include 'convenient' teas: instant tea, and ready-to-drink (RTD) tea, for which the TRI has obtained national patents, in 1975 and 1988, respectively.

The use of green leaf and fermented dhool has resulted in the manufacture of instant tea with a pronounced tea character. Cold water-soluble instant tea developed at the TRI could be used as a base to prepare RTD tea beverages for sale in cans and tetrapacks.

The tea concentrate for the RTD tea developed in the late 1980s contained 4 - 5 per cent soluble solids, but in the last few years we have raised this figure to 10 per cent. The concentrate's keeping qualities have also been improved.

Much interest has been shown by local and foreign commercial interests in our RTD tea, which they have found to be superior to, or comparable with, similar products already in the world market.

Teas scented with essential oils are popular in the Middle East and in some western countries. Technology for the scenting of teas has been perfected at the TRI.

Up- and low country teas were used as the starting material for a fermented tea product (a sherry or wine). Tea brews were fermented for five weeks, giving an alcohol content of about 10 per cent. In order to reduce bitterness and prevent an uncomfortable coating of polyphenols on the tongue, the fermented brews were matured in casks made of wood from the tree Berraya cordifolia. After about two months, a product with good clarity and colour resulted, and is now ready for commercial exploitation.

Another recent product is yoghurt into which tea has been incorporated in order to make use of tea's antioxidant properties for increasing shelf-life and enhancing the health benefits of the yoghurt, and to act as a natural colouring agent.

The incorporation of 1 - 2 g of tea per litre of milk during yoghurt production was found to be suitable for appearance, colour, texture and flavour, spoonability, the desired organoleptic properties and general acceptability.

Recent Sources of Information

Anon. 1999. The Tea Research Institute of Sri Lanka Corporate Plan, 1999 – 2003.

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* For example, see Intercropping in Tea Lands in this issue