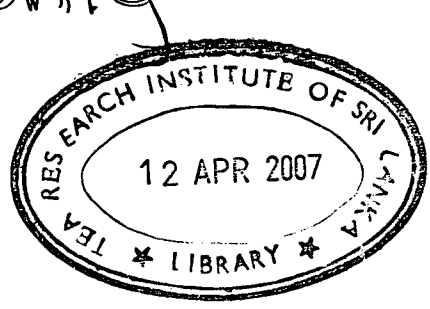
REVIEW OF THE

TEA RESEARCH INSTITUTE

OF SRI LANKA

December, 2006



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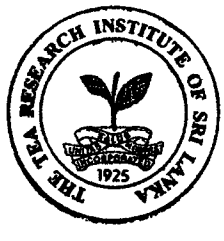

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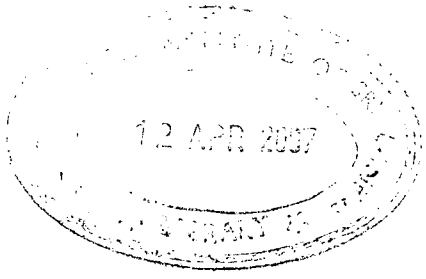

The Review Committee

Dr. Sarath Amarasiri (Chairman)

Prof. Daya Ahangama

Prof. Sirimali Fernando

Prof. Sumith Jayasekera

Mr. K M Opananda

Dr. Sarath Samaraweera

Mr. Dan Seevaratnam

Dr. Tilak Wettasinghe

Mr. Suranimala Wirasinghe

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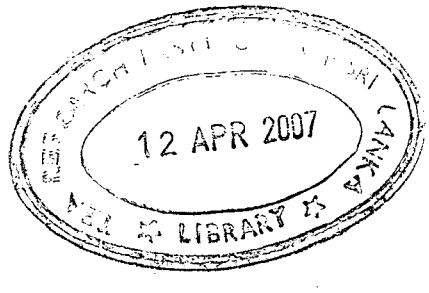
ACRONYMS

ADB	Asian Development Bank
AED	Advisory and Extension Division
AgECOND	Agricultural Economics Division
AgGDP	Agricultural Gross Domestic Product
BB	Blister Blight
AR	Annual Report
CADMAR	Composite Approach to Decision Making in Agricultural Research
CARP	Council for Agricultural Research Policy
CEO	Chief Executive Officer
CIS	Commonwealth of Independent States
COP	Cost of Production
CP	Corporate Plan
CRI	Coconut Research Institute
CTC	Crush, Tear and Curl
CTTA	Council of Tea Traders' Association
CWSI	Cold Water Soluble Instant
DNA	Deoxyribonucleic Acid
DZ	Dry Zone
E & E	Experiments & Extension Forum
ERP	Eppawela Rock Phosphate
EU	European Union
FBD	Fluidized Bed Dryer
GMP	Good Management Practices
HTKW	Hard-to-Kill-Weeds
HOD	Head of Division
HWSI	Hot Water Soluble Instant
IPGRI	International Plant Genetic Resources Institute
ISO	International Standards Organization
LC	Low Country
LCLWT	Low Country Live-Wood Termite
LTC	Liquid Tea Concentrate
MOU	Memorandum of Understanding
MRL	Maximum Residue Level
NSA	Net Sale Average
OST	Old Seedling Tea
PAH	Poly Aromatic Hydrocarbon
PM	Planting Material

RA	Research Assistant
R&D	Research and Development
RPC	Regional Plantation Company
RSC	Regional Scientific Committee
RTD	Ready To Drink
SHB	Shot Hole Borer
SLS	Sri Lanka Standards
SLTB	Sri Lanka Tea Board
SPND	Soils and Plant Nutrition Division
SR	Soil Rehabilitation
TRB	Tea Research Board
TRI	Tea Research Institute
TSHDA	Tea Smallholdings Development Authority
RCBD	Randomised Complete Block Design
SW	South West
TOE	Tons Oil Equivalent
TOT	Training of Trainers
TSTH	TRI Selective Tea Harvester
UAE	United Arab Emirates
UC	Up Country
UCLWT	Up Country Live-Wood Termite
VP	Vegetatively Propagated
VSD	Variable Speed Drives
VAM	Vesicular Arbuscular Mycorrhizae
WZ	Wet Zone



EXECUTIVE SUMMARY

This review of the TRI is carried out by a committee appointed by the Tea Research Board and consisting of Dr. Sarath Amarasiri (Chairman), Prof. Daya Ahangama, Prof. Sirimali Fernando, Prof. Sumith Jayasekera, Mr. K M Opananda, Dr. Sarath Samaraweera, Mr. Dan Seevaratnam, Dr. Tilak Wettasinghe and Mr. Suranimala Wirasinghe. The Terms of Reference (TOR) of the review include: review of the performance of TRI with respect to the Corporate Plan (1999-2007), the recommendations made to stakeholders, their adoption and impact, the Institute's effectiveness in technology transfer, the effectiveness of the inter-disciplinary approach in execution of research projects and the Institute's capacity to meet the challenges of the future. The full text of the TOR is given in Annexure 1. This is the second review of TRI, the first having been carried out in 1993.

THE ORGANIZATION AND CHALLENGES

1. The Organisation

The Tea Research Board (TRB) was established by the Act No. 52 of 1993, which was later amended by Act No. 30 of 2003. The main functions of the TRB according to these Acts are, "to conduct, assist and encourage scientific and technological research into, and investigations of, all problems and matters affecting the production and manufacture of tea". Furthermore, the TRB is mandated to undertake the collection and dissemination of data in the tea industry and promote investment in tea research.

The Tea Research Institute (TRI) has a much longer history, having been established by the Tea Research Ordinance on 8th October 1925 and managed by the Planters' Association until 1957, when it became a State funded organization.

The TRI is headed by a Director/CEO who is assisted by three Deputy Directors in charge of administration, research (production) and research (technology). The headquarters of the Institute is located at Talawakelle where the main laboratory, estate and factory are situated. The Institute has ten technical divisions. Other TRI establishments are the following: the Low Country Station, Ratnapura, the Mid Country Station, Hantane, and the Advisory and Extension Centres at Deniyaya, Kottawa and Passara.

The TRI has a library that procures 36 well-known international journals, purchases books regularly from leading international publishers, receives publications from other tea growing countries and maintains linkages with all other agricultural libraries in Sri Lanka. The annual budget of the library is nearly Rs. 5 million.

The laboratories of the Institute are very well equipped due to the policies and practices followed by TRI over the years of providing the best possible environment for high quality research. Overall, the laboratories at Talawakelle are probably the best among the national agricultural research institutes.

2. The Funding

The TRI receives its funds from a cess collected at the point of export of tea. The cess which was Rs. 2.50 per kg until mid 2006, has since been increased to Rs. 4 per kg. Other organizations which receive funds from the cess are the Tea Small Holdings Development Authority (TSHDA) and the Sri Lanka Tea Board. The total allocation for the Institute in 2005 was about Rs. 194 million. Delays in obtaining the money however, are rather common

3. Human resources

The most precious asset of the Institute is its scientists, many of who are well trained, highly competent, very knowledgeable and articulate. They have the potential to become internationally recognized experts in their specialties and make the TRI a world leader in technology development in the cultivation and manufacture of tea and its diverse products. However, a strong team effort is absolutely essential to reach such heights that require scientists to work in harmony with colleagues in other disciplines. The researchers should also be more conscious of their responsibilities to the stakeholders.

The Institute has a culture of recognising outstanding contributions by officers. Accordingly, the Director has issued 45 letters of commendation to officers since 1998. These commendations are mainly for contributions made outside their normal duties. For example, they include assisting in arrangements with regard to visits of dignitaries, or in organizing exhibitions and other events attended by the public. Commendations to officers achieving high standards of excellence in their normal duties have been rare.

Unfortunately, many officers are frustrated and disgruntled. The main reasons for discontent are working in locations for long periods with poor educational facilities for the children, inadequate health services, separation from family, low emoluments, lack of promotional prospects, limited opportunities for Human Resources Development and lack of appreciation/recognition by the management as revealed by the Organizational Climate Survey conducted by the Peer Review Committee.

The Director, Deputy Directors and many Heads of Divisions do not appear to have sufficient time to meet their subordinates at their work places, one reason being the frequent travel to Colombo to attend a large number of meetings. In fact visits of some of these officers to the Regional Centres have been extremely rare.

4. The Corporate Plan

A major institutional innovation at TRI has been the development of a Corporate Plan for the period 1999-2003, and its revision up to 2007. The Plan groups the research activities into applied, basic, support and service components. The applied research programme which is mostly interdisciplinary is composed of Thrusts and Projects. The projects have a time frame and are costed, a practice followed by TRI for many years.

The Corporate Plan had been prepared through a consultative process with the participation of representatives of stakeholders that included corporate and smallholder sector tea growers, buyers, brokers, scientists, extensionists and many others.

Although a noteworthy factor in the Plan was the introduction of the interdisciplinary approach to research in a formal manner, the implementation of the new approach can hardly be considered successful. Meetings between Thrust leaders and project leaders have been scarce. Coordination between scientists across divisions has not come naturally. The progress of the entire research programme has not been systematically monitored and evaluated during the last few years. A formal seminar programme at regular intervals is not in place.

The shortage of staff has led to the abandoning of many important research projects and lowered the performance of others. It is likely that the availability of staff in each division was not carefully looked at when 197 projects were included in the Corporate Plan. Some divisions though, seem to have more than the required staff at present.

5. The Challenges

The future challenges for the TRI include: taking the industry forward in the midst of worker shortages and rising energy costs, developing varieties with the potential for higher yield and quality, reducing use of synthetic pesticides to a minimum, maintaining soil health, improving fertilizer use efficiency, increasing the economic life span of replanted tea, developing the scientific base to help promote tea as a safe and healthy beverage that will increase its consumption world wide and to remain in the forefront in all aspects of research and technology development.

TECHNOLOGY DEVELOPMENT

1. Varietal improvement

The origin of most of the TRI cultivars has been traced to a single parent known as Assam 4/10. Of the 62 recommended TRI cultivars 57 are related to this parent. Developing and cultivating cultivars with a common origin could predispose plantations to genetic vulnerability. Therefore, stepping up the acquisition of diverse germless from within or outside the country is important.

DNA markers have been used to a limited extent in the characterisation of tea germless. Molecular Biology is expected to play a very important role in speeding up varietals development.

Presently varietals recommendations consider four broad regional categories: up, mid, low country and Uva. There is a necessity for more specific recommendations to cover variations in ecological, edaphological and other factors affecting growth.

Inadequate collaboration from other divisions in screening lines for resistance to biological and physiological stresses is hampering the progress of the breeding programme.

2. Fertilizer responses

A large number of field experiments on fertilizer use have been conducted in lands belonging to TRI, Corporate Sector and smallholders. A majority of trials has not given a response to the addition of N. The lack of response to added N fertilizer while reaching a yield level as high as 5000 kg/ha at Lumbini Estate, Deniyaya, and 6000 kg/ha at Talgaswela Estate, Galle (AR 2000), where the lowest treatment level was 240 kg N/ha, is difficult to comprehend when the TRI recommendation for a yield of 3500 kg tea is 400 kg N/ha/yr. Such unusual behaviour calls for careful study and thought.

In the case of P and K, none of the experiments conducted recently have shown an increase of yield to addition of these two nutrients. This raises the question whether there is a significant build up of P and K levels in tea lands from the addition of rock phosphate and muriate of potash for over 70 years. The time for large-scale adoption of site-specific fertilizer application is at hand. A large number of projects listed in the Corporate Plan with respect to the Soils and Plant Nutrition Division has been abandoned due to staff shortages.

3. Intercropping

A number of tea-rubber intercropping experiments have been conducted in the low country in collaboration with the RRI since 1989. In intercropped rubber planted at a spacing of 8' x 40', the tea yield per bush is halved by the 3rd cycle. By the 12th year, tea yields decline to very low levels. It appears the tea will fade out well before the rubber. The rubber that remains would be at a less-than-optimum stand (about 65% of the monocrop stand) and therefore very likely to be uneconomic. Intercropping tea and coconut is a far more feasible economic proposition than rubber, but there is only one experiment testing this combination. Investigations on intercropping tea with coffee, pepper and vanilla have made very poor progress. The potential of densely planted short rotation coppicing trees, as intercrops to produce fuel wood, should be explored.

4. Effect of shade

Field experiments under artificial shade have suggested that shade would increase productivity. A survey of many estates and smallholdings and an extensive literature survey, which commenced five years ago, have identified 84 species with desirable characteristics for shade trees. The next step of testing their suitability for different regions is at a standstill due to staff limitations. Formal field research to determine the optimum density, spacing and spatial arrangement of a mix of different species, of different stature (tall and medium), and their management is a daunting task that will take decades for completion. Clearly, a more practical, rough and ready approach is required to address this question.

5. Soil rehabilitation

Alternative techniques for speedy soil rehabilitation are being tested in the high, mid and low elevations. In most trials, the alternative systems tested did not match the traditional soil rehabilitation (under grass for two years) in terms of establishment, growth and yield of tea. However, the reasons for this superior performance in rehabilitated soil are not clear. Although this Thrust aimed to develop 'economically viable' alternatives this aspect has been neglected. *In situ* soil rehabilitation with grass, before uprooting the old tea, merits further

investigation. So would soil rehabilitation, over an extended period (4-8 years), under dendro energy crops.

6. Soil Health

A healthy soil has desirable physical, chemical and biological properties that enable realization of high levels of crop productivity. Soil health is improved and maintained by good husbandry. Soil rehabilitation is but one of the ways of keeping a soil healthy.

7. Water management in drought prone areas

It is clear that irrigation to mitigate drought problems is not generally feasible. Apart from a few exceptions with perennial streams, estates cannot find a source of water during the drought. Consequently, the focus of the research has shifted from drought mitigation to fertigation, as a general practice. There was a high yield response to fertigation, especially with the drought susceptible cultivars, and also an indication of increased fertilizer use efficiency.

8. Use of herbicides

Many herbicides and mixtures of herbicides have been screened for general use in weed management as well as for the management of hard-to-kill weeds. Preliminary information on optimal rates and frequencies of application is available. However, the control of a few weeds by chemicals has been difficult. Owing to possible environmental hazards and concerns on herbicide residues in made tea, mechanical, cultural and biological techniques are also being explored. There is considerable progress in these approaches.

9. Mechanical devices

Harvesting is the most labour intensive and costly operation in tea cultivation. The very disappointing performance of motorized plucking machines, in terms of both leaf quality and yield, prompted the development of the TRI Selective Tea Harvester (TSTH). The TSTH which has won several national and international awards is a light, manoeuvrable device that can achieve a level of selectivity comparable to plucking by hand whilst increasing the intake per plucker considerably. A new lightweight hand-held pruning machine, developed by TRI, has an output of 750 bushes per worker per day. It is claimed that this machine can effect a labour saving of around 65% and reduce costs by about 35%. TRI has also developed a lightweight plucking basket and a Deep Fertilizer Applicator.

10. Adoption rates of mechanical devices

The adoption of the TSTH and the plucking basket is surprisingly poor. They are not being used in the TRI estates either. The reasons for poor adoption have not been fully understood.

11. Plant Protection

High yielding lines selected by the Division of Plant Breeding are screened for resistance to Shot Hole Borer (SHB), Live-Wood Termites (LWT), Nematodes, Blister Blight, root diseases and Stem canker. Although a considerable number of trials have been carried out, resistant cultivars were identified and recommended only for SHB, LWT and Blister Blight. Seven projects have been conducted with a view to developing cost effective methods for integrated management of SHB. These projects have not generated any new practical findings to improve the

management strategies for SHB. Studies on biological control of root diseases, and nematode management by addition of organic material and use of solarisation as an alternative to methyl bromide show satisfactory progress. Research on the management of seasonal pests like Tea Tortrix and mites is inadequate.

12. Product diversification
Tea sherries and tea wines prepared at TRI have been well received by consumers at local and foreign trade fairs. The products however, remain to be commercialized.

13. Tea and Health
Researchers have found that tea components could be used to treat mild inflammation of the oral cavity caused by *Candida* species. Tea extract can inhibit the growth of *Streptococcus* bacterium.

14. Pesticide residue analysis
Multi-residue analytical procedures have been developed to save costs and time in pesticide residue analysis.

15. Saving electricity
The cost of electricity for withering in tea manufacture is about Rs. 1.0 billion annually. Variable Speed Drives (VSDs) can reduce the speed of fans during the latter hours of withering and has the potential to save Rs. 400 million to the industry annually. Although the TRI has no facilities or competence for the design of VSDs, it can make a significant contribution here by testing the performance of the various makes of VSDs in the market and making recommendations to the factories. Only a small number of factories, not exceeding 20%, has converted the conventional trough fans to VSD controlled trough fans in spite of this important finding and the inherent economies. The Institute does not seem to have used its influence with policy makers towards saving energy and in reducing cost of processing through this initiative.

Several makes of high efficiency withering fans have come to the market and these are being tested by TRI.

16. Energy auditing
TRI lacks competence and facilities in the field of energy auditing. Officers of the Technology Division with some training and confidence building can provide an energy audit service to the industry that will be highly appreciated.

17. Packaging Standards
TRI has over the years tested several makes of sacks for bulk packaging of tea. This may have contributed towards introducing new suppliers and makes of sacks and thereby increased the competition and reduced the costs. However, as the Institute has not followed a formal testing procedure, it may have inadvertently contributed towards reducing the overall standards of packaging, which the industry can ill afford.

18. Advisory and Extension

The Advisory and Extension Division (AED) provides a number of services operating from Talawakelle, Ratnapura, Hantane, Passara, Deniyaya and Kottawa. Their activities include seminars, field days, demonstrations and training. Adaptive trials programme of the AED covered nursery practices, fertilizer use, pruning and plucking, but only the project on fertilizer use has been completed. The poor performance here is due to staff shortages. The AED has not been able to convince the tea growers of the advantages of the new fertilizer recommendation. The progress on the preparation of wall charts is poor. Only very few copies of the Ready-reckoner have been circulated to the stakeholders, although this activity began in 1999. The TRI web site is not updated regularly. Email/Internet facilities are not available at Hantane and Kottawa. The AV Saloon and the Reading Room projects have been abandoned due to lack of staff and lack of a suitable location.

Progress on the supply of planting material to smallholders is poor. The supply cannot meet the demand. Certification of VP plants has not been carried out. The project on evaluation of agricultural performance of tea plantations has been abandoned due to lack of staff.

19. Forums and Seminars

The E & E Forums and the RSC seminars have found much favour with the stakeholders. However, the presentations by TRI scientists are sometimes reported to be too advanced technically for some members of the audience.

20. Agricultural Economics

The activities of the Agricultural Economics Division (AgECOND) have been seriously disrupted owing to staff shortages. Notwithstanding this limitation, several publications on matters of importance to stakeholders have been released. The comprehensive publication titled "Cost of tea cultivation from nursery to the field" released in 2002 stands out for its relevance and usefulness to the stakeholders. The AgECOND needs to be strengthened immediately for it to effectively carry out an expanded research agenda that is dictated by the changing needs of the industry.

21. International Scientific Forum

Although a large number of scientists are engaged in tea research and development activities in more than a dozen countries, there is hardly any known formal mechanism for developing linkages between them. Formation of a scientific forum of the tea scientists of these countries will bring the scientists together, enable them to share their knowledge and experience, develop fellowship, and help attain high levels of professionalism which can ultimately lead to the promotion of tea as a natural, safe, healthy and inexpensive beverage worldwide.

RECOMMENDATIONS

GOVERNANCE

1. An enabling environment
The Tea Research Board should provide an enabling environment to the TRI to conduct research on all problems and matters affecting the production of tea, and to disseminate such findings to the stakeholders in accordance with the Tea Research Board Act No. 52 of 1993 and Act No. 30 of 2003. The Board, in particular, should ensure that the Institute receives adequate funds to execute its planned activities. Funding should increase from the present level of about 0.4-0.5% of the value of the commodity to 1%, which is the general recommendation for investment in agricultural research, and nearly the level of investment by the Government of India.

2. Shortage of staff
Attempts should be made to solve the problem of shortage of staff in some divisions by re-deployment from those that have an excess. Careful attention must be paid to staff requirements and availability when the next Corporate Plan is prepared.

3. Developing human resources
Very high priority should be accorded to the development of human resources. The principle that the skill requirements of all categories are changing and that every officer requires training throughout the career must be accepted. TRI should establish an In-Service Training Centre with residential facilities, audio-visual and other equipment and qualified staff. Some of the facilities currently available at the Low Country Station at Ratnapura could be utilized for this purpose.

4. Appointments on a fixed term
Consideration should be given to the appointment of the Director, Deputy Directors and Heads of Divisions on a fixed term basis not to exceed three years, with provision for re-appointment. Before introducing such a system however, the TRB should seek the views of the Institute staff, review past experience with fixed term/contractual appointments to the directorate, and also study how the fixed term system operates in other institutions such as the universities where the Vice Chancellor, Deans and Heads of Departments are appointed for a specific time period.

5. Strengthening the Agricultural Economics Division
The Agricultural Economics Division should be strengthened to undertake studies identified by stakeholders including market analysis, policy analysis and tea information.

6. Strengthening the Advisory and Extension Division
The Advisory and Extension Division should be significantly strengthened in order to ensure better transfer of technologies developed by the scientists.

7. **Strengthening the Agricultural Mechanization programme**
TRI should focus on mechanization of agricultural operations as a mainstream research activity. The small team in the Agronomy Division that has already made a signal contribution in this regard should be strengthened, with persons with a track record of innovating in the field of mechanical engineering and encouraged to innovate, develop, test and introduce tools and equipment that are even more advanced.

8. Establishing an International Scientific Forum

The Tea Research Board should initiate action to establish a Scientific Forum for tea scientists of the tea growing countries that will bring multiple benefits to the industry.

RESEARCH MANAGEMENT

1. Making plans
Action must be initiated to prepare the Corporate Plan for the period 2008-2012, employing the lessons learnt from the preparation and implementation of the previous plan. The Plan must be in conformity with the challenges of the industry, the goals of the Institute and the availability of financial, human and other required resources.

2. Preparing research proposals
The research project proposals must be prepared with meticulous care, spelling out their relevance and importance, the chances of success, the costs associated with their execution and the anticipated benefits to stakeholders. A standard format should be prepared for a project proposal, obtaining assistance from CARP if needed. The proposals should be subject to internal and external reviews as appropriate.

3. Monitoring and evaluation
Monitoring and evaluation of the research and extension programme at the Institute level should be considerably strengthened. For this purpose, a well structured quarterly meeting should be held chaired by the Director. A research project monitoring unit must be set up in the office of the Deputy Director. Monitoring and evaluation at the Thrust and Project levels should also be strengthened, formalized and be more frequent.

4. Interdisciplinary research
The shortcomings of the operational aspects of the interdisciplinary research programmes should be reviewed immediately by an in-house committee consisting of the Director, Deputy Directors, Heads of Divisions and representatives of each Division, and workable procedures to carry out such programmes effectively in the future should be agreed upon.

5. Annual Work Plan
An Annual Work Plan must be developed for each research project that clearly indicates what is to be done, when and by whom.

6. Seminar programme
A formal seminar programme should be initiated at headquarters on a monthly basis with a mix of TRI and leading scientists from other research institutions as presenters.

7. Publishing research findings
Increased efforts should be made to publish the research findings in refereed journals from the wealth of information that is available from completed research projects.

TECHNOLOGY DEVELOPMENT

1. Varietal development

Germplasm collection available at TRI should be expanded, preferably through the introduction of accessions from foreign countries, especially in the light of low genetic variability of the local material.

Molecular biology techniques must be further developed and used in strengthening the varietal screening development programme.

Agroecological conditions other than elevation should also be considered in varietal development.

Screening for tea quality should be done at an early stage of the screening process to avoid the elimination of high quality lines.

2. Addition of fertilizers

The absence of response to N in a large number of fertilizer trials conducted in estates should be studied in depth.

Advisory Circulars on chemical fertilizer recommendation presently deal with inorganics only. They should be amended to make provision for reducing levels of inorganic fertilizer when organics such as green manure containing significant quantities of N, K or other nutrients are added.

Site-specific fertilizer recommendations and their adoption must be pursued with vigour since P and K fertilizer additions can be significantly reduced by use of soil test results in many tea growing lands. Soil analytical services must be strengthened. Establishing a soil testing mobile service operating from the headquarters and substations should be considered.

3. Intercropping

Economic analysis of the available data on tea-rubber studies should be carried out. The data from the ongoing experiments should be used for computer modelling.

The preliminary results obtained from the ongoing tea-coconut field experiment should be used to design and establish at least two more experiments owing to the high potential of this combination.

The advice and collaboration of the Department of Export Agriculture should be sought in conducting investigations with coffee, pepper and vanilla.

Investigate the feasibility of intercropping tea with dendro energy cum green manure crops such as Gliricidia and Calliandra planted at a high density.

4. Shade trees

Shift the focus of research on shade from up country to low and mid country where shade is likely to have a greater impact.

Taking into consideration the vast store of practical experience and research findings on shade trees and their effects, as well as the projected changes in climate, develop a few

shade models to be promoted in the different regions. This should be a desk exercise undertaken by an interdisciplinary group. The models should consist of high and medium shade species, their spacing and spatial arrangements and management practices.

5. Soil rehabilitation
Economic analyses of the data from the soil rehabilitation trials under the Corporate Plan should be carried out.

Results of the many experiments conducted over the last thirty years should be studied and reviewed with the participation of scientists from relevant disciplines, before embarking on further research.

6. Managing weeds
The continuing education of growers on the dangers of using herbicides in an improper or careless manner should be strengthened in the light of the concerns expressed by Japan and the EU on the presence of herbicide residues in black tea exported to these countries.

Advisory Circulars on the management of weeds in young tea, and guidelines on developing basic year-round weed management programmes in mature tea should be issued.

7. Fertigation
Fertigation as a general practice, for both young and mature tea, during periods when water is available, merits further investigation. More cost-effective drip systems should also be explored

8. Mechanical devices in agricultural operations
The TRI Selective Tea Harvester (TSTH) and the light plucking basket are important advances, and should be promoted vigorously. TSTH is the best option currently available for mechanical harvesting. TRI must give the lead by using it in its estates. Advisory Circulars on their use should be issued. In the meantime, reasons for their low adoption rates must be found. A win-win situation has to be created to overcome the reluctance of workers to use the TSTH and the light weight plucking baskets.

Arrangements should be made to manufacture, promote and market the hand pruner.

A comparative study on the Deep Fertilizer Applicator and the conventional method of fertilizer application in terms of quantum, frequency and labour requirement, and growth of the tea plants should be expedited.

Efforts must be made to popularize these innovations that have the potential to effect a sizeable saving in the worker requirement, reduce the COP and increase the NSA.

9. Pest management
Advice growers to monitor pest populations to decide whether chemical insecticide application is essential.

Strengthen research on mass rearing and release of predators, parasites and pathogenic microbes to limit the dependence on chemical pesticides.

The validity of the methodologies used in screening pesticides should be thoroughly examined.

Enhance the safety measures presently adopted to protect personnel working in pesticide laboratories.

10. Ready to drink teas, tea beverages and other products

The lack of interest shown by entrepreneurs to produce and market the TRI developed RTDs, tea yoghurts, tea wines and other such products should be examined and the reasons ascertained. A mechanism to identify new products should be in place. Likewise, a potential collaborator should be identified, after calling for expressions of interest, before starting work on developing a product. This must be followed up by a MOU that would give confidence to both parties and an assurance of exclusivity.

TRI, while continuing to assist factories in solving their technical problems and optimising processes in manufacture of tea, must research on Ceylon tea character, define it scientifically, take Ceylon tea character as a primary criteria at early stages in screening of new cultivars, examine manufacturing processes that lead to preservation of Ceylon tea character and device methods of presenting a tea having Ceylon tea character to the tea bag and RTD tea markets.

The Institute should consider setting up a pilot plant to study the economic feasibility of producing tea wine.

11. Electrical energy

The installation of Variable Speed Drives in factories should be promoted to save electrical energy and reap the benefits of very substantial savings. TRI should train the factory staff on the use of this device.

TRI should set up a facility to test and evaluate the various types of fans being marketed for use in tea factories.

TRI should promote the use of energy efficient fans.

12. Heat Energy

TRI should develop technologies on the gasification process.

13. Energy from wood

With the cost of fossil fuel escalating and fuel wood becoming more expensive, TRI should initiate a multi-locational forestry research programme in collaboration with the Forest Department and the relevant universities. TRI should also develop a model for growing fast growing species like Gliricidia in smallholder lands.

14. Experimental design, field layout and statistical analysis

The advice of the Biometrician should be obtained prior to the initiation of experiments. The Biometrician should visit the substations at least twice a year to meet the officers, see the experiments in the field and assist in the statistical analysis if required.

1.INTRODUCTION

Tea was introduced to Sri Lanka in 1824 but it was nearly forty years later that James Taylor, a Scottish planter established the first commercial planting of tea at Loolecondera Estate, Hewaheta. The manufacture of the beverage on a commercial scale was also pioneered by Taylor in 1867.

By 1875 Sri Lanka had about 4000 ha under tea which increased to 120,000 ha in 1900 and to 195,000 ha in 2000. The tea industry which was dominated by company estates for more than a century was jolted by nationalization in 1972, that transformed an efficiently managed, profitable concern into a neglected, mismanaged, loss making national burden. Belatedly though, much of the company lands thus taken over were leased out in 1992 by the State to 20 plantation companies for a 50 year period. This action has led to a very significant improvement in the management of the lands and the productivity of the crop. Currently the country has about 214,000 ha of tea grown in up country, mid country and low country of which about 40% is managed by the corporate sector and the rest by the smallholders.

According to the Central Bank, Sri Lanka produced about 315 million kg made tea in 2004 at an average of 1461 kg/ha, of which 24% came from the high grown, 16% from the mid grown and 60% from the low grown areas. Nearly 96% of the production was exported, mainly to CIS countries, U.A.E., Syria, Iran and Libya. The export earnings in 2004 were Rs. 74,897 million. While the national production has been nearly static during the last few years, the average yield has shown a slight decreasing trend. The cost of production of tea has risen from Rs 110.64 per kg in 2000 to Rs. 157.34 in 2004, representing an increase of 42%. Consequently, the profit margins of most tea growers have declined. In fact the cost of production of tea in 2005 in 14 out of 23 plantation companies has been reported to be higher than the net sale average according to the Plantation Sector Statistical Pocket Book 2006 of the Ministry of Plantation Industries.

Since a very large proportion of Sri Lankan tea is exported, it can be said that the success of the industry depends mainly on its ability to compete with other tea exporting countries that include India, Indonesia, Kenya, Bangladesh and Malawi. The production of tea by some of the major growing countries is given in Annexure 2 and the cost of production in Annexure 3. The average yields of made tea in Kenya and Malawi in 2000 were 1967 and 2211 kg/ha respectively, which are substantially higher than the corresponding Sri Lankan figure. Furthermore, Sri Lanka should take note of the fact that the land area under tea is increasing significantly in Kenya at present.

In order to develop the tea industry in a professional manner on a firm scientific footing, a Tea Research Ordinance was enacted in parliament as far back as 1925, setting up a Tea Research Institute (TRI). It was financed and managed by the Planters' Association of Ceylon until the government took it over in 1957. Many significant contributions were made by the TRI since its establishment that made a big impact on the tea industry in Sri Lanka. Furthermore, the quality, relevance and adaptability of the research findings in the tea growing countries made the TRI a household name in the world of tea.

Among the milestones of TRI research were the establishment of Eden's famous factorial fertilizer experiment, the first of its kind in the world for a perennial crop, the biological control of the Tea Tortrix caterpillar, the management of the Blister Blight leaf disease, development of high yielding clones through vegetative propagation, introduction of the

selective shear harvester and the plucking basket, popularization of integrated pest management, pioneering the production of made tea with low agrochemical residues, improvement of factory technologies including the Fluid Bed Dryer and development of value added products. More recently, TRI has shown that regular drinking of black and green tea could reduce the risk of degenerative diseases such as heart disease, stroke, cancer and diabetes owing to the presence of antioxidants, polyphenols and numerous other chemicals in tea that have a beneficial effect on health. It can be said that TRI accomplishments have contributed towards expanding the tea cultivation in Sri Lanka, making the country famous the world over for its quality tea, increasing profitability to the growers, providing a means of livelihood to many of the inhabitants, earning substantial amounts of foreign exchange and spurring national economic development. It can be further said that TRI has been a partner in enabling billions of people across the world to enjoy a safe, healthy, and stimulating natural beverage at a reasonable price.

Getting back to the present, it must be admitted that the problems facing the Sri Lankan tea industry are numerous, varied and complex, and require short and long term solutions. Among issues that need immediate attention are the narrow margin of profit to the producer, the declining trends in yields, the acute shortage of labour in the plantations and the impending danger of traditional importers rejecting Sri Lankan shipments purportedly due to the presence of harmful substances. Additional issues that require attention are the long period required for soil rehabilitation, high levels of soil erosion, improper use of fertilizer, yield reduction by pests, narrow genetic base of the available tea germplasm, poor quality of planting material, declining life span of replanted tea, sluggish development in value added products and lack of modernization in factory technology. The effectiveness of the transfer of TRI developed technologies to its stakeholders is also in question.

Research is needed to develop alternative methodologies to field experimentation that often requires more than ten years for completion.. Methods of adding fertilizer and the number of split applications have to be reassessed in the light of recent research findings that have revealed that nitrate levels of some domestic wells in the upcountry are four to five times higher than the safe limits recommended by the World Health Organization, the matter assuming special importance since the quantities of fertilizer used by tea per hectare at present are high, being more than ten times the corresponding amounts used by rubber and coconut. Long term experiments are needed to determine the suitability of crops such as rambutan, duriyan, macadamia and spice crops as alternatives to tea or as candidates for intercropping. Adequate information on fuel wood species that can be successfully grown on lands unsuitable for tea is lacking. A full research agenda awaits the attention of the Institute.

This report is a review of the Tea Research Institute conducted by a Committee appointed by the Tea Research Board, consisting of Dr. Sarath Amarasiri (Chairman), Prof. Daya Ahangama, Prof. Sirimalee Fernando, Prof. Sumith Jayasekera, Mr. K M Opananda, Dr. Sarath Samaraweera, Mr. Dan Seevaratnam, Dr. Tilak Wettasinghe and Mr. Suranimala Wirasinghe. The Terms of Reference of the Committee (TOR) include reviewing the TRI Corporate Plan, the recommendations made by the researchers, the effectiveness of the technology transfer, the management structure and the capacity of the TRI to meet the emerging challenges. The detailed TOR is given in Annexure 1.

In the conduct of the review the Review Team visited the Headquarters on several occasions and the substations at Ratnapura, Hantane, Passara, Deniyaya and Kottawa.

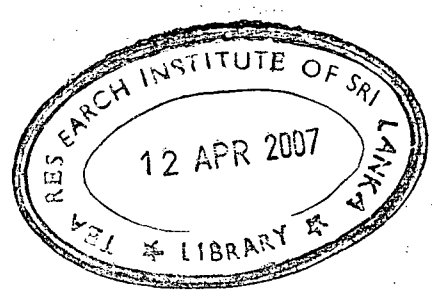
Meetings were held with the Chairman and members of the Tea Research Board, the Director, Deputy Director, Heads of Divisions, Research Officers and many other officers at TRI. An Organizational Climate Survey was carried out with nearly 150 officers. In addition, one to one interviews were held with officers at Headquarters and at the substations at Hantane, Passara, Deniyaya and Kottawa. All staff members were invited to send written comments to the Review Team on any matter, to which there were many responses.

The Team met with CEOs of several Plantation Companies, Officers of the TSHDA and office bearers of Tea Smallholder Societies. The Team also visited a number of estates.

A list of people met and places visited are given in Annexure 5.

The Review team listened to oral presentations made by all HODs in regard to their activities on the Corporate Plan and studied the reports submitted by them. In addition, the Team read the Annual Reports, E&E Forum Reports and several publications of the Institute.

The Review Team wishes to thank the Chairman and members of the Tea Research Board, the Director and staff of the TRI, CEOs of Plantation Companies, Secretary General of the Planters Association, Estate Superintendents and others who gave so freely of their time and support for the conduct of the Review. Thanks are also due to the TRI for providing transport facilities, meals and accommodation to Team members. A special word of appreciation to Dr A Anandacoomaraswamy for carrying out his duties as liaison officer for the Team so cheerfully and to perfection.



2. THE ORGANIZATION AND FUNCTIONS

The Tea Research Board (TRB) was established by the Act No. 52 of 1993 which was later amended by Act No. 30 of 2003. The main functions of the TRB according to these Acts are, "to conduct, assist and encourage scientific and technological research into, and investigations of, all problems and matters affecting the production and manufacture of tea". Furthermore, the TRB is mandated to undertake the collection and dissemination of data in the tea industry and promote investment in tea research.

The Tea Research Institute (TRI) has a much longer history, having been established by the Tea Research Ordinance on 8th October 1925 and managed by the Planters' Association until 1957, when it became a State funded organization.

The Tea Research Institute which began its operations in Nuwara Eliya in 1925 moved from its temporary holdings there to St. Coombs, Talawakelle in 1930 after the construction of the laboratories and the factory. This was followed by the establishment of five regional stations at Passara in 1935, Kottawa, Galle in 1960, Hantane, Kandy in 1961, Ratnapura in 1963 and Deniyaya in 1985. The activities at Deniyaya have been suspended owing to landslides in the area.

St. Coombs estate having a land area of about 170 ha is at an altitude of 1382 metres above mean sea level. The headquarters of the TRI are located at Talawakelle with the office of the Chairman of the Tea Research Board, the Director of TRI, and the Administration and Finance divisions alongside. The estate has been extensively used for the conduct of numerous field experiments from the very beginnings of the Institute, and continues to do so even at present. The main laboratories are also located at the headquarters and are among the best equipped laboratories in the country. The Institute has ten divisions that include; Agricultural Economics, Agronomy, Biochemistry, Entomology/Nematology, Plant Breeding, Plant Pathology, Plant Physiology and Propagation, Soils and Plant Nutrition, Technology and Advisory and Extension, supported by a Biometry Unit. The Advisory and Extension Services Division is also housed at the headquarters.

The Low Country Research, Advisory and Extension Centre was established at Ratnapura in 1963 to meet the needs of the low country holdings, which at present produce more tea than the mid country and up country combined. Research work is in progress in the fields of Agronomy, Plant Breeding, Entomology and Technology. Likewise, another similar research and advisory centre is located at Hantane, Kandy that serves the mid country. Small substations have also been established at Passara, Deniyaya and Kottawa. These stations provide extension services, supply planting material, conduct field experiments in the research stations and adaptive research trials in growers' lands.

The Research cadre at TRI includes two Deputy Directors, 10 Senior Research Officers, three Engineers, 37 Research Officers, 57 Experimental Officers and 21 Technical Assistants. The total cadre for the research division is 128.

The functions of the Tea Research Board are given in the Tea Research Board Act No. 52 of 1993 and in the amendments to the above by Act No. 30 of 2003. The functions include:

a) Conduct of research into and investigation of all problems and matters affecting the production and manufacture of tea
b) Conducting research to ascertain the development potential of the tea industry
c) Dissemination of results of such research
d) Maintaining and administering TRI stations at Talawakelle and its substations
e) Collection and dissemination of data on the tea industry
f) Advising the Minister on appropriate policies in relation to the tea industry

Furthermore, according to the above mentioned Acts the Director of the Tea Research Institute is responsible for the administration of the affairs of the Institute, subject to the general direction and control of the Board, and to exercise, perform and discharge any such powers, functions and duties of the Board as may be delegated to him by the Board.

At present the TRI receives its funds from a cess that collects Rs. 4.00 from every kg tea exported. This fund is shared by the Tea Research Board with the Tea Small Holdings Development Authority and the Sri Lanka Tea Board. In 2005 the TRI received 26% of the cess collection amounting to about Rs. 194 million. The amount of money thus provided to the TRI is often inadequate to meet its basic needs and is much smaller than that provided for agricultural research in many other developing countries as a fraction of the respective AgGDPs. In fact this figure is less than 0.5% for TRI compared to nearly 1% invested on agricultural research by the Government of India.

The TRI has a library that obtains 36 well known international journals, regularly purchases books from leading international publishers, receives publications from other tea growing countries and maintains linkages with all other agricultural libraries in Sri Lanka. The annual budget of the library is nearly Rs. 5 million.

The laboratories of the Institute are very well equipped due to the policies and practices followed by TRI over the years of providing the best possible environment for high quality research. In fact overall, the laboratories at Talawakelle are probably the best among the national agricultural research institutes.

The most precious asset of the Institute is its scientists, many of who are well trained, highly competent, very knowledgeable, articulate, and have the potential to become internationally recognized experts in their specialties.

The Institute has a culture of recognising outstanding contributions by officers. Accordingly, the Director has issued 45 letters of commendation to officers since 1998. These commendations are mainly for contributions made outside their normal duties. For example, they include assisting in arrangements with regard to visits of dignitaries, or in organizing exhibitions and other events attended by the public. Commendations to officers achieving high standards of excellence in their normal duties have been rare.

Unfortunately, many officers are frustrated and disgruntled. The main reasons for discontent are working in locations for long periods with poor educational facilities for the children, inadequate health services, separation from family, low emoluments, lack of promotional prospects, limited opportunities for Human Resources Development and lack of appreciation/recognition by the management as revealed by the Organizational Climate Survey conducted by the Peer Review Committee.

3. REVIEW OF ACTIVITIES UNDER THE CORPORATE PLAN

A major institutional innovation at TRI has been the development of the Corporate Plan for the period 1999-2003, that has been since revised upto 2007. This is the first such plan in the history of the Institute. The Plan groups the research activities into applied, basic, support and service components. The applied research programme which is mostly interdisciplinary is composed of Thrusts and Projects. The Plan lists 197 projects, giving the expected outputs and the time frame. All projects are costed, a practice followed by TRI for many years.

The Corporate Plan had been prepared through a consultative process with the participation of representatives of stakeholders that included corporate and smallholder sector tea growers, buyers, brokers, scientists, extensionists and many others.

The main objective of the Review as indicated in the Terms of Reference (Annexure 1) is to assess the quality, effectiveness, relevance and impact of TRI Research and Development programmes carried out since 1999 under the Corporate Plan.

Many of the projects are however, of a very long term duration and are therefore, not yet ripe for assessment of their effectiveness and impact. For example, the Thrusts A1, A2, A3, A4, A5, A6, A7 and A8 on varietal improvement have a time frame of 20 to 22 years. The Thrusts on intercropping, development of harvesting devices and fertilizer scheduling are of 10 years duration, and projects on soil rehabilitation, management of insects, diseases and weeds take 5 to 6 years for completion.

On the otherhand, there are projects of a relatively short term nature, mostly in the divisions of Biochemistry and Technology that have been already completed.

The progress and results thus far obtained from the projects conducted under the Corporate Plan are presented in the following sections of the report along with comments and suggestions.

Many of the applied research projects are interdisciplinary with two or more divisions participating. For the purpose of this Review however, such interdisciplinary projects are usually reported under the particular discipline taking the greater responsibility for its execution.

3.1 PLANT BREEDING

Background

Breeding a crop of perennial nature, such as tea, is a much time taking exercise, requiring 15 – 20 years to develop a new cultivar with the desired characteristics. Hence, an improvement program in tea needs to be carried out carefully with a clear vision and objectives taking into consideration the future requirements. High yield, acceptable quality, pest and disease resistance, drought tolerance, adaptation to varying agro-ecological conditions and better response to agronomic and cultural practices are some important aspects to be considered.

Accordingly, the Plant Breeding Division of TRI, has launched its breeding programme based on eight major Thrust areas for the development of high yielding cultivars and seed cultivars (biclonal and polyclonal) for the up country, mid country wet zone, mid country

dry zone (Uva), and low country wet zone, with good quality, having resistance to major pests and diseases, suitable for mechanical harvesting and for variable soil fertility regimes.

Under each Thrust several projects have been planned and carried out towards achieving the identified targets and goals. The number of projects identified under each thrust is given below.

Thrust	No. of Projects (1999-2003 CP)	No. of Projects (2003-2007 CP)	Present Status
A_1	7	6	5
A_2	5	3	3
A_3	5	3	3
A_4	6	2	2
A_5	5	2	2*
A_6	4	2	0*
A_7	5	3	0*
A_8	4	2	0*

(CP – Corporate Plan * - Amalgamated in to one thrust)

From the above it is clear that several projects identified in the first Corporate Plan (1999-2003) have not commenced or have been abandoned. Further, it was noted by the review team that the thrusts identified as A5, A6, A7 and A8 have been amalgamated into one and included in A-5 with lesser number of projects. These alterations and changes to the Corporate Plan of 1999-2003 and subsequently to the 2003-2007 Plan have been brought about mainly due to the lack of human resources in the division during the implementation process.

In addition to above thrusts and projects, a basic project (D-1) is being carried out by the division, to develop protocols and to use them as *in-vitro* techniques to supplement the conventional tea breeding program.

To support and maintain the above plant breeding activities, the division has also undertaken several projects which form the backbone of the breeding program. They are,

1. Maintenance, characterization and evaluation of germplasm.
2. Controlled hybridization
3. Polyploid breeding
4. Mutation breeding
5. Estate cultivar selection
6. Maintenance of seed gardens
7. Issuance of planting material

Progress and results

During the period between 1999 and 2006, the division has shown progress by short listing and recommending cultivars of TRI-4000 series based on the results generated from multi-regional commercial evaluation trials and by incorporating latest available information on clonal characteristics. Advisory Circulars from C_1 to C_{13} were revised and a new Advisory Circular PN 1 on latest cultivars and recommendations was released in

2002. Further, the division has issued over 1.2 million cuttings of TRI 3000 and 4000 series to 277 estates in the up, mid, low country and Uva and established mother plant stocks of TRI 3000 and 4000 series cultivars in collaboration with TSHDA with the view of distribution of planting material (PM) to serve the small holding sector.

The division has also issued over 1 million cuttings of recommended tea cultivars to establish mother bush stocks and completed evaluation of cultivars on all sites of ADB funded mother bush stocks to confirm identity, correct labelling and purity prior to distribution of planting materials. Thirty accessions have been identified as potential cultivars (TRI 5000 series) from populations based on their performance on regional adaptability and preliminary yield trials. These have shown 15 - 28% yield increase over the standard cultivars, the highest yield being 7300 kg made tea/ha. Further, the division has established several field trials to identify promising lines for release in four regions and has identified 16 seed progenies derived from biclonal and polyclonal seed sources for further testing. Division has also established a satisfactory communication system with the stake holders, either directly or through the Extension and Advisory service.

The division has published several documents based on the progress mentioned above. They are as follows.

1. The suitability of tea cultivars for different regions. TRI Advisory Circular PN I (2002)

2. Booklet on 'Distribution of cuttings of TRI 3000 and 4000 series clones to tea estates in Sri Lanka for establishment of mother plant bushes' (2001)

3. Survey on the distribution and utilization of the new cultivars issued by TRI to the tea growers in the low country (2002)

4. Systematic establishment of mother plant bushes (multiplication plots) of tea cultivars (TRI update 2004)

Progress and results from several basic research projects are also indicated below

Controlled hybridization

Though hybridization was carried out at TRI during the early period, the main source used for selection during the recent past was open pollinated seed progenies. From 1960s and 1980s several parents have been used recurrently. Hence, to revive the breeding program with diverse genetic variability, controlled hybridization was introduced with inclusion of genetically diverse parents and ones which have not been used earlier. More diverse progenitors such as '*Yabukita*' and '*China*' and wide hybridization using C. *sasanqua*, was also included.

Over 20000 crosses using 188 parental combinations have been effected and hybrids are being evaluated. The relative genetic contribution from ancestral lines in the development of recommended cultivars of TRI 3000 and 4000 series has been determined using coefficient of parentage to increase the efficiency of the breeding program. The true genetic picture or the relatedness among the cultivar development so far has revealed that there is a considerable genetic potential available to be tapped and utilized in future breeding programs.

Germplasm

Tea germplasm is the back bone of tea breeding. Having realized the importance of germplasm, the division has taken steps to maintain, characterize and document the variability available in the present tea germplasm collection. A systematic approach has been adopted to characterize the germplasm using the descriptors developed by the IPGRI. Passport data and description of accessions derived for estate selections, since 1930's, have been documented.

Over 600 accessions have been conserved in *ex situ* field gene banks. Some accessions have been duplicated at Ratnapura and Kottawa. Among 688 accessions originating from estate selections, 45% were secured by conserving them in the field gene banks at four different locations.

Two hundred germplasm accessions conserved in the gene bank at Talawakelle were characterized using vegetative and reproductive descriptors. Using biometrical approach these accessions were discriminated and characterized into 3 main groups using 12 morphological descriptors while identifying discriminating descriptors.

A new concept of genetic resource conservation method known as 'Tea Reserves' was introduced in 2003 to conserve and maintain in the *in-situ* sites. Though inter specific hybridization has not been effected by the division, *C. sasanqua* has been identified as a possible progenitor for such crosses with *C. sinensis* particularly to create genetic variability and transfer the character of blister blight resistance to cultivated varieties.

Use of other breeding and screening techniques

Several other basic projects have been carried out by the division. They were mainly focused around developing protocols and use of *in-vitro* techniques to supplement the conventional tea breeding program. These studies would assist inter specific hybridization program through embryo rescue technique and preservation of isolated zygotic embryos of hybrid seeds. Further, several studies have been carried out on application of biotechnology in tea breeding such as perfection of reproducible *in-vitro* protocol from plantlet formation from zygotic embryo axes to enhance germination ability of hybrid seeds and *in-vitro* rooting of micro shoots of tea. Protoplast isolation technique has been perfected using leaf tissues for the first time in tea. In addition, work on polyploidy and mutation breeding has been initiated.

Another project has been successfully carried out by the Biochemistry Division, to identify a chemical marker to differentiate between blister blight resistant and susceptible cultivars thus making the screening procedure of tea cultivars faster and accurate.

In order to increase the made tea yields from the current average figure of about 1620 kg/ha to at least reach the levels attained by some other tea growing countries, new varieties with substantially higher yield potentials have to be developed. Furthermore, these should have pest resistance, good quality character and be amenable to mechanical harvesting. Some constraints and drawbacks in the present breeding program as identified by the review team are highlighted below.

The Narrow Genetic Base

The origin of most of the TRI clones has been traced back to a single parent known as Assam 4/10. Of the 62 TRI clones recommended so far, 57 are directly or indirectly related to this parent. Developing and cultivating clones from the same origin would

narrow down the genetic base leading to genetic vulnerability. Therefore, it is necessary to adopt a sound methodology for using diverse parent material in breeding work, and in general, use of a mix of planting materials to broaden the genetic base of the tea populations in plantations.

Agroecological based recommendations

Evidence is forthcoming to indicate that all high productive cultivars may not perform equally well under all growing conditions, even within the same region (i.e. up, mid, low and Uva). Although certain regional recommendations with respect to cultivars are being adopted, there is a necessity for location specific recommendations within a region. Hence steps need to be taken to evaluate cultivars in several locations based on agroecological or other considerations. For implementation of a program of this nature, assistance from plantation companies and small holders has to be obtained.

Multidisciplinary approach

To achieve success in breeding, expertise from several disciplines should work as a team. Although the research projects outlined in the Corporate Plan have been formulated on a multi-disciplinary basis, the collaboration between the disciplines has been far from satisfactory in the conduct of the research programme.

Success of screening methodology and its effectiveness

Success of the breeding program identified in the Corporate Plan (Thrusts A_1-A_4) largely depends on the contributions received from almost all other divisions. The priority for screening of important traits given by other disciplines depends on the work load they handle at a particular time, thus often not receiving sufficient input for cultivar screening though they have been identified and agreed upon in the CP. Therefore, it was clear to the review team that required input is often not received from other divisions for screening advanced breeding lines maintained by the Breeding Division of the TRI. Screening for some traits that have not been carried out effectively include resistance to shot hole borer, Blister Blight, collar canker, poria, live wood termite, nematode and drought. The suitability of lines for quality and mechanical harvesting and their behaviour to shade regimes have also not been studied thoroughly.

Furthermore, screening is done for some characters purely based on *in-situ* evaluation in the field and sometimes even the pest and disease infestations are not present adequately. No controlled conditions are imposed, such as spraying of disease inoculum on to the plants during the process. This makes researchers to repeat the experiments for several years for confirmation of results. The reviewers also noted that a method of detecting blister blight resistance through molecular markers has been developed by the biochemistry division. However, this facility is not effectively being used for screening the germplasm and the advanced breeding populations against blister blight resistance. Obviously this is a very fast and reliable method and it can significantly reduce the time period spent on screening.

It was also noted that, screening for collar canker and live-wood termite problem (UC & LC) are not properly addressed by the respective divisions. According to the Corporate Plan, these problems have been identified as high priority areas, but are not being attended to by the respective divisions.

It has been reported by the scientists at TRI on several occasions that, quality of tea should receive importance in the overall research program of TRI. Since yield and the

productivity were the key objectives in the breeding program in the past, the quality aspect has been neglected or given less importance. As Sri Lanka is known for her quality tea, quality should be also improved, besides increasing the yield. The present screening methodology does not permit screening for quality at early stages but only at the latter stages. By this time most valuable material (quality wise) may have been rejected based on other criteria. This procedure allows only high yielding cultivars to get selected for recommendation, which may or may not have quality characteristics.

It was also noted that screening methods used for different characters are not efficient. They are time consuming and sometime depend on weather conditions or natural infestation of pests and diseases. Therefore, use of refined, early screening methods would certainly enhance the efficiency of the selection procedure of the breeding lines.

Comments and suggestions

1. The germplasm collection available at TRI should be expanded through introduction of accessions from foreign countries.

2. Continuation of wide hybridization program is recommended. Since there are certain limitations for 100% success in hybridization, studies on floral biology, environmental effects, germination of F_1 and F_2 seeds, and some basic studies need to be carried out to overcome the limitations.

3. Inter specific and intra specific hybridization is recommended to transfer appropriate characteristics to *C. sinensis*. This may include some wild or ornamental species. While affecting these crosses, attempts are to be made to overcome the incompatibility through biotechnological processes.

4. It is recommended to undertake a study to identify highly heritable characters which are less influenced by the environment. Early selection should be based on highly heritable characters whether they are morphological, chemical or biochemical.

5. It is recommended to introduce laboratory assays or molecular markers for screening clones for pest and disease resistance thus making this process fast and reliable.

6. It is recommended that regional specific recommendations should be developed without confining to broad based recommendations.

7. It is recommended to continue with development of improved seed progenies, adaptable to different tea growing regions to use as PM. This would enable TRI to develop progenies that would be capable of tolerating more diverse and heterogeneous environments to address the needs of growers and to use seeds as an alternative source of PM.

3.2 AGRONOMY AND PLANT PHYSIOLOGY

Intercropping systems for tea lands

The following Thrusts on intercropping are included in the Corporate Plan:

Thrusts A12 and 13: Development of intercropping systems (with pepper and coffee) for marginal tea lands in the mid country smallholder sector (A 12); and the mid country estate sector (A13)

Thrust A14: Development of intercropping systems (with rubber and coconut) for the low country and Uva.

Background
Some tea smallholdings in the mid country carry a miscellany of other crops, including pepper and coffee, as per the Kandyan Forest Garden model. However, organized, systematic intercropping of tea, coffee and pepper is not practiced. A few estates in the low country (eg Panawatte and Kiriporuwa Estates) tried out mixed planting of tea and rubber, around 1980.

TRI commenced experiments on intercropping tea and rubber in 1989, in collaboration with the RRI. Guidelines on tea and rubber intercropping (prepared in collaboration with the RRI) were issued to the tea growers as an interim recommendation in March 1997. For tea cum rubber mixed plantings, TSHDA provides a tea replanting subsidy of Rs 50,000 per hectare, and Rubber Control Department provides a subsidy for the rubber component. Guidelines for tea and coconut intercropping have been issued jointly by the TRI and CRI, in April 2000.

During the 1995 problem census, in discussing the 'low productivity of land' and 'non-optimization of profit' the following issues were raised:

- lack of multicropping and diversification
- lack of guidance on intercropping
- TRI has inadequate research data on intercropping tea with other economic crops (rubber, export agriculture crops)

Thrusts A 12, 13 and 14 that address these issues are now in progress.

Intercropping with coffee/pepper/vanilla (A12 and 13)

Progress and results
Five experiments had been established under A 12 and 13 in the mid country. However, 3 experiments were terminated prematurely for various reasons (high percentage of casualties in pepper and coffee due to drought; change of ownership of the smallholding, non-cooperation by estate). These experiments did not yield any useful information.

At present, two experiments are in progress: 1) at New Peacock Estate, on intercropping tea with pepper and coffee, and 2) intercropping tea with vanilla on a smallholding. Details have not been reported.

Progress with these thrusts has been very poor. Although five projects had been identified under each thrust, only 2 experiments are in progress, after seven years. These are also at a very early stage.

Comments and suggestions
Generally, intercropping systems are high intensity production systems, and the Thrusts were presumably designed to address the problems raised by stakeholders viz. low productivity and the need to raise profits per unit of land. However, as indicated by their titles, Thrusts A12 and 13 aim to develop intercropping systems for marginal tea lands. Surely, marginal land is not appropriate for high intensity cultivation.

The reasons for the slow progress should be examined. Does it reflect a lack of interest among growers? Three of the five trials set down were terminated prematurely – were the landowners discouraged by the poor performance of intercrops, which is not unlikely on marginal land. Re-examine the need for these thrusts and explore the possibility of collaborating with the Department of Export Agriculture.

Identify growers who have successfully cultivated these intercrops on their own initiative. If there are any successful cultivations they could be used as case studies and for demonstration and promotion purposes as well.

Establishing observation plots to demonstrate the possibility of growing coffee and pepper in association with a full stand of VP tea should precede formal experimentation. The high nitrogen levels required by tea may adversely affect fruiting in coffee and pepper.

Intercropping with Rubber

Progress and results

A number of experiments have been conducted in the low country in collaboration with the RRI since 1989. Two experiments at the RRI Kuruwita Station and three experiments at the TRI Low Country Station have completed around 15 years. The results are not presented in adequate detail in the annual reports and other progress reports. The general conclusions are:

Tea yields gradually decline as the shading from rubber increases.

In rubber planted at a spacing of 8' x 40', the tea yield per bush is halved by the 3rd cycle.

When the spacing of rubber is increased the yield reduction of tea is less severe.

The yield of rubber, on a per tree basis, is not affected by interplanting with tea.

Comments and suggestions

The emphasis in reporting has been on the yields per rubber tree or per tea bush. This parameter is inadequate to assess the success of a multicropping exercise where neither crop is planted at the stand per hectare recommended for monoculture. The economic evaluation of these trials has been neglected. The profits per unit of land should be the main criterion used for this assessment.

The experimental design is not always indicated in the reports. In one case where the design was mentioned, there were three treatments replicated only thrice. Not surprisingly, in the 11th year of this long-term trial, it is reported that the yield of 0.419 kg/bush for tea under rubber is not significantly different from 0.726 kg/bush in monocropped tea (Annual Report 2001, p 35). A poorly designed experiment is worse than no experiment – it can mislead!

Rubber and tea are perennial tree crops. The choice of these two as a crop combination is questionable on the basis of their very different economic life spans. The question arises as neither crop is to be planted at (or nearly) the recommended monocrop stand. At the outset, when this combination was first tested, in the 1980s, tea would have been regarded as having the longer life span. Now, with some experience of tea cum rubber

plantings, it appears the tea will fade out well before the rubber (by the 12th year tea yields decline to very low levels). In combined planting both crops would be planted at only about 65% of the monocrop stand. When one crop fades out the other would be at a less-than-optimum stand and therefore very likely to be uneconomic. This feature must also be considered in the economic equation. Another problem that confronts the Economist is the fluctuations in the profits from these two commodities, over their lengthy life spans.

Tea cum rubber multicropping seems to be a good candidate for a computer modeling study. The data from the ongoing experiments would be a valuable input for such studies. An in-depth economic analysis of the available (and projected) data should be carried out. The grower will expect guidance on which cropping system, in the long run, is more profitable: intercropping tea and rubber; monocrop of tea; or monocrop of rubber.

Intercropping with Coconut

Progress and results

Two experiments were established in collaboration with CRI. However, the trial at the Tea Shakthi Mawarala Estate has been abandoned.

In the experiment in progress at Citrus Estate, Poddala, established in 2000, the tea has been planted, with and without soil rehabilitation, in coconut planted at different spacings. The density of tea is not mentioned. Coconut is being tested at 2 spacings, giving stands per hectare similar to that recommended for monoculture.

The experiment is a RCBD; six treatments in three replicates. A biometrician will most probably advocate four replicates. No results have been reported although the tea should now be in plucking and the coconut near to flowering.

Comments

The trial at the TSHDA Mawarala Estate is reported to have been abandoned due to a change in the management. Abandoning a long-term experiment due to a change of management is not acceptable. It is even more deplorable as the estate concerned is managed by a sister organization that stands to benefit from the results of this experiment.

The Citrus Estate experiment was the first one and, to-date, it is the only experiment on the ground. No results have been published even in an annual report, as yet. However, the guidelines issued by the TRI and CRI state that "intercropping of tea and coconut is considered feasible in the mid and low country, in the agro-ecological regions, WM1, WM2, WM3, WL1 and WL2, where conditions are conducive to both these crops". Strangely, these guidelines were issued in the year in which the first experiment was planted. There is no indication that these 'guidelines' are tentative and of an exploratory nature. Intercropping perennials is a long term and expensive venture. The status of the 'recommendation' should be clear to avoid growers being misled. Action should be taken to include the necessary provisos in the guidelines.

Intercropping tea and coconut is far more likely to be an economic proposition than rubber. At least two more experiments should be laid out to test this combination. Preliminary results of the Citrus Estate trial would be useful in designing the new experiments.

General comments and suggestions
Although intercropping is a high priority Thrust, very few crop combinations have been tested to-date. Trees such as Gliricidia and Calliandra that could be coppiced to produce dendro energy and green manure, in addition to providing shade, would be worthwhile testing as intercrops. Plant the trees at densities much higher than that recommended for medium shade trees. Harvest a proportion of the trees in rotation, to extract fuel wood and to prevent excessive shading. Research is required to determine the optimum density of trees and their management, and economic feasibility. This option may be more suited for smallholdings to maximise productivity and profits. It is an environment friendly production system with numerous benefits: produces fuel wood and green manure, provides shade, conserves soil, improves soil fertility and efficiency of applied fertilizer, and reduces the fertilizer requirement, leaching, weed growth, ambient temperatures and drought effects. The system is also quite flexible; the intercrop density could be decreased/increased quickly and easily, as required.

Shade trees and shade effects in tea
Research activities on shade effects and shade trees are conducted under Thrust A34: Development and management of shade, included in the CP during the 2003 revision.

Background
Planting shade trees in tea fields is a practice that goes back to the beginnings of tea cultivation. The need to provide shade in tea fields by planting shade trees is now an established fact. The levels of shade employed now are lighter than in earlier times when heavy shade was the norm.

TRI recommendations on shade in tea
The latest recommendations on shade are contained in Advisory Circulars SI 1 and 2, issued in 2003. Circular SI 2 covers planting, establishment and management of both medium and high shade trees. Shade tree species and planting distances are recommended for the up country, mid country (wet and semi-dry zones), and the low country. Circular SI 1 deals with the management of medium shade trees to produce considerable quantities of green manure.

It is interesting to note that no questions at all were raised on the 'shade question' or on shade trees during the 1995 problem census. This is an incredible turn around – if a similar census was conducted in the late 1960s or the 70s, shade would have held centre stage. Again, shade had not been an issue when the TRI met with the CEOs of the Regional Plantation Companies in preparation for the 2003 revision of the CP. In a recent survey (2005) of stakeholder problems, through an advertisement in the newspapers, there was a request for "New varieties [of shade trees] suitable for Uva. Planting shade in Uva had been a failure due to the prolonged drought and damage caused by cattle, goats and wild buffaloes". One wonders whether drought tolerant saplings will survive if buffaloes continue to roam!

Progress and results
The objectives of this Thrust are to determine a) the effects of shade on photosynthesis, yield and other physiological parameters of mature tea, and b) to select alternative species appropriate for use as shade trees in different ecological regions. The basic physiological information generated on photosynthesis and productivity of tea in relation to shade is also expected to provide some useful pointers to improve the current shade management practices, and also in selecting species to be used as shade trees.

Work in progress has produced some interesting physiological information on photosynthesis in tea. The photosynthetic efficiency of tea is low due to certain inherent deficiencies in the light reactions and enzymes involved in dark reactions of photosynthesis. In comparison to other perennials, tea has a low photosynthetic rate. It appears that both source and sink limitations are responsible for this low rate. It has also been established that photoinhibition of photosynthesis occurs in tea at light intensities beyond 1300 μmol m^{-2} s^{-1}. Perhaps as a consequence, at least partially, shade increases the photosynthetic capacity of tea. A field experiment under artificial shade showed that the maximum photosynthesis (A_{max}) of unshaded leaves was nearly 40% less than shaded leaves which suggests planting shade trees would increase productivity.

A survey has been carried out among estates in the corporate sector and smallholders to gather information on tree species likely to be useful as shade trees. Some 200 species were initially identified, and based on available literature on their climatic requirements and natural habitat, plant height, ability to stand pollarding/lopping, leaf shedding and rooting characteristics, the list has been reduced to 84 species. The next step is the selection of short lists of candidate species, appropriate for different regions, but the project is now at a standstill due to lack of staff.

Other physiological studies

Some interesting results from studies on partitioning of assimilates, tea roots and drought mitigation are recorded at the end of this section.

Comments and suggestions

Experiments under this Thrust are located exclusively in the up country. While the 'shade problem' is relevant to all regions, shade is most important and is likely to have the greatest impact in the low and mid country tea areas, including Uva. Tea in these areas is likely to benefit most from having a proper stand of shade trees. It would therefore be more rational to shift the focus of shade research to the low country.

The project to identify alternative species of shade trees, through a review of available literature, commenced in 2001. After five years, we still do not have a short list of trees that merit testing in the field. Surely, this is not acceptable under any circumstances. The project is bogged down in a tedious academic exercise of dubious value. The approach adopted is questionable. Alternative procedures to 'fast track' selection should have been explored. This case also reflects poorly on the monitoring and review process at the TRI. A few trees each of about 10 'probable' species, planted in 2001, would have been a more rewarding option. Or, is that too simplistic?

Physiological studies to understand the underlying science, have, and will continue to generate more evidence to confirm and support the traditional wisdom of planting shade trees in tea fields. The consensus is that shade is required. The question is how much shade. Even determining the optimum level of shade per se, using artificial shading, is a complex exercise with many variables to contend with, such as cultivar, elevation, climatic, edaphic and cultural factors. However, in the field shade has to be provided by means of shade trees. Translating optimum shade levels to the density, spacing and spatial arrangement of a mix of different species, of different stature (tall and medium), and their management is a far more complex exercise. To add to the complexity shade trees provide many benefits other than shade, and also offer competition.

Clearly, formal field research to determine the optimum mix and management of shade trees is a daunting task. In the past shade trials did not provide conclusive evidence of the benefits of shade in terms of tea yields, and there is little to suggest that it will be different in the future. The results were variable – the downside of doing too many trials! The positive feature was that the differences were not large and generally within tolerable limits.

In this context, a practical approach is called for. Regard shade as a non-negotiable good agricultural practice in the same league as soil conservation measures. The performance of the trees currently used has been observed and researched for decades. Use the vast store of practical experience and research findings to develop a few models to suit different regions. Consider also the recent adverse changes in climate with extended dry spells, higher temperatures and higher frequency of high intensity erosive rainfall. This should be essentially a desk exercise undertaken by an informed group. Their output would be available in a relatively short period and is not likely to be way off the mark. Shade trees are multipurpose trees. Err on the side of too much rather than too few trees. The other benefits of shade trees will balance the equation. Anyhow, it is easier to thin out than to introduce shade trees.

When the models have been developed, they should be planted in the TRI properties to encourage their adoption. Baseline information on all soil parameters – organic carbon, nutrient levels, soil moisture levels during dry spells, microbial populations, pH, erosion etc also ambient temperatures and humidity should be recorded. These measurements should be repeated at appropriate intervals. Such information would be valuable in promoting the adoption of these models.

Research should, in the first instance, be directed towards the problems that may be encountered in establishing and managing the recommended models. For instance:

- Growers seem to have problems in establishing even the common Gliricidia. This is especially so in the fields being rehabilitated with grass. Establishing shade during soil rehabilitation will ensure a full stand of shade when the tea is planted.
- Methods to establish shade in mature tea fields.
- Determine the best type of planting material (seeds, cuttings, different types of cuttings).
- Production of planting material and nursery practices.
- Management of high shade (pollarding; rotation) appears to be another area that needs attention.
- There are some area-specific problems e.g. growing Grevillea in Kotagala area (Maskeliya soil series); Dadap and Gliricidia in Madulsima and Lunugala areas. If remedies are not possible other species should be tried out (e.g. Cassia spectabilis, Tecoma stans, Acacia spp).

The longer-term aim should be to make the recommended shade regimes the norm for tea cultivation. Recommendations on cultural practices for tea, especially fertilizer use, weed management, soil and moisture conservation etc should in due course be geared to suit the recommended shade regimes.

In view of the considerable benefits to the environment and society at large the provision of a subsidy to establish shade could be justified.

It is pertinent here to refer to the climate change studies carried out under Project D/AGRY. Climate change, brought about by global warming, is a phenomenon we can no longer ignore. Predictions for Sri Lanka are a rise of 0.4°C-1.0°C in mean temperatures by 2050, and more variable rainfall with a greater intensity and frequency of extreme events such as floods and droughts. Ambient CO_2 concentration is predicted to increase from the current level (around 370 ppm) to 600 ppm, which could increase tea yields by as much as 35%.

A study of the productivity and rainfall data, over 1976-1995, from 25 tea estates representing the five main agro ecological regions for tea (WU, IU, IM, WM, WL) showed that the optimum temperature was about 22°C and the optimum rainfall ranged from 223 to 417 mm per month depending on the region. A 100 mm/month decrease in rainfall, decreased productivity by 30-80 kg made tea/ha/month, in different regions. Based on these parameters, a crop model was developed for predicting tea yield under future climate scenarios.

Crop model projections for 2050 show that the increase in temperature, considered on its own, is likely to reduce tea yields in IU, WM and WL regions while increasing the yield in WU region. However, reduction in rainfall would decrease yields in all tea growing regions. Although increases in CO_2 increases tea yield, this effect of CO_2 fertilization is nullified by the high temperatures at low elevation. It appears that tea yields are likely to increase at high elevations due to climate change. In contrast, the productivity of tea plantations at low elevations is likely to decrease.

The low and mid elevations are more vulnerable to the adverse impact of climate change. Shade trees, no doubt, will play an important role in our efforts to minimize the adverse effects of global warming.

Some highlights from **other physiological studies** carried out under B11, B64, B65 thrusts and D/PHYS projects are recorded below:

- Although there is a decline in yield in the 4th year, in up country VP tea, the rates of photosynthesis were found to be similar in the 3rd and 4th years of the pruning cycle. Studies show that differences in the way assimilates are partitioned causes the yield decline. In the 4th year, more biomass is partitioned to tertiary branches and medium sized roots, and less to canopy leaves and harvestable shoots.

- The root system in seedlings is significantly deeper than in VP tea, but the active root zone is deeper in VP tea than in seedlings. However, there are cultivars that have root systems as deep as in seedlings and with deep active root zones.

- Organically grown tea has a deeper root system than conventionally grown tea

- Organically grown tea roots also have thicker cork layers, smaller xylem vessel diameters & smaller xylem wall diameters.

- The presence of allelopathic compounds in tea has been established. This is the first record in tea in Sri Lanka.

- A user-friendly method was developed for testing root starch content.

- In terms of the physiological responses, foliar application of K_2SO_4 was better than KCl to impart drought resistance in young tea

Soil rehabilitation prior to replanting tea

The following research thrusts on soil rehabilitation are included in the Corporate Plan (CP):

Thrusts A9, A10 and A11: Development of an economically viable system to eliminate/reduce soil rehabilitation period prior to replanting in the up country (A9); mid country (A10); and low country (A11).

Background

Planting of a break crop after uprooting the old tea and prior to replanting commenced four or five decades ago to prevent the carry over of root diseases to the new tea. Although these root diseases were a problem in the up country and mid country estates, two years of soil rehabilitation (SR) was mandatory in all tea areas under the replanting subsidy scheme. This did not apply to tea planting on rubber lands.

During the 1970s, the Tea Controller permitted 'direct replanting' without SR of a limited extent of land, in low country estates, on the recommendation of the TRI. Of course, the clearings had to be mulched with loppings from grass grown elsewhere.

More experimental evidence of the advantages of SR and the better performance of tea on rehabilitated soils became available during the 1980s. Tea planted in rehabilitated soils (2 years of grass) showed better survival and higher yield in the first cycle. The better performance was presumably related to improved soil factors; not due to root disease control.

TRI recommendation on soil rehabilitation

Soil rehabilitation with Guatemala or Mana grass for 18-24 months before planting tea was the TRI recommendation in 1999 at the time of preparing the CP. SR for 24 months was required when root diseases, nematodes or Live Wood Termites were detected in the old tea. This recommendation applied not only to replanting tea lands but even for planting tea on rubber land, with trees affected by White Root Disease, and abandoned tea lands under scrub jungle. This recommendation has been in effect since the mid 1980s.

During the 1995 problem census, the issues of high cost of replanting, long payback period due to soil rehabilitation and the lack of alternative techniques of speedy soil rehabilitation were raised. Thrusts A 9-11 were designed to address these concerns and investigate alternative procedures for SR, which would eliminate or reduce the 'unproductive' period between uprooting and replanting.

Progress and results

Thrusts A9, 10 and 11 are in progress and eight experiments, some of which commenced before CP, are being conducted in the high, mid and low elevations. The alternative procedures being tested are basically:

1. No soil rehabilitation (No-SR)
2. No soil rehabilitation; compost, refuse tea or coir dust is incorporated in the planting hole/trench at the time of planting
3. Growing economically important crops such as cowpea, tur dhal, green gram, citronella and sweet corn between the rows of replanted tea to reduce the cost of rehabilitation
4. *In situ* soil rehabilitation: with grasses (Mana, Vetiver) or *Flemingia congesta* planted in the replanted tea rows; and mana planted in the old tea before uprooting.

The results are presented in the annual reports (ARs) and other progress reports. However, they are very brief (especially in ARs 2002 onwards). The general conclusion presented in these reports is: in most trials none of the alternative systems tested matched traditional soil rehabilitation (under grass for two years) in terms of establishment, growth and yield of tea.

Comments and suggestions

The testing of alternative procedures 3 and 4 listed above is questionable. Interplanting the replanted tea with economic crops is independent of SR, and if feasible, could be practiced with or without SR. Planting Mana or Vetiver between the young tea rows, at a density likely to have any impact in terms of SR, is very likely to seriously retard the young tea. Surprisingly, a rehabilitation period of 12-14 months under grass has not been tested in any of the trials.

In the most recently established trial, planting Mana in the old tea, 2 years before uprooting and replanting, is being tested as an alternative system. This approach to *in situ* rehabilitation should be explored further. There are opportunities here for reducing the inevitable soil erosion during land preparation. The grass could be planted at a density that does not unduly affect the movement of pluckers, and maintained over an extended period.

The results are not presented in adequate detail in the ARs. The latest yield data is not presented, nor is there any information on whether the yield gap between No-SR and SR treatments is closing or widening. Sometimes the yield difference between treatments is given only as a percentage. The yield in absolute terms is important in these studies - percentages could be deceptive. No assessments of soil carbon levels, root disease or nematode incidence in the experimental plots have been reported.

It appears that the soil rehabilitation (SR) treatments are assessed solely on agronomic considerations. Although some trials have completed the second cycle, and the thrust is to develop an 'economically viable alternative', the results of economic evaluations, if any, are not reported. During the problem census the growers' concerns were the high cost of replanting and the long payback period due to soil rehabilitation, but this aspect has been lost sight of.

An economic analysis of a soil rehabilitation experiment carried out in the 1980s is available. It concludes that rehabilitation prior to replanting is highly economical and profitability is so high that any government assistance to encourage the practice is not necessary (S.L.J. Tea Sci. **55** (2), 89-93). Complacency stemming from this very favourable report may account for the lack of interest in conducting economic analyses of the ongoing experiments. However, the conclusion of the published report may be flawed.

The economic analysis is based on the yield data presented in the below. The yield over the 8-year period was taken as 8,585 kg for SR and 7,844 kg for No SR. Therefore, the production of SR was greater by 741 kg over the 8 years. The additional costs incurred in growing grass in SR, and infilling casualties in No SR have been taken into account in the computations.

Yield of tea in kg per ha, over the first eight years, with and without soil rehabilitation

Year	No soil rehabilitation (No SR)	Soil rehabilitation for 2 years (SR)
1	800 from old seedling tea	Nil – under grass
2	800 from old seedling tea	Nil – under grass
3	Nil – immature plants	Nil – immature plants
4	Nil – immature plants	Nil – immature plants
5	655	1,382
6	1,266	2,212
7	1,873	2,242
8	2,450	2,749
Total	7,844	8,585

Including the yield of the old seedling tea (1600 kg in years 1 and 2) in the first 8 years of No SR is questionable. It may be acceptable for analyzing the experiment, but it does not make sense for practical purposes. In the real-life situation of replanting without rehabilitation, the first 8 years would be comprised of 2 unproductive years (bringing into bearing), and 6 years of new tea in production, with years 7 and 8 producing around 4000 kg/ha, totaling 10,244 kg against 8,585 kg for SR. This makes all the difference, and we have a completely different picture! Moreover, going by the yield trends in the two scenarios, yields after 8 years are not likely to be significantly different.

Clearly, the economics of soil rehabilitation has not been studied adequately. An in-depth economic analysis of the available (and projected) data from the soil rehabilitation trials should be carried out.

There is experimental evidence that soil rehabilitation increases the yield of young tea. Sometimes the difference is substantial. The reasons for this however are not clear. As the response to compost and other organic amendments tested is marginal, it appears that yield response is not entirely related to soil fertility or organic matter status. Nor has it been ascribed to disease incidence. All treatments in these trials had been mulched; if so, the yield differences cannot be ascribed to differences in weed competition, moisture stress or soil erosion. It is necessary to have a better understanding of the underlying reasons for the superiority of soil rehabilitation.

Is it the deep incorporation of organic matter by way of the grass roots? Is it caused by allelochemicals or toxins produced by the old tea? This could be quite easily studied in pot experiments with soils derived from different SR treatments. Differences, if any, between grass species could also be ascertained in this way.

Very poor establishment and growth of the young tea was reported in No-SR plots, during the first year after planting, in spite of incorporating 3 kg of compost in the planting hole, at Ratwatte, Balangoda and Handford Estates (AR 2001, pp 30-32). Was this unexpected result due to an overdose of a high pH compost raising the pH to above optimal levels? The pH should be a consideration in all treatments with organic amendments. In the trial at St Joachim Estate however, the performance of young tea in No SR plus compost (rate not mentioned) was equal to that of SR.

In an experiment in the mid country, SR plots were reported to have yielded 3871 kg/ha, in the first cycle, as against 1248 kg/ha in No SR without soil amendments (Jubilee Volume, p 58). In another trial (that utilized for the economic analysis quoted above) the casualties during the first year were 68% in No SR plots as against 13% with SR. There may be other trials with such high responses, and still others with a very low or no response. Comparing past events and circumstances associated with these trials may throw some light on how SR improves the growth of young tea. Were there exceptional circumstances, which could explain the different responses? Check on site characteristics [land suitability, slope, soil depth, stoniness etc.], weather factors [dry spells, heavy rains with uneven water logging or erosion], quality of nursery plants used, whether mulching was adequate, etc. Were the No-SR plots infested with nematodes, affected by root disease or subject to erosion? Such details may have been recorded but not reported. Would it be possible to get some clues by revisiting the records? If the experiment (quoted above) is continuing, what is the present position? Every attempt should be made to extract as much information as possible from these expensive long-term experiments.

In situ soil rehabilitation with grass before uprooting the old tea merits further investigation. This should be approached as a soil rehabilitation cum soil conservation measure; the soil conservation aspect may even be more important. The grass should be planted at a density that does not unduly affect the movement of pluckers, and maintained over an extended period (say 3 years). It may suffice to neutralize any allelochemicals or toxins produced by the old tea. In addition, establish contour hedges of closely planted grass, spaced every 20 to 30 feet depending on the slope.

Some tea plantations cannot properly harvest all their fields due to a shortage of workers. An alternate approach to soil rehabilitation may be tried out on such plantations. Temporarily diversify fields earmarked for future replanting to Gliricidia, Calliandra or similar species to produce dendro energy and green manure. An extended period (4-8 years) under these species, with income generation to offset costs, may prove adequate to rehabilitate the soil.

Weed Management

Research on weeds is conducted under Thrust A24: Development of weed management strategies in tea.

Background

Cleanliness (of his tea fields!) was the yardstick by which a tea planter was judged!! 'Clean weeding with the scraper' was the accepted weed control practice perhaps since tea cultivation began. Monthly rounds of scraping the soil surface to remove weed seedlings was the norm. A simple and extremely effective technique. Unfortunately, it was equally effective in scraping the top soil downhill and into the ravines. Although 'selective weeding' which, in effect was 'selective scraping' was advocated since the 1930s, and sporadic attempts were made to use herbicides in the 1950s, and in spite of

banning the scraper by an Act of Parliament in 1951, the use of the scraper went on unabated into the fourth quarter of the twentieth century. Nor has it completely vanished yet (TRI Update June 2006). In 1985, TRI estimated that a clean-weeded, poorly-managed tea land in the mid country lost 20 tons of soil per ha, in six months.

The advent of paraquat provided the opportunity to develop practical alternatives to manual weeding. The first series of TRI Advisory Circulars on the use of herbicides was issued in 1971 and schemes of weed control integrating the use of simazine, paraquat, diuron and manual weeding were recommended. This set of circulars was replaced in 2003 by Advisory Circulars WM 1, 2, and 3.

Weeds and weed management was not an issue during the 1995 problem census. In meetings with Regional Plantation Company CEOs, in preparation for the 2003 CP revision, they drew attention to the need for control measures for problem weeds such as Passali Kodi and Getakola.

Thrust A24 is comprised of three projects 24.1 Screening of herbicides, 24.2 Control of problem weeds, and 24.3 Integrated methods of weed management (listed as Economics of weed management in the CP). This is basically a monodisciplinary thrust; only project 24.3 has a 10% input from Agricultural Economics.

Progress and results

In Projects 24.1 and 24.2, a large number of herbicides and mixtures of herbicides have been screened for general use in weed management, as well as for the management of hard-to-kill weeds (HTKW) such as Passali Kodi or Wal Nivithi *(Anredera cordifolia)*, Getakola *(Spermacoce hispida)*, Arunadevi *(Wedalia trilobata)*, Borreria *(Borreria latifolia)*, Habarala *(Caladium bicolor)*, Amalai *(Commelina sp.)*, Wel Kohila *(Syngonium podophyllum)*, Bovitiya *(Clidemia hirta)*, Morning glory *(Ipomea learii)*, Couch grass *(Panicum repens)* and Illuk *(Imperata cylindrika)*.

The herbicides and mixtures of herbicides, which could be integrated into the management of many of the HTKW, have been identified. Preliminary information on rates and frequencies of application is available. Control measures for Getakola, Arunadevi, Borreria, Couch and Illuk have been included in Advisory Circular WM 2 issued in 2003. Progress made in the management of Passali Kodi, Habarala, Amalai, and Morning glory have been reported in Annual Reports and in other publications, and further testing is underway. However, the control of Wel Kohila and Bovitiya has proved to be very difficult; none of the chemicals tested up to now gave adequate control.

Project 24.3 Integrated weed management: Recognizing the looming problems of worker shortages, high cost of herbicides, herbicide residues in made tea and environmental hazards, mechanical, cultural and biological weed management techniques are also being explored. Using a wire cord mounted to a brush cutter was found to be more economical than slashing and sickle weeding. *Brachiarria* grass and *Arachis pintoii* were tested as bio-control agents to suppress an infestation of a Panicum sp. at Venture Estate. Both species can invade Couch grass within two years; *Arachis* appears to be more effective. Investigations on the bio-efficacy of an aqueous extract of Ginisapu seeds *(Michealia champaca)* are in progress. A 16-32% solution gave good control of Passali Kodi, and an array of weeds. An application for a patent is pending.

Cost appraisal studies on use of various herbicides and herbicide mixtures are in progress at Hemingford, Galphella, Balangoda and New Peacock estates.

Comments and suggestions

TRI recommendations on weed management are presented in Advisory Circulars WM 1, 2, and 3. WM1 and 3 cover general aspects. WM 1 explains the different components of integrated weed management, and WM 3 gives advice on the safe and effective use of herbicides.

WM 2 describes the seven recommended herbicides, their mode of action and dosage, and very brief notes on their use. It also includes the dosages of herbicides/herbicide mixtures for controlling five HTKW weeds.

WM 2 serves as a good summary, but this is too important a subject to be restricted to a single circular. Each herbicide and each problem weed deserves a separate circular.

WM 1 is a good account of the various elements that go to make up integrated weed management. But the grower will appreciate more practical advice as applicable to real life situations. There is a need to provide guidance on developing basic year-round weed management programmes, for example, "an average stand of seedling tea (with vacant patches) in a wet low country area, with weed flora comprised of (include some problem weeds) etc." Provide guidance on how to slot in control measures according to seasons (January-March dry season, onset of SW rains, mid monsoon period, August dry spell etc. etc), and the density and composition of weed flora. Discuss the options available for each application and the basis of selecting the appropriate herbicide. Indicate the weed species that are likely to 'escape' and build up. Emphasize the need to assess the field situation before each operation, and that control measures are not applied on a routine basis but must always be tailored to the weed growth. Provide guidance on spot spraying. Also, how and when to deal with 'problem' weeds.

An Advisory Circular on weed management in young tea clearings should be published. This circular should cover the period starting from levelling the land for replanting up to the first prune.

A new challenge has arisen. EU countries have recently imposed a general restriction on the use of certain herbicides. Some herbicides recommended by the TRI such as MCPA, Oxyfluorfen, Diuron and Glufosinate Ammonium are included in this list. Responding to representations made by the TRI, the inclusion of these four herbicides in the EU positive list for tea is under consideration.

Glyphosate and 2, 4-D residues were recently detected in tea consignments exported to Japan and the EU. Following this detection TRI conducted trials according to FAO guidelines on maximum residue level (MRL) studies. The results demonstrate that when the herbicides are used, as per recommendations, the residues are below the stipulated MRL. Consequently, the temporary ban of 2, 4-D was lifted by Japan.

These incidents are a timely warning. They emphasize the need for urgent and continuing education of growers on the danger of misusing pesticides.

Water management in tea fields in drought prone areas

The Corporate Plan lists the following research activities on water management:

Thrust A19 Development of water management for young and mature tea in drought prone areas to minimise casualties and to enhance yields.

Background

Although tea is generally cultivated in the wetter parts of the country, receiving rains from both monsoons, extended spells of dry weather are not uncommon. The low country and mid country tea areas and the Uva are more likely to be affected by droughts. In most tea areas, which receive rain from both monsoons, the main dry period extends from January to March. In areas such as Uva that depend mostly on northeast monsoon rains, the dry period extends from June to September. Both young and mature tea plantations are affected by drought and suffer considerable losses due to poor establishment and casualties in young clearings and among infillings, poor recovery from pruning, stem dieback, increased susceptibility to stem canker, deaths and loss of crop. Shallow, gravelly soils with a low water holding capacity, and the high temperatures experienced during these times aggravate the drought effects.

Thrust A19 was planned to investigate the scope for and feasibility of irrigation to mitigate the problems caused by droughts. This is a relatively new area of research in the TRI that commenced in 1998, and has been accorded high priority (Priority Group1) under the CP. The following projects, A19.1 to 19.3 were planned in 1999, and 19.4 and 19.5 were added in the 2003 roll over.

A19.1 Determining quantity of water and frequency of application for drought susceptible clones
A19.2 Evaluating existing technologies for water application in tea
A19.3 Evaluating the microclimate in irrigated tea
A19.4 Water harvesting in tea lands
A19.5 Climatic forecasting for cultural operation in tea lands

These projects address the concerns expressed at the 1995 problem census: 'Early warning system from TRI on weather/drought forecast not available' and 'No guidance on water management'.

Progress and results

Project A19.3 has not commenced. Project A19.5 is not being pursued as short term forecasting is not technically feasible.

Under Project A19.4 an experiment on rainwater harvesting at Craig Estate, Bandarawela, was planned in collaboration with Maskeliya Plantation Ltd, Central Engineering Agency of the Irrigation Department and Hydrology Department of University of Peradeniya. However, the project was abandoned due to its high cost – the estimate for construction of check dams was over Rupees one million.

Five experiments were laid out under A19.1 and 19.2 in low country, up country and Uva estates. The yield response of selected cultivars (TRI 2023, TRI 2025, TRI 3072, DT1 and DN) to fertigation (frequency, quantities of water and nitrogen) were investigated in these trials. Drip irrigation equipment was used for fertigation. The trials have been in progress for 1-2 cycles and the results could be summarized as follows:

There was a higher yield response to fertigation with the drought susceptible cultivars. A very high response was seen in TRI 2023. The lowest response was recorded with DN. The fertilizer requirement in fertigation was about half the standard recommendation. Water use is about 1.8-2.4 liters plant^{-1} day^{-1}. The best frequency during dry weather was daily fertigation at 1.5 liters plant^{-1} day^{-1}. Tasters did not detect any differences in quality between teas from the fertigation and control plots.

Comments and suggestions

Considering the high level of priority accorded to this thrust the progress has been slow. The focus of the research has also veered away from the original objective of drought mitigation to fertigation, as a general practice, irrespective of season. All this, no doubt, reflects the impracticable nature of the exercise undertaken. Apart from a few exceptions with perennial streams, estates cannot find a source of water during the drought. And unless water is available under gravity head it would not be feasible. Pumping is not likely to be economical.

The response to fertigation is only in wet weather. During dry weather, humidity is also very low and a response to fertigation is unlikely. The availability and cost of liquid fertilizers are the constraints to fertigation.

Further studies in order to develop fertigation as a general practice, for both young and mature tea, during periods when water is available, are recommended. More cost- effective drip systems should also be explored.

In an earlier study (not under this thrust), a soil injector was tested for sub soil irrigation of young tea. This appears to be a more feasible proposition for drought mitigation in young tea plants up to 2 years of age. If water is available close to the field a person can inject 500-750 plants per day. Review the results obtained with this technique with a view to formulating interim recommendations.

Another approach to overcome drought casualties in high yielding popular cultivars is to exploit the advantages of using grafted tea plants (Thrust A38, project 38.8). Graft combinations for drought tolerance were identified in the 1980s and the advantages of using these grafts have been demonstrated (TRI Update). In 2003, two machines, for making the scion and the stock have been developed to speed up the process. However, adoption by growers has been poor and ascribed to insufficient information, insufficient skill development and higher costs.

It is now more than two decades since TRI commenced work on grafting. Stock-scion combinations that confer drought tolerance and nematode tolerance have been developed. High yield and high quality combinations are being tested, and more research of a similar nature is in progress under the CP. Obviously, the TRI has faith in the soundness of the technique and that the grafts deliver the desired results – drought tolerance, etc. Although the cost of a grafted plant is marginally higher, the long-term advantages would more than offset this. It is really a simple technique well within the capabilities of our workers. Although it is not well known as to who developed this technique first, South India is using it in a big way. Why have we failed? Who lacks the enthusiasm to make it work – TRI or the industry? Most probably both, in equal measure.

Introduction of mechanical devices for harvesting and other agricultural operations
Research activities on mechanical devices are conducted under the following thrusts:

Thrust A20 Development of harvesting devices to overcome labour shortage, and
Thrust A21 Development/Adaptation and introduction of mechanical pruning methods

Background
Harvesting (or plucking) is the most labour intensive operation in tea cultivation. It also makes the largest contribution to the cost of production. Over the past three to four decades, from time to time, estates have on their own initiative tried out manually operated shears or motorized machines. At first, the objective was to cut costs but later on, reducing the labour requirement was the main goal. However, these early attempts were soon aborted due to the inferior quality of the harvested leaf. With the worker shortage assuming alarming proportions especially in the low country the TRI initiated the evaluation of available machines in the 1990s.

Manual removal of branches with a sharp knife is the traditional method of pruning. Selective pruning requires a high level of skill; it is also labour intensive, requiring 40-60 workers/ha. To overcome the shortage of workers and escalating costs some growers resorted to using motorized brush cutters. Inability to selectively remove debilitated branches and dead wood, requiring follow up work with the knife, splitting of branches and damage to the cut ends leading to dieback, and the poor maneuverability of machines with long levers were the major drawbacks of using brush cutters.

During the 1995 problem census, issues such as the shortage of workers, lack of mobility of workers within the plantation sector, and out-migration of workers were discussed. "Lack of labour for harvesting in the low-country", "Lack of mechanical plucking systems" and "Inadequate research on suitable mechanized harvesting for rush crops" were specifically emphasised.

Thrusts A 20 and 21 were designed to address these issues.

Progress and results
Thrusts A20 and 21 are in progress. A number of experiments have been conducted on machine plucking at Hapugastenne, Raigama, Balangoda, Noragalla and Galaboda Estates. The Kawasaki NV 60H motorized machine was evaluated extensively on different clones and at different frequencies of plucking, and at higher rates of zinc and K fertilizer. The results however were disappointing with machine plucking significantly reducing yields by 33-40% and increasing coarse leaf by 20-30%.

Prompted by the poor performance of the motorized machines a manually operated selective tea harvester has been developed. The new TRI Selective Tea Harvester (TSTH) is a light, maneuverable device that can achieve a level of selectivity comparable to plucking by hand whilst increasing the intake per plucker considerably. The TSTH has won national and international awards and TRI has obtained a patent [Patent No 11206] for the device together with Messrs P P P Jinadasa (Pvt) Ltd that produces the TSTH for sale to the tea industry.

Under Thrust A21, modified versions of a knapsack type brush cutter were tested. As the improvements resulting from the modifications were marginal, TRI embarked on developing a new pruning machine. The new lightweight hand-held pruning machine developed by the TRI consists of a geared motor and a circular saw with tungsten tips, powered by a portable generator. Being light in weight and small in size it is highly maneuverable and allows branches to be cut at any desired height and to clean the frames. This operation is facilitated by a trigger type switch placed on a side handle. The high speed of the blade gives a sharp, clean cut. The output of the pruning machine is 750 bushes per man-day. The circular saw blade needs to be replaced after pruning 5-6 hectares at a cost of around Rs 600/-. It is claimed that using this pruning machine will effect a labour saving of around 65% and reduce costs by about 35 %. A 0.6 KVA generator can operate two pruning machines.

The hand pruner has been patented in Sri Lanka [Patent No 12345] and arrangements are being made to manufacture the machine. In a typical operation, three workers are needed to operate the machine and one for manually cleaning and tidying up the pruned frame. Its advantages in comparison to manual pruning are:

- 15 pruners/ha against 50 pruners/ha
- Cost saving of 35%
- No difference in recovery
- Lopping medium shade: 0.6 workers/ha against 3.0 workers/ha
- Lopping mana: 5 workers/ha against 20 workers/ha.

Although it was not a component of these thrusts, the TRI has developed and patented a lightweight plucking basket [Patent No 12519]. If the TSTH is used together with this plucking basket, a remarkable improvement in the quality of leaf delivered to the factory could be expected.

TRI has also developed and patented a Deep Fertilizer Applicator [Patent No 13467]. Further testing and modifications are in progress.

Comments and suggestions

The operation of the TSTH was observed during a visit to Gouravilla Estate, Upcot. Gouravilla has 300 ha of tea in bearing and a large extent is being harvested with the TSTH (74 ha: VP 44 ha and 30 ha old seedling tea [OST]). This estate has successfully introduced the TSTH in spite of having an excess of workers. Gouravilla has 1160 registered workers, with a female to male ratio of 55:45, and an outturn varying from 65-85%. In many aspects, the performance of the TSTH has been encouraging:

- Plucker-intake increased: in OST 16.2 to 23.6 kg; VP 19.2 to 24.7 kg
- Labour requirement reduced: in OST from 10.8 to 7.9 per ha; VP from 22.3 to 13.2 per ha
- Good leaf % increased: from 62% to 74%
- Plucking cost reduced: by 13%
- Rounds increased, and refuse tea reduced by 1.5%
- Better yield
- Average monthly earnings of a worker increased from Rs 4,156 to Rs 5,365

A major reason for this success was the commitment, patience and perseverance of the superintendent and the supervisory staff. Restricting the TSTH to men, to start with, appears to have contributed to this success. At first women pluckers did not want to give up their blocks for machine harvesting as they felt the men will spoil the plucking table. Now, after the men have acquired the skills to use the tea harvester, they are happy to pluck fields harvested with the TSTH. Men are able to deliver a very high standard of leaf without damage to the plucking table. They are very quick with the TSTH – they can earn two names by noon, and are capable of doing a third name, if allowed. There were no complaints of difficulties/problems such as wrist pain. The only complaint was that the quality of the selective harvesters presently available is poor – the tray tends to crack. Harvesters available earlier were of better quality. TRI should bring this to the attention of the manufacturer.

Success stories however, are few. A large number of field programs had been conducted for tea pluckers, field staff and management on the use of the TSTH and the new plucking basket. The program consisted of a lecture, video film, demonstrations and training sessions. During the January to April 2002, '100 day program' 106 estates (about 1800 workers, 620 staff members) and 300 smallholders were covered (AR 2002). In spite of all this effort, the adoption of these innovations is well below expectations. Surprisingly, it is hardly used in the TRI estates either.

The TSTH is an important advance and it is a pity that the level of adoption is poor. It may not be perfect but it is a handy devise that is effective and efficient. It is far superior to the machines that have been tested before, and is the best available option. The TSTH should be promoted vigorously. Improvements can be made based on the feedback from the users. As an essential step, both estates of TRI must adopt the TSTH to the maximum.

Estates should consider reasonable monetary incentives to pluckers using the TSTH. Estate practices may need to be changed: extra names, cash plucking, contract plucking etc. A win–win situation has to be created to overcome the reluctance to use the TSTH.

It was interesting to note that the men using the TSTH at Gouravilla are averse to using the new plucking baskets. They feel it is infra dig. They ask, "Plucking is bad enough, are you trying to turn us into 'women', and make us a laughing stock in the community?" Although it may seem an insignificant or comical remark there is a lesson to be learnt here. It indicates the importance of anthropological studies when attempting to introduce major changes to the plantation culture.

By 2002, the TSTH had been patented, won awards at national and international events and was being promoted among growers. However, there is no advisory circular devoted to the subject of mechanical harvesting. Advisory circular HP 2 on Plucking, issued in March 2003, carries just two lines on mechanical harvesting as follows: "Mechanical harvesting should be sought if hand plucking is impractical due to scarcity of labour. Under such conditions TRI Selective Tea Harvester could be used". There is not even a reference to any other publication on the subject. Why such step-motherly treatment to a Gold medal-winning invention? Nor is there an advisory circular on the gold medal-winning light weight plucking basket!

Work on the hand pruner was completed in 2004 but it is not yet in the market. Arrangements should be made to manufacture, market and promote the hand pruner without any further delay.

The Deep Fertilizer Applicator shows much promise. Likely benefits from this applicator are: deep placement of fertilizer in the root zone, greater uniformity in the quantum applied per plant, minimising losses due to volatilization and washing-off, reduction in the worker requirement to fertilize young tea, and possibly a reduction in the fertilizer requirement. Experiments to determine the growth response of young tea to fertilizer applications with this device should be expedited.

3.3 SOILS AND PLANT NUTRITION

The Corporate Plan lists 22 applied research projects and 12 basic research projects under the programme of the Soils and Plant Nutrition Division (SPND). The progress with respect to these research projects is given below.

Thrust A 15. Development of regional and site specific fertilizer recommendations for improvement of productivity and made tea quality.

Project A 15.2. Estimating crop response to macro nutrients at regional level.

Background

TRI conducts laboratory, glasshouse and field experimentation to make recommendations to stakeholders on all aspects of fertilizer use. Although requiring considerable planning, much time and high financial input, the Institute has consistently adhered to the practice of conducting field experiments in its substations as well as in growers' fields before issuing recommendations. Accordingly, the project under discussion describes field studies on urea and sulphate of ammonia as sources of nitrogen, rates of addition of muriate of potash and use of Eppawela rock phosphate (ERP). The development of site specific fertilizer recommendations is also discussed herein.

Progress and results

Nitrogen

TRI has carried out a number of experiments for over thirty years comparing the effectiveness of urea and ammonium sulphate. These studies have proven conclusively that urea is as effective as ammonium sulphate for mature tea grown in the up country, mid country and the low country as a source of nitrogen. Furthermore, urea is cheaper than sulphate of ammonia on a kg N basis and does not cause problems of soil acidification as sulphate of ammonia.

Out of 80 reports from field experiments conducted from 1999 at St. Coombs and at estates in Deniyaya, Galle, Hali Ela, Maskeliya, Passara,, Pelawatte, Ratnapura and other locations, only 29 have given a response to nitrogen. This low number of responses is rather surprising given the large losses usually associated with soil nitrogen, the high uptake by the tea plant and yield sensitivity of the crop to this element. The nitrogen levels used in the field experiments varied from 0 to 720, 100 to 500 and 240 to 600 kg/ha/yr. The range tested in most experiments was 240 to 600 kgN/ha/yr.

Potassium

Out of 31 reports from field experiments conducted from 1999 with potassium on the sites mentioned above, not one showed a yield response to this element. The levels of K tested were 48 to 480 (only one experiment), 100 to 500, 120 to 300 and 120 to 480 kg K_2O per ha/yr. These and other experiments conducted during the earlier decade have not provided data to justify recommending more than 100 kg K_2O/ha/yr to the tea crop.

Phosphorus

Two long term field experiments were begun at St. Coombs in 1989 and at Walahanduwa Estate in Galle in 1994 testing ERP at levels ranging from 0 to 120 kg P_2O_5/ha/yr. These have not given a yield response after 10 and 5 years respectively. The 0-15 cm soil P values of the control plots at St. Coombs and Walahanduwa were 7.5 and 8.8 ppm P respectively in 1999.

Site specific fertilizer recommendations

The Circular No SP 3 of TRI issued in July 2000 has recommended fertilizer nitrogen on the basis of targeted yields of made tea for a given block of land. In addition guidelines have been prepared recently on P and K fertilization based on the soil test values. These approaches can bring substantial savings to many growers from reduced P and K fertilizer use.

Comments

1. The lack of response to added N fertilizer while reaching a yield level as high as 5000 kg/ha at Lumbini Estate, Deniyaya, and 6000 kg/ha at Talgaswela Estate, Galle for the addition of only 240 kg N/ha, as stated in the Annual Report for 2000, is difficult to comprehend when the TRI recommendation for a yield of 3500 kg tea is 400 kg N/ha/yr. Such unusual behaviour calls for careful study and thought. One possibility is that a considerable amount of N in the soil is in organic form that mineralises and adds to the inorganic pool. Another factor is the question of reliabililty of the data gathered by the field staff of the estates. While it is not possible for TRI staff to be present at each plucking event, it must be admitted that if the field staff furnishes inaccurate data, results obtained from such trials may lead to incorrect recommendations to the industry and adversely affect the reputation of TRI as well. Bringing the Estate Field Officers to the research stations occasionally, providing them with training, explaining the importance of their work and offering them hospitality may have a desirable effect in developing fruitful partnerships between the TRI and the collaborating estates.

2. Another consideration in the conduct of field trials is the uniformity of the land. In fact it is reported that the first action Eden took in 1928 was to carry out a uniformity trial at St. Coombs on the proposed experimental site before laying out the famous trial. This seems to be a lost art at present.

3. That application of green manure adds N and other plant nutrients to the soil is well known and even mentioned in TRI Advisory Circular No.S 11 of September 2001. The nutrient content of loppings of shade trees in tea growing lands has also been published. However, the TRI Advisory Circular No. SP 3 of July 2000 that gives the fertilizer recommendations for mature tea, refers only to the application of chemical fertilizers. Since it is likely that fair quantities of N can be added to the soils by green manure, by way of loppings from shade trees, reducing the quantities of recommended chemical fertilizers in such circumstances should be taken into consideration. The non-issuance of an Advisory Circular on the plant nutrients brought into the tea growing lands by organic

sources seems to be a shortcoming, especially when the Institute is actively promoting application of such materials.

4. While the responses to potassium from field experiments conducted in the last ten years have been extremely scarce, those conducted earlier have given responses in some trials. However, the Committee has not come across any evidence of a yield increase beyond the addition of 84 kg K_2O/ha/yr in the entire history of field experimentation by TRI. It must be remembered that muriate of potash has been continuously added to much of the tea growing lands for nearly 80 years, and since the quantities recommended have been always higher than the estimated K removal by plucking, a K build up in the soil may have inevitably taken place. This could be a reason for the lack of responses at present. It is unfortunate that TRI did not include a zero treatment of K in the trials of the last decade, having known from the earlier trials that studies are needed in the range 0 to 100 kg K_20/ha/yr.

5. At Glennore Estate, where the range of K tested was 48 to 480 kg K_2O/ha in an experiment begun in 1991, there was no response to addition of K above 48 kg K_2O. The soil test value here was only 72 ppm K. The results of these experiments seem to indicate that potassium fertilizer additions can be substantially reduced, or even curtailed for a few yeas in soils having "high" K values. What this high value should be, may be arrived at by examining the K soil test values of the locations at which the field experiments have been conducted. A perusal of the K soil test values of many lands from the records available at TRI indicate that very large amounts of money could be saved by reducing K fertilizer usage in some properties. In fact if the present recommendation of 100 kg K_2O/ha is halved, a saving of about Rs. 2500 per ha can be made per year.

6. A reduction of phosphorus fertilizer application is likewise possible after looking at the soil test values for P, as responses to application of phosphorus fertilizers in the hundreds of field experiments conducted across the country for a number of years are extremely scarce. As for potassium, phosphorus too has been added for more than 80 years and has probably built up over the years in the soil to a level where addition of P fertilizer is not necessary at present. P soil testing may also provide substantial savings.

7. The adoption of site specific fertilizer recommendations by stakeholders is expected to increase in the future as they realize that the soil nutrient values particularly P and K, vary from one land to another, have accumulated over the years and that fertilizer requirements will depend much on the P and K soil test values. Accordingly, TRI must develop new skills and adopt new strategies in this field. Increased attention must be paid towards obtaining representative soil samples from growers' lands where soil characteristics may vary significantly within short distances. Analytical methods should be developed that are simple, reliable, rapid and inexpensive. Publicity in the media, preparation of leaflets and distributing them and in-house training of extension officers of TRI and TSHDA should be carried out. The subject should be discussed at E & E Forum, RSCs and Crop Clinics. Additionally, consideration must be given towards setting up a mobile service that analyses soil samples and provides recommendations at the property itself.

Project A 15.2.1.1. Application of different proportions of sulphate of ammonia and urea on soil/plant status and yield on Clone TRI 2025.

Background
Although TRI had made a provisional recommendation for use of urea for tea way back as 1967, the first Advisory Circular recommending fertilizer mixtures for mature tea containing only urea as the source of N, was issued in 1983. With the withdrawal of sulphate of ammonia that contains more sulphur than nitrogen, from application to mature tea, concerns were expressed on the possibility that sulphur may become a limiting plant nutrient in time to come. Several field experiments were thus initiated to look into this aspect.

Progress and results
A 20 year field experiment testing urea and sulphate of ammonia carried out at St. Coombs Estate, Talawakelle, has shown that the soil sulphur levels in plots receiving urea have decreased over time, although the crop did not show sulphur deficiency symptoms, nor a yield decline in comparison to sulphate of ammonia treated plots.

Comments and suggestions
It is very likely that if the trial is continued, both appearance of deficiency symptoms and yield decline could occur in urea applied plots. Such field experiments are extremely valuable as they provide very useful information.

TRI should initiate long term experiments in every substation and in carefully selected growers' lands, so that all major soil types are covered, to enable finding out the following:

(a). The soil sulphur level for each soil type where yields are limited by lack of S in soil.

(b). The levels and sources of sulphur that should be added for optimal economic benefits.

Such experiments could produce sulphur deficiency symptoms that will provide opportunities to scientists, extensionists and growers to learn to identify the deficiency.

Project A 15.3. Estimating crop response to micro nutrients (Zn, B and Mn etc.) at regional level

Background
Deficiencies of micronutrients have occurred in cultivated crops in many parts of the world during the last few years. This is mainly owing to crop removal of micronutrients from soil without replacement, as the practice followed has been largely the addition of only fertilizers containing N P and K. Although chemical fertilizers have been added to tea grown in Sri Lanka for more than 70 years, the addition of micronutrients has been confined only to a few of them, and that too begun relatively recently.

Progress and results
Field experiments to study the effect of commercially available micronutrients containing foliar formulations Multiplex and Kiecite along with conventional zinc sulphate solutions on yield of tea have been initiated. These experiments were started at St. Coombs, Talawakelle, Baddegama Estate, Baddegama, Madulkelle Estate, Madulkelle, Greenwood Estate, Nawalapitiya and Indola Estate, Deniyaya. The experiment at St.Coombs was

initiated in 1999 while the others commenced in 2000. The trial at Baddegama Estate seems to have been discontinued in 2003, since the Annual Report of 2004 makes no mention of it. The other trials are continuing.

The results obtained thus far indicate that application of Multiplex and Kiecite have shown an increase in yield of tea.

Comments and suggestions
1. The testing of Multiplex and Kiecite that contain more than one micronutrient does not permit identification of the particular nutrient responsible for yield increases. If some of the micronutrients are not required, the grower incurs an extra expense with no returns. Furthermore, additions of unnecessary micronutrients, many of which are in the heavy metal category, can cause toxicity problems to plants. Having high levels of heavy metals in made tea may become matters of concern to importers from a human health point of view.

2. A comprehensive survey of the micronutrient content in the different soil types in the tea growing lands would be useful in identifying deficient areas and facilitating site selection of future field experimentation.

Thrust A 16. Development of regional and site specific dolomitic limestone recommendations for ameliorating soil acidity and enhancing soil productivity.

The projects A 16.1, A 16.2 and A 16.3 for establishing dolomite requirements for soil rehabilitation with grass, for tea nurseries and for young plants have not commenced owing to lack of staff and resources.

Project A 16.4. Establishing dolomite requirements for better growth of mature plants in different tea growing regions at soil series level

Background
Tea is a plant that prefers soils with a pH range of 4.5 to 5.5. While many of the soils in the tea growing areas are acidic, use of nitrogenous fertilizers that carry an ammonium ion such as ammonium sulphate causes further soil acidification as ammonium is converted to nitrate in soil by bacterial action. In fact urea causes soil acidity too since urea is converted to ammonium carbonate when added to soil, and the ammonium gets converted to nitrate to produce hydrogen ions. But owing to the presence of the carbonate ion, the acidifying effect of urea is much less than that of ammonium sulphate.

Since excess acidity is harmful to the tea crop, dolomite is commonly added to the land. The research here is on the quantity of dolomite to be added, frequency of addition and the optimal particle size to be used.

Progress and results
A large number of field experiments to determine the effect of addition of dolomite has been conducted across the tea growing areas for a very long time. Some of the trials are continuing. A few experiments have shown yield increases to the addition of dolomite. However, yields have often declined when more than 2t/ha/yr dolomite was added. Particle size of dolomite did not influence the yield of tea, or its addition yearly, mid cycle or at the beginning of the cycle. The effect of adding dolomite on the changes in the pH of the soils has been reported only once and for one estate.

Thrust A 17 Development of fertilizer/dolomite applicator for improving broadcasting efficacy and to overcome labour shortage.

Project A 17.1 Evaluating and improving the efficiency of fertilizer applicators.

Progress
The progress in the development of the fertilizer applicator has been slow during the last six years mainly owing to limitations in availability of technical expertise. The project continues.

Thrust A 18. Development of regional analytical laboratories for soil, plant and fertilizer analysis.

Project A 18.1 Establishment of regional analytical laboratories.

Background
Apart from the well equipped analytical laboratory at Talawakele, TRI has established laboratories at Hantane and Walahanduwa, Galle, for the purpose of providing chemical analytical services in soils, plants and fertilizer materials to estates and smallholders.

Progress
The total number of soil samples analysed at the laboratories in Talawakele, Walahanduwa and Hantane in 2005 was 19,620, 3012 and 20 respectively. The very low number at Hantane is owing to lack of laboratory staff. Two Atomic Absorption Spectrophotometers used for determining micronutrients and costing over Rs 5 million each are not in working condition at Hantane and Galle laboratories. Service charges for such equipment are very high and spares are hardly available in Sri Lanka.

Comments and suggestions
1. With the future trends towards use of site specific fertilizer recommendations, the number of soil samples from the 435 estates and 397,223 small holders requiring chemical analysis is expected to increase significantly. The three laboratories need to be upgraded and suitably staffed to meet the upcoming situation. If efficiently operated these laboratories may receive requests for soil analysis from those cultivating other crops as well. Setting up a new laboratory to serve Uva also merits consideration.

2. Limiting the acquisition of very expensive equipment such as the Atomic Absorption Spectrophotometer to only one location and transporting the samples or their extracts for final analysis to this laboratory is another matter for consideration.

3. The Walahanduwa laboratory has ample space and much adjoining land for building construction. Expanding the services of this laboratory to include entomology, nematology and plant pathology as well may find favour with stakeholders in the region.

Projects not commenced, not completed or abandoned due to lack of resources .

The following projects although listed in the Corporate Plan, have not commenced, not completed or abandoned owing to lack of resources, mostly staff.

A 1.3 Screening lines for response to native and applied nutrients in up country.

A 2.3 Screening lines for response to native and applied nutrients in mid country.

A 4.5 Screening lines for response to native and applied nutrients in low country.

A 5.3 Screening seed stock for response to native and applied nutrients in up country.

A 6.3 Screening seed stock for response to native and applied nutrients in mid country

A 7.3 Screening seed stock for response to native and applied nutrients in Uva

A 8.3 Screening seed stock for response to native and applied nutrients in low country.

B 32 Estimating N utilization coefficients using labelled isotope techniques

B 33 Refining foliar sampling techniques

B 36 Developing a technique to estimate dolomite residues with a view to estimating suitable particle size

B 37 Assessing effects of soil applied dolomite on mobility of cations and nutrient uptake

B 39 Refining methodologies to determine the fate of soil applied nutrients

B 40 Evaluating nitrifying inhibitors for urea under controlled conditions

B 63 Downstream pollution by fertilizer application to tea fields in central hills.

The interruption of the SPND research programme will adversely affect other programmes as well owing to the interdisciplinary links with other divisions. Ultimately, stakeholders will not get the services due to them and are not likely to be satisfied with TRI excuses of staff shortages.

General comments

1. The Review Team noted that in many of the NPK experiments testing different levels of the nutrients, the lowest level of nutrient employed was on the high side. For example, many of the nitrogen trials began with 240 kg N/ha/yr, while the corresponding value for potassium was 120 kg K_2O/ha/yr. When no yield response is obtained as for K, the large number of experiments conducted that take almost 10 years for completion end with no valuable information. In hindsight, it is clear that the experimenter should have had a zero control, or say about 20-30 kg K_2O/ha/yr. It is most unfortunate that the TRI did not have the correct control treatment considering the fact that many of the experiments did not give a significant yield increase as mentioned before.

2. The concern of TRI that control plots may signify an economic loss and an unsightly appearance to the grower is indeed valid. On the other hand, having lush growth in all the trial plots is not going to help solve the problems of the stakeholder, for which purpose the trial is initiated in the first place. It is the view of the Team that TRI explains these issues carefully to growers whose lands are being requested for field experimentation, explaining the need for proper controls. We very strongly recommend that the TRI develops a mechanism to compensate the growers for any economic loss suffered as a result of the conduct of the trials.

3.4 PLANT PROTECTION

Introduction

Divisions of Entomology and Plant Pathology are involved with carrying out research related to screening of new cultivars and seed stock bushes for resistance or tolerance to various plant diseases, pest insects, mites and nematodes and research related to the management of these diseases and pests to minimize the crop losses to maintain the profitability of tea cultivation while contributing to the environmental conservation. In addition to applied and basic research projects catering to these needs, divisions of Entomology and Plant Pathology deal with service type research projects to assist growers and marketing organizations especially in identifying and controlling damage causing microorganisms, insects, mites and nematodes in field cultivations and in made tea. As all the other divisions in the Tea Research Institute, Divisions of Entomology and Plant Pathology too are expected to focus their research on thrust areas identified in the Corporate Plan for the period of 1999 – 2007 along with attending to currently emerging field problems related to diseases and pests.

Screening lines for resistance to Shot Hole Borer (SHB), Live Wood Termites(LWT), Blister Blight (BB), Stem Canker and *Poria* Root Disease, and Root Lesion and Burrowing Nematodes

Being a perennial crop in a more stable habitat, dependence on sustainable methods of pest management like cultivation of tolerant or resistant clones or cultivars would be a long term solution for most of the pest and disease problems affecting tea. One of the objectives of the crop improvement programme of TRI is to develop high yielding cultivars of good quality with resistance to pests and diseases. Thus, a major emphasis has been given to the screening of high yielding cultivars for pest and disease resistance in identifying thrust areas of research in the institute's Corporate Plan. Screening lines for pests and diseases are carried out under Thrust Areas, A 1.2, A 2.2, A 3.2, A 4.2, A 1.6 and A 2.5.

Screening lines for resistance to SHB

Assessments for Shot Hole Borer resistance have been carried out at the time of prune in phase trials established by the Plant Breeding Division. Out of the Annual Reports published since 1999, AR 2001 reported about 9 PB series clones as susceptible compared to the standard susceptible clone TRI 2026 at Deniyaya, 11 clones more susceptible compared to TRI 2026 at Ratnapura and 35 PB series clones as susceptible compared to TRI 2025 at St. Coombs. Annual report of 2002 reported that out of 59 test clones screened at St. Coombs, 9 clones were found to be resistant to SHB and 3 were extremely susceptible (Clones were not specified). As prevalence of SHB is considerably low in some of these areas, it does not seem logical to carry out screening

trials for resistance to SHB in locations like Talawakelle and Ratnapura with low pest pressure. In the assessments done in Hantane TRI 4046 has been found to be resistant to SHB. Twenty nine clones had been reassessed to revise an Advisory Circular and clones TRI 4043, 4042 and 4045 have been certified as suitable for borer active areas in Uva. Laboratory bioassays done to screen for SHB resistance using mean number of galleries in 30cm length stem cuttings can be considered as a quick method of screening. Inadequacy of details of results presented in ARs and lack of continuation of presenting progress of on going trials in ARs is noted. Serious consideration has to be paid if this lapse is due to discontinuation of the projects identified as vital in fulfilling the objectives of the thrust area. TRI Advisory Circular PM 2 (2/03) lists 26 clones tolerant or resistant to SHB.

Screening lines resistant to Live Wood Termites (LWT)
Maintenance of experimental blocks for screening of clones (152 clones in one division, 37 clones in another and a number of 4000 series clones in another) planted in 1990, 1998 and 1997 in Hapugastenna Estate for LWT resistance and the progress of selections are continuously reported in ARs from 1999 to 2004. Advisory Circular PM 3 (6/03) lists 31 high yielding clones tolerant and 11 high yielding clones resistant to LCLWT.

In these trials, where different cultivars are screened for resistance to SHB and live wood termites, no mention is made on the degree of pest pressure in the respective locations. Estimation of population densities of the relevant pests at the time of assessment for tolerance or resistance is essential to compare the performance of tested clones in various locations. Basic research projects, B 29 and B 30 will be very valuable, if the protocols can be developed to screen cultivars by laboratory bioassays because in laboratory bioassays, performance of clones under varying pest densities can be observed.

Screening lines for resistance to Blister Blight (BB)
Old seedling tea bushes with varying degree of resistance to BB have been selected in UC to be included in the breeding programmes. Cuttings taken from the selected bushes were screened for BB resistance in the nursery and the progeny of TRI 2043 has been found to be less susceptible to BB than that of clone TRI 2023. Further screenings have been carried out in phase I and phase II trials in 2003. There is no mention on the clones selected as resistant in ARs. TRI Advisory Circular DM 1 (1/02) on BB management lists 9 resistant and 5 moderately resistant clones to be grown in areas with BB incidence.

Screening lines for resistance to *Poria* Root Disease
In a screening trial established in 1998 at St.Coombs, out of 5 clones exposed to *Poria* Root Disease for two and a half years, clones TRI 2025, 4052 and 3072 were found showing high level of resistance to *poria*. In another trial, clones TRI 4042, 2025, 3014, 4006 and 4046 were observed to be resistant in that order. These screenings for *Poria* resistance were carried out continuously at St. Coombs. However, no resistant clones are recommended in the Advisory Circular DM 2 (2/02) for the management of the disease.

Screening lines for resistance to *Macrophoma* Stem Canker in the low country
Though some screening trials have been carried out for resistance to *Macrophoma* Stem Canker in low country no resistant clones are recommended in the Advisory Circular on the management of this disease.

Screening new cultivars for resistance/tolerance to Root Lesion and Burrowing Nematodes in UC and MC

Screening trials have been started at Talawakelle to screen TRI 4000 series clones for Root Lesion Nematode resistance and at Hantane to screen 3000 and 4000 series clones for Root Lesion as well as for Burrowing Nematodes. Another screening trial for these Nematodes was started in Passara. In the trials at Talawakelle, clones TRI 4052, NIL 53 and K 145 were found to be suitable for Nematode areas. Clones, TRI 4052, and 3069 are reported as resistant and clones 4006, 4014, 3019, 3055, 3015 and 3069 are reported as tolerant in mid country. Though the screening of lines issued by the Plant breeding division have been continued in UC, establishment of new trials for screening for Burrowing Nematodes in MC station has been abandoned since 2002. No resistant clones are recommended in Advisory Circulars for Nematode management .

In trials screening for resistance to Root diseases and Nematodes, it is reported that the pits are inoculated before planting the new clones there by creating a pathogen or Nematode pressure on the clones to select resistant clones.

Screening seed stocks for resistance to SHB, LWT, BB, Stem Canker and Poria Root Disease

These screenings are to be carried out under Thrust Areas, A 5.2 (UC), A 6.2 (MCWZ), A 7.2 (MCDZ) and A 8.2 (LC). Though the discussions with the relevant scientists revealed that some of these screenings are carried out, details of such screenings are not reported in ARs.

Development of cost effective control methods for Integrated Management of SHB (A 22)

A 22.1 – Screening synthetic insecticides for SHB

A considerable number of experiments (4 in 2000, 2 in 2001, 4 in 2002, and 3 in 2003) have been carried out to screen a number of insecticides for SHB control and the results are given in ARs. It is rather unusual to note that in many of these studies there was no significant difference between insecticide treatments and the untreated control (E27 of 1999, E 275, E 295, E 296 of 2000, E 303, ME 15, LE 87, E 307 of 2002). In some experiments, post treatment pest population levels in treatments are higher than in the untreated control. If the experiments were correctly designed and correct methodology was adopted, this kind of result indicates that the insecticides tested have no effect at all in controlling the pest. Or else, the methodology used is not correct. May be that the distribution of the pest in the field and pest population levels are not taken into consideration in designing the sampling units.

A 22.2 – Screening Biocontrol agents for SHB

Four strains of the fungus, *Beauveria bassiana* imported from CABI Bioscience and two strains isolated locally have shown promising effects in laboratory bioassays. But the performance of these fungal strains in field applications is reported to be not satisfactory. Attempts made to mass culture of these fungal strains are promising. Studies need to be carried out to increase the field efficiency through formulation and perfecting the method of application. Popularization of microbial pesticides is required because of the need to restrict the dependence on synthetic insecticides.

A 22.3 – Identifying shade tree species as diversionary hosts for reducing SHB
Plant species attracting SHB and allowing gallery making without further development of the beetles have been identified and are been field tested with the aim of using them in fields with high reported incidence of SHB.

A 22.4 – Time and method of pruning for reducing SHB
Results of a study carried out in 2001 confirmed the earlier findings and it is recommended to prune at 45cm retaining lungs at the beginning of the monsoon as a prophylactic measure. These specifications on pruning are not included in the Advisory Circular PM 2 for SHB management.

A 22.5 - Modifying K fertilization for reducing SHB
No conclusive results shown.

A 22.6 – Identifying semiochemicals for reducing SHB
Volatile compounds capable of attracting the beetles from tea bark have been identified and tested with positive results. Project is abandoned in year 2000 as the research officer working on the project has resigned from TRI. Abandoning research projects due to resigning of one scientist is not an acceptable reason for a premier research station like TRI.

A 22.7 – Computerized data base and modelling of yield damage relationship
A population dynamics model has been developed and collection of necessary data are being carried out. Introduction of such novel methods using modern technology is commendable and the necessary facilities and encouragement should be given to such researchers. Establishment of a data base for SHB using long term population data maintained at the TRI should be initiated for this purpose and lacking information should be collected through further studies. SHB population distribution maps covering all the tea growing areas have been developed as an initial step.

Though 7 projects are designed to generate information necessary to formulate an IPM program for SHB, there seems to be no new improvements in the management strategy for SHB. Failure to work out economics of crop loss in different tea growing areas, cost of control and correlations of pest density and crop loss are serious lapses in the research plan as these are essential in designing pest management programs in a perennial crop like tea.

A 23 – Biological control of major pests and diseases of tea with a view to reduce usage of pesticides
Under this thrust three projects have been initiated to isolate and test natural antagonistic microbes and VAM for the regulation of root diseases and a series of experiments to isolate and test antagonists for Nematode suppression. Studies carried out in relation to the effect of adding organic manure and in relation to the evaluation of Nematode incidence in organic tea fields are promising and will be of value in formulating IPM strategies for tea nematodes.

Basic Research Projects

B 29 – Refining screening techniques for resistance to LWT and SHB
Though laboratory bio-assaying methods have been tested as rapid screening techniques for resistance to SHB and LWT no usage of these techniques in screening programs is reported.

B 30 – Biochemical and physiological bases for resistance to SHB, LWT and Root Lesion Nematodes
Work initiated on the biochemical basis of resistance to SHB and termites has been abandoned due to resigning of the relevant research officer. This is not an acceptable reason. Relevant studies related to Root Lesion Nematodes are in progress.

Supporting Projects

D 17 – Nematode management
Necessity to phase out the use of CH_3Br had lead to conduct a series of studies to test alternatives like solarization and new nematicides and incorporation of organic material for Nematode control. However, the current Advisory Circular on nematode management PM 4 (5/02) does not recommend the use of such non-chemical approaches except the use of wild sunflower.

D18- Management of UCLWT
Though a considerable number of insecticides have been tested, no success has been achieved in controlling these termites. Lack of information on proper method of application, proper method of assessment of efficacy of treatments and a method for early detection of termite infestation are reported as constraints.

D 19 – Management of LCLWT
Initiated work on this project has been abandoned due to the resigning of the research officer handling the project.

D 20 – Identification of safe insecticides, acaricides and designing IPM methods for seasonal pests
A series of chemicals have been tested for Tea Tortrix, mites, Scavenging Termites and Deniyaya Ants but without any promising results. However, the Advisory Circulars recommend a series of chemicals to control these insects. In practicing IPM, chemical pesticide application for curative purposes has to be done in accordance with the development of pest populations. In none of the advisory circulars, growers are advised to monitor the pest populations as a decision making tool for application of synthetic pesticides. Even in the recommendations for a pest like Tea Tortrix which is regulated by an effective parasite, no guidelines are given regarding the situations under which a grower should use the recommended chemicals. A great concern is shown in recommending only a single acaricide, Omite for the control of mites and the limited availability of the chemical for the growers. In the management of mites, as the introduced predatory mites are reported to be effective, TRI could initiate a programme for mass rearing of these predators and supply to the growers on demand at a reasonable price. As biological control is identified as a priority area in the Corporate Plan, TRI needs to initiate such projects as long term solutions for such pest problems. This is a feasible strategy and the necessary know how could be obtained from Coconut Research

Institute, where cultures of biological control agents are continuously maintained for augmentative releases in the grower's fields.

D 21, 22, 23,24 – Management of Leaf, Stem, Root and Phloem Necrosis Diseases
Based on the field screening of fungicides, the revised advisory circular DM1, 1/02 is released for the control of leaf diseases. Application of a protective paint and training of bushes are being tested for the management of stem diseases. Screening of fungicides has lead to the release of revised advisory circular DM2, 2/02 for the control of root diseases. Work on Phloem Necrosis Disease was abandoned in 2001 due to financial difficulties.

D 25 – Miscellaneous projects
Some work has been carried out in identification of the agent causing High Forest Problem and Horse Hair Blight.

Comments and suggestions

1. Lack of considerations for worker safety is noted in laboratories. Storage of fungicides in working laboratories, non-availability of fume cupboards in laboratories where chemicals are handled and preparation of tea for the staff in laboratories itself are some examples noted.

1. None of the research stations where entomological work is carried out are equipped with an Insectory. An insectory is a basic requirement for rearing test insects and carrying out laboratory bioassays using insects.

2. During discussions it was revealed that there are no protocols developed for the functioning of laboratories. If protocols are available, smooth functioning and continuation of work will be possible even in the absence of a particular member of the research staff.

3. Lack of laboratory facilities for Plant Pathology and pathologists at Ratnapura substation can be a constraint in dealing with pathological problems in fields in that area.

4. Junior level research staff members are not given adequate opportunities to learn new techniques and/or to get exposed to any other research institutes at least within the country.

5. In the division of Entomology, the interest shown for the control of seasonal pests such as Tea Tortrix and mites is not adequate. As reports indicate a reduction in effectiveness of the Tea Tortrix parasite, *Macrocentrus homonae* imported and released as far back as 1930s, TRI should give more attention to that problem and find solutions to remedy that situation. TRI should not loose such a valuable parasite after more than 70 years of its existence. If the necessity arises, TRI should attempt to have a facility for mass rearing and augmentative releases of that parasite.

Emerging challenge

1. Maintain the quality of made tea in terms of pesticide residues with increasing restrictions on Maximum Residue Levels (MRL) imposed by importing countries.

Recommendations to meet the challenge

1. Promote non-chemical methods of pest and disease control. More emphasis has to be given to biological methods of control and use of natural products.

2. For emergency applications when pest/disease incidences increase very rapidly, work out pesticide recommendations (doses, frequency of applications, time of applications, pre-harvest intervals etc.) based on local conditions rather than using recommendations given by pesticide manufacturers. This requires properly designed pesticide screening studies under different climatic conditions and analytical facilities for residue analysis.

3. Growers should be advised to monitor the development of pest populations and to use pesticides only when it is essential when giving insecticide recommendations in Advisory Circulars.

3.5 BIOCHEMISTRY

Project B 26. Preformed and induced chemical resistance in tea plant against Blister Blight

Background

This study is conducted to determine how enzymes are regulated during infection of tea plants by the Blister Blight causing fungus *E vegans*. It also seeks to establish a chemotaxonomic guide which could be used to screen tea cultivars for blister blight resistance. While the multiple benefits of shaded trees to the crop and the land are well known, the potential risk of spread of Blister Blight owing to excess shade is also common knowledge. This study assumes importance for that reason.

Progress and results

The formation and enhancement of proanthocyanidin in the plant as a defence response after blister blight attack is a new finding. The anthocyanins derived from cyanidin and delphinidin present in cultivar TRI 2043 have been shown to be fungitoxic.

The enzymology of flavonoid biosynthesis in the tea leaf has been reported for the first time. This opens the door for development of tea plants with better defence mechanisms against infection by pathogenic organisms.

Comments

The information gathered on the enzymology of the flavonoid pathway can help in the breeding programme to incorporate disease resistance to tea. The work carried out has produced original contribution to knowledge and resulted in several publications in reputed international journals. Advanced research of this nature can help Sri Lanka to develop better varieties for the future at greater speed.

Project B 18. Use of DNA markers for molecular characterisation of tea

Background

The identification and characterisation of tea cultivars is commonly performed by using morphological characters at present. A limitation of this method is dependence of plant growth on soil, climate and other conditions that affect the growth of plants. The

project seeks to determine the genetic identity of existing cultivars that could be used to plan breeding strategies.

Protocols for large-scale and mini-scale extraction of DNA have been developed. Genetic diversity and relatedness of several tea accessions have been successfully assessed. These have shown that they are generally very close, particularly the estate selections.

Few genetically diverse cultivars have been identified as potential parents in plant breeding towards generating heterozygosity.

Comments
These breakthroughs are likely to ultimately reduce the time required for breeding and releasing new cultivars and should be encouraged and pursued.

B 60. Comparison of quality parameters of organic vs conventionally grown tea

Background
There is world wide concern on adverse health effects brought about by the consumption of food that has been produced with the use of pesticides and other chemicals. Consequently, many people pay much higher prices for organically produced food items. This project seeks to find out whether organically grown tea possesses better quality characteristics than those from conventionally grown tea.

Progress and results
Results showed that conventional teas have significantly higher TF and TR content while some organic teas have higher fibre content. There was no significant difference in polyphenols, caffeine and soluble solids between the teas, nor did tasters find any difference between them.

59. Determination of Polycyclic Aromatic Hydrocarbons in tea.

Background
Tea can get contaminated with carcinogenic poly aromatic hydrocarbons (PAH) owing to leaks in the heat changers during manufacture. The project seeks to determine the levels of PAH in Sri Lankan teas.

Progress and results
Levels of carcinogenic polycyclic aromatic hydrocarbons found in tea were well below the limits set by importing countries. PAHs could not be detected in the tea liquor.

D 30. Development of multi-residue methods for the analysis of pesticide residues in tea.

Background
The tea importing countries are expressing concerns about the levels of pesticide residue in made tea. Residue analysis is both expensive and time consuming. Development of multi-residue analytical methods would reduce costs and save time required for analysis.

Progress and results
Methods of analysing a number of commonly used pesticides by a single analytical procedure have been developed. These studies also showed that the residues from commonly used pesticides were well below the stipulated limits set by the main importing countries.

Comments
Findings of this study will reduce the costs of pesticide analysis residues as well as shorten the time required for such analysis.

A 22.6 and B 17. Development of Chemical/Biochemical methods in the control of Shot-Hole Borer

Project postponed due to lack of staff

B 19. Establishment of biological effects of black tea consumption

Background
The supply of tea in the world at present is estimated to be in excess of the demand by 1-2%. In fact this has supposedly led to stagnant tea prices in the world market during the last few years. The active promotion of tea as a natural beverage with numerous health benefits is likely therefore, to assume much importance. The objective in this study is to establish the health benefits of tea to support its generic promotion.

Progress and results
The growth of *Candida*, a yeast like fungus that is found in the oral cavity, is inhibited by tea extract. Likewise, pathogenic species of *Staphylococcus* bacteria that cause root canal infections in the oral cavity are inhibited. This is brought about by the catechin and theaflavin present in black tea.

Comments
The competition, the tea industry will face in the future will not be so much between the tea growing countries as much as with the producers of other beverages. Therefore, the health benefits of tea must be further researched upon and brought to the attention of the world. Active collaboration between the TRI and the universities in forming a strong partnership in research on health aspects of tea would indeed be fruitful.

Chemical characteristics of different types of tea produced in Sri Lanka

Background
Although a very small country, Sri Lanka possesses a wide array of soils, climates and water regimes. It is therefore likely that tea grown in diverse environments may have different characteristics that give rise to different flavours and health benefits and many other benefits hitherto not identified. This study is expected to bring out these differences regionwise. Such information may be useful in marketing of teas as well as in blending them to offer products with a range of characteristics.

Progress and results
While very useful information has been thus far gathered in the chemical and biochemical characteristics of teas grown in different regions, the project has been suspended owing to lack of staff.

Effect of tea on health

A considerable amount of research has been conducted on the effect of black tea on health in collaboration with the National University of Singapore, University of California, Davis and Sri Lankan universities.

3.6 TECHNOLOGY

The goals of the Institute, as stated in the Corporate Plan among others included, improving Quality of made Tea and developing value added tea products,

- Automation and computerisation of tea manufacture and reducing of energy and other costs, and
- Establishment of Food Hygiene and attaining ISO Standards.

As progress made during few years prior to the formulation of the Corporate Plan 1999-2003, it identified,

- Recommendations that lead to replacement of plywood tea chests by paper sacks for packing of Leafy Teas,
- Recommendation of a revised Formula for a Made Tea to Green Leaf outturn percentage in the Low Country, and
- Establishment of a simple rapid method for determination of moisture content in Green Leaf, Withered Leaf and Made Tea using a Microwave procedure.

The Corporate Plan 1999 – 2003 identified the need for reduction of cost of processing as the main area of activity on post harvest technology. This is to be approached by research on,

- Devising a more rational Made Tea to Green Leaf Outturn Formula
- Cheaper packing materials
- More effective energy use and
- Cheaper ways of energy production.

The Revised Corporate Plan 2003-2007 had no changes to the above aims.

Reduction in Cost of Electrical Energy

The following research Thrust relating to Cost of Electrical Energy is included in the Corporate Plan (CP).

Thrust A 25: Development of technologies to reduce the cost of energy used in the tea withering process.

Background

As per the CP, work on this Thrust was expected to benefit all regions, had an estimated Cost of Rs.1, 490,207 over a three-year period and the expected output was recommendations on rational energy use.

The process of withering consumes electrical energy to drive the fans and heat energy to enhance dryness of air when atmosphere is too humid. This Thrust concentrates on reduction of electrical energy component only.

Specific Consumption of electrical energy for processing of Tea is approximately 0.75 kWhr/kg Made Tea. For the production of 310 Million kg/yr, Sri Lankan Tea industry

therefore consumes 232 million units of electricity for processing of tea. This is 2.6% of the total electrical energy produced by the Ceylon Electricity Board and is 7.1% of the total consumed by the industrial sector including agriculture. The National Supply meets more than 90% of the electrical energy requirement of tea factories and the balance is self generated using diesel as the source of fuel. At present (January 2007) the unit cost is Rs. 9.72 per kWhr and taking the kVA cost etc, effective cost of electricity works out to nearly Rs 10.80 per kWhr and the cost of electricity for tea processing works out to over Rs 2.5 billion annually.

The process of withering, where a large quantity of moisture is removed at near ambient temperature within a 10 to 18 hour period, consumes about 40% of the total. In Rupee terms it is Rs 1.00 billion per annum.

Today, Electricity is the largest cost item in the manufacturing process. Research on possible saving in the expenditure on Electrical Energy is therefore highly relevant. If cost effective methods are found that could have a substantial impact across the processing sector.

It could be surmised that the targeted output of research on this thrust would lead to a recommendation, which

- Is cost effective
- Is applicable across the processing sector
- Has no negative impact on quality and
- Have no risks to the image of Ceylon Tea.
- The Thrust continues to be important in the future as well.

Prior to the CP, an investigation on suitability of variable speed drives for controlling speeds of withering fans has been done under the Project B/ENGY. Rationale for this project was the following.

Process of withering slows down as leaf withers and that there is no necessity to supply the same volume of air throughout the process to get the required wither.

- Electrical energy consumption of a fan motor is directly proportional to the cube of the fan speed whereas the volume flow is linearly proportional. Therefore speed reduction is a very efficient method of reducing volume flow of fans.

- Prior to popular acceptance of electronic technology, changing of speeds of fan motors involved belt drives, clutches, etc., which were rather cumbersome in Axial Fan applications such as in the withering process. Alternatively, use of two speed motors was possible, but these were not commonly available in the market. With electronics, speeds of motors could be changed at will using speed controllers, also referred to as Variable Speed Drives (VSDs) which basically converts the AC wave form to DC form and reverts to an AC form at any desired frequency which determines the speed of the motor.

- VSDs are used extensively in industries where different speeds are necessary in processes.

- VSD as a method of reducing the speed of withering trough fans during the latter hours in the process may therefore be a suitable method to be adopted.

Progress and results
Thrust A 25 had three projects.

1. Project 25.1: Evaluating the use of speed controllers in trough withering system
2. Project 25.2: Modifying existing trough withering system
3. Project 25.3: Development and evaluation of dehumidified air techniques

The Project 25.1 has been confined to testing of VSDs supplied by traders. During the course of testing VSDs, the importance of controlling the hygrometric difference has been studied as well. It has been found [AR1999] that by controlling the wet and dry bulb temperatures at the recommended range a 20% saving in electrical energy can be achieved. *[This finding is not clear at all]*. It was also found that a 40% saving could be achieved by controlling the flow of air by VSDs. In subsequent years the saving noted with another make had been 39%.

At the E & E Forum in 2002 as well as in AR 2002, the results were presented and there was a reference to harmonics generated by the VSDs, which was not quantified and the use of harmonic filters was suggested. No negative effect whatsoever on the quality of the tea produced or any other risks have been documented.

The rationale of the Project 25.2 is not clear. In 2000, this project was terminated.

The same is true for the Project 25.3, which was referred to as testing of a "cost effective" dehumidified air unit developed by the University of Moratuwa. There is no record of the technique being employed. Expectations have been to reduce cost of drying by reducing the temperature of drying air and to determine any improvements in tea character. The project seems to have been abandoned in 1999 and there is no reference in subsequent Annual Reports or in the Revised Corporate Plan 2003 - 2007.

Additionally, a non-numbered activity has been reported in AR2004 where, reduction of the cost of electrical energy in withering, using an improved withering fan driven by a low horsepower motor was investigated. This was found to save 26% of the energy. No cost benefit analysis was shown.

TRI recommendations
Institute has published a recommendation as Guideline 2/03 in June 2003 titled "Towards saving electrical energy", with a caution on harmonics. Later, use of speed controllers has been recommended in the Circular No. 14/03 in September 2003 titled "Trough withering of tea", with little emphasis on the new finding.

Comments and suggestions
The Institute neither possesses the competence nor the facilities required for development of electronic units such as VSD. Furthermore, there is no need for such development as VSD is a widely used electronic item. Therefore, the approach adopted by the Institute in confining to the task of testing of VSDs for its suitability for adoption in the withering process is correct.

Primary objective of this project should have been

- To assess the suitability
- Confirm existing knowledge
- Develop the technique using units supplied by the traders
- Quantify the saving and therefore the cost effectiveness
- Make these findings known to the industry and
- Influence policy makers at national level in promoting adoption.

Suitability of VSD has been demonstrated and savings quantified in AR1999 to AR 2004. Details given in these reports however show that withers achieved was very soft despite the length of withering period being well over 12 hours. This is totally unacceptable, at least to the discerning audience. Reader, if went into detail, would have doubted the ability of the VSD controlled fans in getting a proper wither. It appears that the researchers were not alert to this obvious shortcoming. It also appears that psychrometry, the science of moist air, is totally ignored by the researchers.

The question of harmonics generated by VSDs has been over-stressed. Creation of harmonics should have been known and nothing to be alarmed of, if the researchers had the required knowledge in Engineering or at least the habit of browsing the Internet! The suggestion in the AR2003 that the harmonic filters available in the market are not up to the requirement is rather naïve and the decision to develop it in house so as to overcome this problem is even more so.

The Project 25.1 was declared as completed in 2004. Only publication was the one in S.L.J. Tea Sci. in 2002, which was based on 1999 findings. It is not clear why the findings on VSDs were downplayed in the Circular 14/03 and in fact why a separate Circular was not issued. Considering the huge impact, Institute could have done more research on this subject and used all its influence to promote the use of VSDs across the Industry. This is particularly surprising when the impact is over Rs1.50 per kg at that time and the payback period is only 2 years. Findings have been reported at the Energy Managers Association of Sri Lanka. Regrettably that is not a place Planters or Factory Owners go for reference.

Reference to speed controllers in the Circular 14/03 is totally out of proportion to the impact it can make in the industry. It is very likely that most readers would not even have read the Circular fully as it was a revision of a very old Circular on a subject well known to them.

Further, there is no record of the Institute taking the message to the national policy makers. With proper influence Sri Lanka should have converted all its troughs to VSD Controlled troughs, saved Rs 400 million per annum by spending Rs 800 Million across the Industry. It is not too late to get this message across even now. No assessment of the adoption rate of VSDs has been carried out. It is guessed that not even 20% of the factories use this technique, a technique with very attractive return on investment.

The Institute thereby lost a golden opportunity to make a significant impact to the industry.

The attempt to develop harmonic filters better than what is available in the market is a good example of the Institute failing to identify its core group of researchers (by profession). Engineers have had only very short spells with the Institute; particularly the Electrical Engineers who would under normal circumstances find the scope of work at the Institute and professional recognition very unattractive. Expecting an occasional traveller to take root at the Institute is wishful thinking indeed.

Projects 25.2 and 25.3 are not well thought of projects. Thinking process prior to starting up a project where clear identification of methodology, expectations and assessment of the value of likely results does not seem to have taken place. It is not surprising that these two projects were aborted soon.

Details of results of the investigation on low horsepower fans are not documented for the stakeholder to see. Even in the AR2004, no cost benefit has been demonstrated. It is known that these fans are efficient but a very careful test is necessary to identify real efficiencies from the fake. The Institute once again failed to discharge its responsibility.

It is to be noted that stakeholders, along with the traders, conduct investigations such as the projects in this Thrust, without necessary equipment or the competency. No doubt many get caught to traders who take undue advantage of the ignorance of the user. This is not satisfactory. The Institute must become the advisor of choice to the stakeholder. Institute must as a matter of urgency equip itself to test fans, not in factories but at a special testing site. Thereby, the Institute will be able to carry out investigations of this nature in a more professional manner.

Once benefits are quantified, the Institute should use its influence to make recommendations adopted across the industry without delay. Published information, if genuine, indicate substantial savings that could be accrued with no risk to the industry.

Reduction in Cost of Heat Energy

The following research Thrust relating to Cost of Heat Energy is included in the Corporate Plan (CP).

Thrust A 26: Development of technology to reduce the cost of energy used in the tea drying.

Background

As per the Corporate Plan 1999 –2003, the purpose of this Thrust was to reduce the cost of drying. The work was expected to benefit all regions, had an estimated cost of Rs. 948,875 over a two-year period and the expected output being recommendations on rational energy use.

The process of drying consumes heat energy to raise the temperature of air to the required level and electrical energy to drive the fans and ancillary motors. This Thrust concentrates on reduction of the heat energy component only. Any achievement may give a spin off benefit in reducing the cost of withering and re-firing [a process common in Leafy Tea process] as well.

Firewood is the source of fuel for generation of 90% of the heat energy requirement of tea factories, and diesel or other fuel oils that are more expensive than firewood provide

the balance. Diesel fired installations, which are mostly in the corporate sector factories, are now being changed to firewood. This has become possible due to these estates expecting to achieve self sufficiency in the near future by planned fuel wood plantations. In contrast, private tea factories have no control over the land base and as far as the fuel wood supply is concerned they are today in a most vulnerable position.

At the present delivered cost of Rs.1, 200 per cubic meter [a bulk measurement where each cubic meter can be assumed to weigh about 250 to 350 kg] and with an output of 170 to 200 kg made tea / cubic meter, effective cost of fuel for firing [the jargon used in the industry] works out to approximately Rs.6.00 to 7.00 per kg. Nationally, the process of tea drying costs well over Rs.2.0 billion per annum.

As per estimates made by the Energy Conservation Fund in 2005, total consumption of firewood in Sri Lanka is 4,372 TOE (Tons Oil Equivalent), which is equal to 11,505 tons of firewood. Tea Industry consumes approximately 500 tons per year, which is 4.3% of the total national consumption.

If the conversion ratios alone are considered, the process of conversion of chemical energy from fuel to useful heat energy in air is rather inefficient. However, once it is appreciated that the need is for clean air at near constant temperature and that clean fuels are very costly and that perfect combustion of fuels need sophisticated equipment which are neither cost effective nor affordable to the Tea Industry, the process does not appear as that inefficient. Then the approach is to look for cheaper, sustainable alternatives and elimination of avoidable losses in conversion systems.

When looking for cheap, sustainable sources of fuel, naturally the attention is on solar energy. Sri Lanka is blessed with plenty of sunshine hours everyday and the positivism will have to stop at that. Tea is grown in the wet zone where cloud cover and rain are always possibilities. As such, one would be looking for trapping solar energy when available. It is known that simple solar collector systems cannot generate high enough temperatures required for the process of drying although it can generate sufficient temperature for the process of withering, but then, withering is primarily a night time process. Storage of heat is not a cost effective alternative either.

Research on possible saving in the expenditure on fuel for firing is therefore highly relevant.

It could be surmised that the targeted output would lead to a recommendation, which

- Is applicable and cost effective across the processing sector or in certain regions and/ or during certain periods
- Has no negative impact on quality and
- Have no risks to the image of Ceylon Tea.

This Thrust continues to be important in the future as well.

Progress and results

Thrust A26 had two applied research projects

1. Project 26.1: Developing and evaluating solar energy techniques

2. Project 26.2: Adapting wood gasifiers [in collaboration with NERD]

Additionally, there had been two basic research projects and a few non-numbered divisional investigations surrounding heat energy and dryers. They are,

1. Project B43: Development of direct firing heaters for drying tea

2. Project B46: Increasing the efficiency of step-wise FBD3 by optimising the weir height in each section

3. Divisional Investigation 1. Design and development of efficient, cost effective waste heat recovery system [A collaborative project with NERD], and

4. Divisional Investigation 2. Development of an electronic temperature indicating and Alarm Unit for the FBD.

Project 26.1 commenced in 1999. However, many years prior to that, similar investigations have been done under the Project B/EDRY.

Work on this project has been carried out at a site near St Joachim Factory. Financial assistance for the project has been received from Swedish International Development Corporation channelled through the National Science Foundation.

A detail report on the findings of this project is given in the Annual Report 1999. There, the air supply to a diesel-fired heater was pre heated by a solar collector. Data suggest a saving of very creditable 33% in the fuel consumption. An estimate of financial returns has been given where the capital cost has been indicated as Rs 2,000,000 for a factory producing 500,000 kg per annum, a saving of Rs.1.60 per kg, which amounted to a 34% saving indicating a pay back period of 4.5 yrs if the unit is used for 8 months in a year. The net present value of such an investment would be around Rs 500,000. At a lower utilisation period of 6 months per year the net present value is negative. Further details have been published in the J. Natn. Sci. Foundation Sri Lanka in 2004.

In the Revised Corporate Plan 2003 – 2007, this Project 26.1 is earmarked for deletion in 2004.

The wood gasifier designed, fabricated and commissioned by the NERD Centre that was installed at St Joachim factory premises in 1999 has been found to have numerous teething problems that could not be overcome successfully. Project 26.2 seems to have been abandoned. There is no reference to it in the revised CP.

The basic research project B43, titled "Development of direct firing heaters for drying tea" commenced in 1999 and was abandoned the same year on a recommendation of the Consultative Committee on Research. This project had an estimated capital cost of Rs 4 Million.

It is reported in the Annual Report of 2000 that findings of Project B46: Increasing the efficiency of step-wise FBD3 by optimising the weir height in each section, is that a constant height Fluid Bed Dryer is not inferior to any step wise arrangement. No details have been given. This Project was terminated in 2000 and was deleted in the Revised Corporate Plan of 2003 –2007.

Other than initial designs, no progress has been reported on the design and development of efficient, cost effective waste heat recovery system [A collaboration project with NERD].

An Electronic Temperature Indicating and Alarm Unit for the FBD has been developed and was made available to factories on request. Thirty four units were in order as at end 2004. This innovation is covered by the Patent No 13620 granted in 2005.

TRI recommendations

There had been no Circular recommendations emanating from results of this Trust.

Comments and suggestions

In Annual reports of 2000,2001,2002,2003 and 2004 no further findings on the solar project have been reported. It is most regrettable that the reason given for not generating further data is frequent breakdown of the heater and the fan [Not the solar collector]. This should never have been an excuse in conducting a research project. Unfortunately, due to absence of maintenance and long periods of neglect, the unit is today in a dilapidated state. The Institute is trying to clear the area by disposing it somehow which indeed is a pity. This may in fact be the only industrial size solar collecting unit in Sri Lanka.

Several technical and viability questions remain unanswered. To list a few,

- What is the relationship between the temperature gain and the efficiency?
- What is the most cost effective loading ratio [between the solar heater and the normal heater]?
- What is the answer to the problem created by temporary cloud cover?
- What are the possible improvements to the design?
- What is the cost of a new unit if fabricated using information gathered so far?
- What is cost effectiveness when coupled to a firewood-fired heater?
- With cost of firewood rising sharply wouldn't this technique be cost effective on a future date and at what unit cost of firewood will it break even?
- Isn't there any area in the tea country where one could expect this technique to become feasible sooner, and so on?

The findings of this project have not gone to a level to get published as a recommendation. Nevertheless, findings are useful and may become more useful in the future. Findings should have been presented at an E & E forum, so that at least the stakeholder gets to know the limitations of the solar energy option.

The Project 26.2: Adapting wood gasifiers, seems to have been abandoned. However, the Institute should not ignore the tremendous scope the industry has in achieving self-sufficiency in its total energy needs and the use of gasifier technology in co-generation. Considering the ever-increasing cost of imported fuels, purchased firewood and the cost of electricity, and the considerable success achieved in growing wood species within tea plantations and the new impetus in growing species such as Gliricidia [already nominated as a fourth plantation crop] one could seriously expect more progressive plantations to achieve self sufficiency in energy in not so distant future. In that instance, the Institute should be prepared to play its role in providing technical know-how and for that reason alone the gasifier project should in fact be activated immediately.

It is not clear why someone thought of a project on direct firing. It is common knowledge that direct firing is a distant possibility only when fuels are very clean, but then clean fuels are expensive and need more sophisticated burning equipment. Further, Sri Lankan tea tasters are very discerning on one part and on the other the industry does not venture into areas where there is image risk to the industry. Sri Lanka must continue to have a very clean, high quality image.

Although the reported conclusion on project on multi step fluid bed dryer finds no improvements to the older design, it is difficult to imagine such an arrangement to be any inferior to a constant height arrangement at least so far as efficiency is concerned.

The development of an Electronic Temperature Indicating and Alarm Unit is a praiseworthy attempt. It is now understood that the project is at a standstill as the officer who developed the unit is not in employment due to Institute's inability to absorb him following rules on recruitment. This is yet another management problem that is worth solving.

Institute lacks competence in the field of energy auditing. For an audit to be useful, auditors must not only be technically competent but also be very familiar with the practical conditions. Officers of the Institute with a little training and confidence building can provide the energy audit service to the industry that indeed would be welcome by the stakeholders. It will also help the officers to get "accepted" by the stakeholder.

Reduction in Cost of Packaging

The following research Thrust relating to Cost of Packaging is included in the Corporate Plan (CP).

Thrust A 27: Development of alternative packing materials for bulk tea.

Background

As per the Corporate Plan 1999 –2003, the purpose of this Thrust was to reduce the cost of tea packing. The work was expected to benefit all regions, had an estimated cost of Rs 405,135 over a four-year period and the expected output being recommendations on alternative packing materials.

Essential requirements of a bulk tea package are its ability to withstand the journey from the Factory to the local buyer and sometimes to the foreign purchaser, its ability to prevent any deterioration of the quality of tea and its ability not to change the size spectrum of the particles. A decade ago plywood tea chest was the preferred form of packaging bulk tea in Sri Lanka. Today, sacks made out of Paper or Paper Board have completely eliminated the chest. The Institute may have had a role to play in effecting this change as claimed in the Corporate Plan 1999 –2003, though it is common knowledge that this was essentially a market driven change.

Typically, cost of packing varies from a low of Rs.1.60 per kg for small leaf tea producer in the up and mid country to a high of Rs 2.50 per kg for large leaf tea producer in the low elevations. Total annual expenditure on packing material can be estimated to be between Rs 600 to 700 million.

Research on possible saving in the expenditure on packaging is therefore highly relevant.

The institute does not possess expertise in paper technology. Therefore the work in this Thrust may be confined to testing of newer products made/ selected/provided by vendors and to influencing national policies on packaging. To effectively conduct these functions the researchers will have to be familiar with the international methods of testing these sacks and components. Lack of knowledge may lead to unscrupulous vendors making use of the Institute to get recommendations on sub standard products, which on the face value appear adequate but capable of causing an image risk to Ceylon Tea. Availability and use of sub standard sacks is a problem facing the industry. Lack of care adopted by the producers, particularly the bulging sack problem is an irritation faced by the buyers. Frequently it comes up for discussion, for example at the CTTA.

It could be surmised that the targeted output of this project would lead to recommendations, which

- Are applicable across the processing sector
- Have no negative impact on quality and preferably give more stable keeping quality
- Have no risks to the image of Ceylon Tea.

This Thrust continues to be important in the future as well.

Progress and results
Thrust A27 had one applied research project.

1. Project 27.1: Evaluating new types of paper sacks

Prior to the CP, investigations of this nature have been conducted under Project D/TECH.

Annual Report 1999 reports the results on two different popular makes of sacks and finds both failing. It is not clear what the corrective action was. Again the Annual Report 2001 reports in detail results on two other makes of sacks. They too have failed the Drop Test. The Annual Report 2003 reports on testing of three makes of sacks without giving any details.

TRI recommendations
There had been no Circular recommendations on packing materials.

Comments and suggestions
In terms of sizes, sacks used in Sri Lankan Tea Industry differ slightly from the ISO. This is not a major concern. It is however important for Sri Lanka is to ensure that the sacks used have the necessary barrier properties to sustain the quality and a construction to give the mechanical strength. The method of testing of sacks is given in the standards ISO 5884 and SLS 1068.

As per reported results almost all sacks tested by the Institute have failed the drop test, thereby failing the ISO 5884 and SLS 1068. What is not clear is the outcome. Did those manufacturers get the problem sorted out and got further tests done to satisfy the standard? There are no records of such actions. If indeed the trader did not get the problem corrected, he would only have a sub standard product to sell. It is possible that some of these traders simply get cover by getting them tested by the institute without

divulging the result. If this was the case, the Institute would have, unwittingly, participated in lowering the standard of sacks used by the Industry. This matter needs careful assessment by the Institute.

Institute does not seem to have a mechanism of getting the stakeholders aware of the results of these tests. They must at least periodically publish a list of models / makes satisfying the standard.

During trials, the bulging sack problem has been completely ignored. Data published indicate that in most instances, test sacks were bulging! At least in the future sacks must be tested with correct packing. It is possible that sacks would pass the Drop test, if they were packed correctly.

Some of the details given in the Annual Reports raise questions regarding the reliability of the experimental data. For example, can the TF levels increase during storage? How come these obvious questions go unnoticed? Are the methods tested for repeatability and reproducibility? Is the staff well trained? If not, what is the purpose in conducting these tests?

It is indeed desirable, if the Institute as a respectable unbiased Organisation were to carry out the tests according to a known methodology/standard and give a formal report confirming whether the sack tested satisfies the standard or not. This does not seem to be happening. The Industry, while wanting to reduce the cost of packaging, would not want any lowering of the standard. On this matter, the Institute can easily earn the position of an independent Judge.

Improvements to Tea Manufacturing Process and Other miscellaneous studies

The following research thrust along with basic projects and other activities of the Technology Division are assessed and commented here.

Thrust A 28: Refinement of Ortho – CTC manufacture in the up country and Uva to enhance colour and strength of tea liquor

Background

As per the Corporate Plan 1999 –2003, purpose of this Thrust was to enhance colour and strength of liquor in teas produced in identified regions. The work was expected to benefit Up Country and Uva regions, had an estimated cost of Rs 719,007 over a two-year period with the expected output being recommendations on manufacture.

Decades ago Sri Lanka was known for its Orthodox teas where the delicate aroma was the main characteristic. By attempting to produce teas having enhanced colour and strength, Orthodox - Rotovane methods were introduced while conserving the most valuable Ceylon character. Over the years, Sri Lanka may be losing this name. One may quite rightly argue that there is no demand for BOP grade any more, what the market wants is smaller grades: BOPF, Dust etc. Towards achieving this result, more and more producers are making not only larger percentage of these grades but also the average particle sizes of these grades have become lot smaller than a few years ago.

Ortho–CTC manufacture is a hybrid of Orthodox-Rotovane method and CTC method. Clearly, the result is anybody's guess. It is possible that at the time of preparing the Corporate Plan, in 1997, this was considered a method worth trying. It is doubtful

whether the industry has the same view now. Nearly all who tried this method produced smaller grades but probably did not pursue it much. There was no rational argument for a hybrid method. Except that by subjecting the latter dhools [that is after taking out more tender parts of the leaf] to CTC process, under totally unsuitable conditions for proper CTC process, one could expect a harsh maceration which may reduce the work load at the sorting stage of made teas and probably hope for a minute advantage in prices due to better grade-mix.

A massive sum has been spent in procuring a miniature manufacturing facility to be used in conducting tests under this Thrust and in many other Thrusts. This facility has the capability to process small quantities of tea by CTC method with least variation from the commercial scale process. Probably the decision to procure this expensive machine [which may be very handy in other projects] was abetted by the mistaken idea that Ortho–CTC is the treatment to all evils.

Progress and results
Thrust A28 had three applied research projects.

1. Project 28.1: Determining optimum conditions for producing best grade mix in the Hatton District
2. Project 28.2: Determining optimum conditions for producing best grade mix in Uva during the Off-season
3. Project 28.3: Studying reasons for the decline in quality of tea produced in Nuwara Eliya and Udapussellawa regions

No work has been reported on the Project 28.1 from 1999 to-date.

Followed by a long two-year period of familiarisation, the Miniature Manufacturing facility has been put to use in 2002 to carry out some preliminary work under the Project 28.2. In 2003 few trials have been conducted at El Teb Factory in Uva and this has continued in 2004 as well. Results have been published in the Technical Report, 2003 without any conclusions.

Project 28.3 commenced after the formulation of the Revised Corporate Plan 2003 – 2007.No reference is made to this project in the Annual Report 2004. It is not clear whether any work is being done.

TRI recommendations
There are no recommendations emanating from activities of this Thrust.

Comments and suggestions
While the Thrust may not be very important anymore, (probably was not worthy of the recognition even in 1997) there is an area of activity that the Institute can perform in working at weak spots where tea prices are below expectation due to unknown reasons. The interaction that the Institute can provide is a continuous one. Probably recommendation of today may not be valid even for the same region in one or two years. Yet the Institute can work with factories for the short-term benefit of the regions. In studies of this nature, probably the most important aspect is the identification of the existence of a researchable problem. Without such identification researcher would be groping in the dark. To be useful, work of this nature must provide results quickly.

It appears that the aim of the Project 28.2 has got lost on the way and the researchers seem to have completely lost track on the importance of conducting research on a time bound basis. This project is a classic example of the weakness in the management of research at the Institute.

In addition to the three Projects conducted under this Thrust, effect of type of manufacture on quality of tea produced was studied recently to answer the eternal question of whether the quality has dropped over the years. As pointed out by Dr Dhayan Kirtisinghe, ex Technologist of the Institute at a recent E & E Forum, to preserve Ceylon quality, BOP grade and not BOPF or Dust grades must be produced. A trial has commenced using the Clone DT1 (One of the finest clones in terms of quality and yield combination for up country). In another trial the (*lack of*) "Nuwara Eliya" Tea character in Nuwara Eliya teas is being studied.

In Project B41 identification of 3000 and 4000 series clones suitable for CTC manufacture are studied. Two Clones TRI 3015 and TRI 3018 have been tested to identify suitability for CTC manufacture. Considerable amount of data were reported in the Annual Report of 1999. Regrettably, only conclusion is that one clone's optimum fermentation is different to that of the other. One really wonders whether research of this nature is cost effective. Surely weren't there much easier ways of getting this information? Were the researchers expecting a drastically different result?

- Experts define Ceylon tea character as a specific taste profile, not found in teas produced in other countries, generally found in teas grown in most areas in Sri Lanka, predominant during quality seasons and believe that it had to do with the climate, soil, the Jat [or mix of clones] and the method of manufacture, Orthodox manufacture being the method that brings out Ceylon tea character better. They insist that tea tasters can identify the Ceylon tea character and that there is a high demand for teas having Ceylon tea character.

This elaboration points to several useful areas of research.

A scientific definition of Ceylon character and some form of indexing.

- Investigation and documentation of soil, climate, cultural practices and methods of manufacture that relate to Ceylon tea character.

- Early identification of clones that give enhanced Ceylon tea character and elimination of clones having poorer Ceylon tea character. [Non-elimination can lead to a situation where distinctly poorer quality clones becoming popular due to other favourable characteristics; TRI 2025 is an example]

- Investigation of reasons why in up country and in mid country, production of BOP grade [considered more suitable for bringing out the Ceylon tea character] is diminishing and production of BOPF and Dust grades [bought primarily for colour and strength characteristics rather than quality]more economically preferable and how this trend could be reversed. Is this driven by the market for tea bag teas? If so, what is Sri Lanka's future? Slightly larger tea bag that can take larger leaf that gives out Ceylon tea character and so on?

This is an area of research not focused at present but certainly worth consideration for the future of Ceylon tea character in teas from Sri Lanka.

As per the Corporate Plan 1999 –2003, this basic project had an estimated recurrent cost of Rs.112, 700 and a capital cost of Rs.10, 000,000 over a three-year period from 1999 to 2001. The capital purchase is for procuring a Miniature Manufacturing Facility. Surprisingly no new clones have been tested in 2000, 2001 and 2002. Project B41 seems to have got hijacked to Project 1.5.

In Project B42 where development of the Microwave oven technique for determination of moisture in withered leaf and made tea was expected. As per the Corporate Plan 1999 – 2003, this basic project had an estimated recurrent cost of Rs.96, 650 and a capital cost of Rs.8, 500,000 over a three-year period from 1999 to 2001. No progress has been reported so far.

In the Project B44, testing No 3 Mesh in the Roll Breaker for Low Country manufacture was undertaken. A similar investigation has been reported in 1997. Whether investigators were looking at any different aspect is not clear.

Project B45 is an investigation on effects of types of manufacture – Orthodox / Ortho-Rotovane in the quality of made tea, yet another shot at an age-old question. What the expectations were is not clear. Trials started in 2001 but have had no report of progress so far.

Under the Project B47, a Tea Bulking machine was developed. However there is no recommendation or a definite outcome useful to the Industry. The Dust Collector developed under Project B48 also has the same fate.

The Sand Separator that kept hopes alive now seems to be buried under a cloud of misunderstanding. Collaborative projects without signed Memoranda of Understanding are bound to have these problems, either the project vanish in thin air or, when the results are promising, one party outsmarts the other. A clear mechanism needs to be formulated to avoid these frustrations and eliminate waste of valuable resources. Such misunderstandings can lead to reluctance to undertake future collaborative projects between these parties. Sand Separator was patented by University of Peradeniya in 1999 as Patent No. 11840.

New projects identified in the Revised Corporate Plan 2003 – 2007 include

1. Project B49: Classifying Tea Grades by particle size
2. Project B51: Evaluating the effects of Tea Cultivation and processing on human health
3. Project B52: Designing a Dust Collector for FBD Dryer [in collaboration with University of Moratuwa]
4. Project B53: Developing a meter to measure moisture content in bulk / blended tea
5. Project B62: Effect of two stage drying using Microwave and Fluid Bed Drying on the quality of made tea.

Comments on Divisional Projects

Under Divisional projects, the correlation between the moisture content and the Net Outturn has been studied in all three elevations. There is a controversial yet useful finding that the Net outturn is independent of the Leaf Standard. Except for that there has been no attempt to compare the experimental finding with all its errors in experimentation, against the obvious correlation available from the definition of moisture content (m.c.). For example, by definition, one gets,

% Net outturn = (100 – % m.c. of Green Leaf) / (100 –% m.c. of Fired Tea) / (100 + % Refuse Tea - % Absorption) * 10000

If % m.c. of Fired Tea = 3%, % Refuse Tea = 8% and % Absorption = 4%, one gets,

% Net outturn = 99.12 – 0.9912 * %m.c. of Green Leaf

After months of investigation Institute found,

For Low Country,

% Net outturn = 91.8 – 0.908 * %m.c. of Green Leaf

For Mid Country,

% Net outturn = exp (21.528 – ln (% m.c. of Green Leaf) *4.246)), and

For Up Country,

% Net outturn = 111.75 – 1.17 *% m.c. of Green Leaf.

In the range of moisture content of interest in this study, all four equations give very close answers. Any variations are due to experimental error alone. Only finding of the experiment is the degree of error in experimentation of this nature!

The study of withering using microwave technique has been done in 1999 and 2000. Clearly, an exploration done without realising the costs involved. Fortunately, product quality has been poor and the Project has been terminated.

In a project conducted in collaboration with the Pathology Division, microbial contamination has been studied. Expectations of the investigation are not clear.

In the shear plucking experiment, preliminary results of commercial scale trials reported in AR 2000 indicate no significant difference in prices realised by teas manufactured from hand plucked leaf and shear plucked leaf. Data reported are very confusing. For example, nearly one third of the weight in the control (hand plucked leaf) is "cut pieces". One would expect nearly no "cut pieces" in a hand plucked leaf and some "cut pieces" in the shear plucked treatment, depending on the expertise of the workers in handling the shear. It is not clear whether this experiment has been statistically designed and analysed. Observation that there is a difference in the dry matter content of leaf by the two methods has had no comment. Results of experiments at Goomera Estate are given without comment. Trials have been done at St Clair in 2001. It was reported in 2002 that, trials at St Clair have shown no significant difference between shear plucking and manual plucking in terms of the yield and the quality of the product. If these tests were to be

repeated today with workers well trained in shear harvesting, results can well be very different.

Automation of Factory / Computer aided Tea Manufacture has been attempted under the Project D 31. Approach has been to check the feasibility of using load cells for in-situ measurement of weight loss. In 2002 it was concluded that this is not possible. Neither the research methodology to be adopted nor the arrangement of getting a consultant was clear. The Project was terminated in 2002.However, again in 2003 it was reported that a system was designed to control the withering process. Efforts continued in 2004.

A computer programme has been developed in 2000 to draw Rolling programmes. This was introduced to the Industry in 2001 as a contribution to the "Hundred Day – Revolutionary Programme". This is a useful tool to processing factories.

In studies connected with ISO 11286 – Tea – Classification of grades by particle size analysis, after some initial work done in 1999, Maximum Likelihood Solutions for each grade of tea have been found in 2000 and were refined in 2001 and continued in 2002. Results based on these trials were published at the ISO Technical Committee on Tea in 2003 and later presented at the symposium on Plantation Crop Research held at the BMICH in July 2004

Investigations such as the study on use of an additive, "teazyme", a pectinase, on the quality of tea, and blackness improvement by adding concoctions of tea are questionable. Questions of Good Manufacturing Practice can be raised on these investigations. Presence of extraneous matter makes a tea to fail the ISO standard. Is a pectinase (a substance naturally found in tea as well) considered an extraneous matter? Is tea juice extraneous? Now that trials have shown useful results is the Institute going to recommend these practises? How about the famous MS (Methyl Salycilate - a compound naturally found in tea, but considered an illegal additive) any different? It is important for the Institute to have a policy on these matters.

A very important and timely investigation has been done on New Plucking Baskets, Plastic Crates etc, which have been proved to reduce post harvest damage to 15%, while getting improvements to TF levels.

Several collaborative investigations have been conducted in 2002. They include,

- Micro controller application in tea withering system (A collaboration project with NERD)
- Biogas and organic fertilizer manufacture from refuse tea [A collaboration project with NERD]
- Energy Audit (A collaboration project with NERD)

Following investigations have also been done.

- Testing of Moisture meters – Victory Digital Moisture meter, though declared as unsatisfactory had a good polynomial correlation, which could have been presented as a chart giving correction factors. Users are likely to prefer a quick, easy reading, non-destructive method rather than infrared bulb type methods used at present.
- Monitoring of Standard of Leaf at St Coombs – A meaningless exercise, unless the estate is prepared to make use of the findings.
- Obtaining ISO 9000 [at St Coombs factory]
- Determination of moisture content and weight percentages of each component of the tea leaf
- Effect of removing coarse leaves at an early stage in manufacture
- Energy related studies in Tea Factories – Officers of the Institute must gain competency in Energy audit functions
- A new and efficient approach for removing surface moisture from leaves -Very useful, if a commercial size unit is developed.
- Factors affecting blackness and curliness of Low country Tea - This is also very useful as long as GMPs are followed.
- Quality ranking of TRI cultivars in the up country – Must give publicity regarding 3000 and 4000 series.
- A study on sorption isotherms in different parts of the tea shoot during withering
- Automated Tea Rollers – Must clearly identify shortcomings of present designs of automated rollers and rectify them.
- Performance test on Stainless Rotovane
- Fabrication of suitable trolleys to be used in tea Factories to prevent damage to plastic crates

Ready to Drink Teas and Tea Beverages

The following research thrusts relating to Ready to Drink Tea (RTD) are included in the Corporate Plan (CP).

Thrust A 29: Improvement of technology for producing a Liquid Tea Concentrate with 7% soluble solids, (later the title was revised to read as...concentrate to meet market requirements)

Thrust A 29 had three applied research projects.

1. Project A 29.1: Evaluating the efficiency of counter current extraction procedure vis-à-vis the existing procedure
2. Project A 29.2: Evaluating enzyme systems for increasing soluble solids in black tea extract
3. Project A 29.3: Optimizing the extraction ratio for black tea

In the revised CP, projects have been amended

1. Project A 29.1: Trials on micro filtration to minimise use of additives
2. Project A 29.2: Trials to produce tea concentrate in the form of powder

Work of this nature has not culminated in a Circular Recommendation form. Details of research are however published in the annual reports.

Thrust A 30: Modification of Instant Tea process for pronounced tea characteristics.

Thrust A 30 had three applied research projects.

1. Project A 30.1: Developing a method for reintroducing flavour lost during processing
2. Project A 30.2: Evaluating cyclic dextrin for retaining flavour during extraction
3. Project A 30.3: Evaluating tea blends for obtaining an improved product.

Background
As per the CP, work on these thrusts, A29 and A30 were expected to benefit all regions, had an estimated Cost of Rs 1, 506,003 and Rs 1,590,073 respectively over a first three-year period and the expected output was improved protocol for these products.

In the revised CP, sums of Rs 35 Million and Rs 5.65 Million respectively have been identified for capital work under the Thrust 29 and Thrust 30.

In the CP, value addition has not been identified as a goal of the Institute. However, the need for being pro-active and foreseeing the changing requirements of the global market place has been identified as indeed very necessary for continued existence of the Sri Lankan tea industry. In the CP it has been conceded that "Sri Lankan marketing is still behind in the scramble to cater for the tastes of the new generation looking for convenient, healthy beverages". The CP then defended "that the TRI has pioneered research into instant and RTD teas".

The institute developed the hot-water soluble instant (HWSI) teas in the 1950s with collaboration by way of pilot plant facilities at the CISIR. In 1960s it was possible to incorporate the Ceylon high grown character to HWSI. First commercial exploitation of HWSI happened in 1961. The institute continued to work on Instant teas and an entirely new process was patented in 1973. Over the years, many improvements have been achieved, namely, improvements in the extractability of soluble solids, identification of appropriate grades and improvements in the tea character by incorporation of small amounts of fermented dhool or withered leaf in the Broken Mixed Fannings (BMF) grade. Product has been made available to commercial interests. So far there have been no takers.

Research on process for cold-water soluble instant (CWSI) teas started in 1967, patents were obtained in 1976 and after a period of inactivity, the project was resuscitated in 1984. The problem of low solubility was researched in the 1990s and a product suitable for formulating a RTD was developed. This product had extremely encouraging reports from professional tasters. So far there have been no takers for this product as well.

Liquid Tea Concentrate (LTC) is the starting material for production of carbonated tea drinks. Research on LTC started in 1973. Particular problems that had to be solved were, stabilizing the concentrate, clarification of haze, overcoming bacterial contamination and stabilizing the colour. In 1980 TRI invited entrepreneurs for collaboration and for market studies but the response was nil. An improved tea concentrate was patented in 1988.

Further work resulted in increasing the soluble solid content to 7%, which allows dilution up to 1:6. Later attempts have been to develop a sugar-less concentrate. A feasibility report was done in 1992 to entice entrepreneurs. LTC too remains to be brought to a useful conclusion.

Research on formulations of alcoholic drink from tea started in 1987. It has been traced back that fermentation of undesirable bacteria is due to contamination of the starting material, the low quality tea. Use of better quality grades eliminated this problem.

Research on Scenting of tea was initiated in early 1980s and now the process is very popular among many packers of tea.

Progress and Results
More recent research on LTC was carried out for achieving desired clarity, keeping quality and organoleptic properties with minimum levels of clarifying agents, preservatives and additives. Results in 1999 indicate that the level of Aluminium, an undesirable element in the final product, increases with the level of Aluminium Sulphate used as the clarifying agent. Results further indicate that the amount of Aluminium Sulphate can be reduced up to 1 g/l. In separate trials it has been found that 100% refuse tea is best for carbonated tea. There was a further conclusion that at least 1.75 g/l Sodium Benzoate is necessary to effectively preserve the liquid for a period of one year. AR2002 reports initial trials on micro filtration as a means of altogether eliminating Aluminium Sulphate and Bentonite from the process. Filter sizes suitable have now been found.

Thrust A 30. No results have been reported on Instant Teas under the Thrust A 30.

Approximately, a sum of Rs 3 Million has been spent over the last seven years in Carbonated Tea project and a sum of Rs 2 Million on Tea Wines and Sherries under this Thrust.

The objective of work on Tea Sherries and Tea Wines is development of methods of preparation with unique taste and aroma and stable storage by fermenting tea infusion enriched with sucrose.

A patent [No 13621] is being registered at the Patent Office in Colombo. The process basically involves, the preparation of the must which involves the adjustment of a diluted tea infusion having low Brix value to get a higher Brix value by addition of sucrose, preparation of starter culture, fermentation, clarification of the fermented liquor which involves mixing with Bentonite and centrifugation, formulation and ageing. Product did not have the problem of bitterness found in earlier preparations and has received good comments from consumers when presented in local and foreign trade fairs and now it remains to be commercialised

Valuable Derivatives of Tea
The Corporate Plan (CP) does not identify any research activity leading to the development of valuable derivatives of tea.

Background
No fund allocation could be seen for these activities in the CP.

A selective solvent extraction technique was used in extracting oil from tea seeds. Oil is present in the kernel of the seed as well as in the shell. This oil is rather similar to olive oil and had superior cooking oil properties and all desirable characteristics such as colour, free flowing property, pleasant odour and stability. Properties such as the iodine value, saponification value and free fatty acid content had been determined.

Caffeine has not only well known pharmacological properties but also extensively used in carbonated beverages, notably, Pepsi Cola and Coca Cola. Caffeine can be isolated from tea. Refuse tea contains 1.5 to 3.5 % caffeine. The process has not been commercialised.

Progress and Results
In a project where beneficial properties of tea were studied researchers have found that tea components could be used to treat mild inflammation of the oral cavity caused by *Candida* species. This is a collaborative project with the University of Peradeniya and Prince Philip Dental Hospital, Hong Kong. The finding was patented as Patent No 13245.

A sum of Rs 800, 000 has been spent over the last five years on this project.

Other Products of Tea and Tea Waste
Although the Corporate Plan (CP) does not identify any research activity leading to the development of other products of tea, the Institute has undertaken studies in this area.

Background
No fund allocation could be seen for these activities in the CP.

Tea seed saponin is a by-product after extraction of oil from tea seeds. Saponin is used in preparation of hair shampoos, antiseptics and cough syrups. The process of production of saponin has been researched at the Institute. However, commercial exploitation has not been done. This is unlikely to be possible in Sri Lanka as the present method of growing tea plants prevents formation of seeds.

Research has been done on preparation of cattle feed from tea waste. Tea waste and spent tea leaves could be useful supplements as feed material.

Progress and Results
Trial under Project 30.2 (a) where incorporation of tea to dairy products had the multiple objectives of using tea as a natural colouring agent, use as a natural flavour, using the antioxidant property of tea to enhance the therapeutic value of yoghurt and to increase the consumption of tea. Trials have shown that 1-2 g of black tea extract per litre of yoghurt had the best acceptability.

About Rs 50,000 has been spent on the project involving yoghurt.

Refuse Tea contains 20 –30% protein. Procedures for extracting protein from refuse tea and recovering and purifying it have been perfected. A crude extract that contains 43% of crude protein has been obtained.

About Rs 400,000 has been spent on the project involving extraction of protein from leaf.

Comments and Suggestions

A cup of tea has a soluble solid content of 0.2% to 0.6% and is brewed by using 2.5 grams of black tea in 170 ml of water. On the other hand, ready to drink [RTD] tea contains 0.1% to 0.6% (typically 0.2%) of tea solids and the process of making a pack of 200 ml requires just over 1.6 grams of tea.

Therefore one could deduce that promotion of consumption of RTD teas to have a negative impact on the demand for teas in general. However that argument is totally invalid if the consumer is not fond of a cup of traditional tea. It is said that most young populations, particularly in the affluent societies prefer more convenient, ice cold trendy can/pack of RTD to the hot cup of tea. Further, tea consumption either way is low in those countries and is decreasing. In this scenario producer must produce RTDs that are pleasing drinks and take the challenge of substantially expanding the consumer base in affluent countries. Sri Lanka on this count should lead the way in introducing traditional Ceylon character that may pave the way for increasing the tea content in the RTD.

None of the tea products developed by the Institute has entered the market with the Institute's identity. This is indeed most frustrating to the researchers who spent years developing a product but find no commercial exploitation of their findings. This could be due to one of many reasons.

1. Are research project selections appropriate? Is the quality of output well below expectations?
2. Are the entrepreneurs not prepared to take risks? Are these risks indeed so heavy?
3. Are there any mechanisms for joint approaches to research?

The Institute has no formal mechanism for identifying research needs for new products. Methods adopted in the preparation of the CP are totally inappropriate for identifying needs on new product development. In the absence of any better guideline, it is natural that researchers merely look for researchable projects.

Is there a question of quality of output? While the absence of world famous scientists may be a negative factor particularly when it comes to developing a product for the global market, researchers need not be unduly concerned because it is only with achievements that researchers get recognised. It is extremely pleasing to note that a crop of energetic researchers is there in the area of product development.

Four to five decades ago Sri Lankan entrepreneurs were few and less aggressive. That may very likely be the reason for some of the early findings, for example of HWSI, not getting commercialised. However today there are many qualified, experienced and dynamic individuals in the business scene in Sri Lanka. It may however be equally true that, except for two or three corporate entrepreneurs, others are not familiar with the plantation sector or any related businesses.

It is very unlikely that entrepreneurs are correctly assessing the risks involved in having collaborations with the Institute. If at all it is the image risk that one needs to be careful. In almost all cases findings are completed or near completion. Chance of failure is indeed very low. What is necessary is for the interested partner to fully assess the marketing trends and efforts required to meet the needs and to have the capability to make a

commitment. If an entrepreneur is expecting 100% guaranteed success, then obviously it is not entrepreneurship.

At present the Institute has no formal mechanism for joint ventures. Present practise is to develop something and calling interested parties for commercialisation. Up to now it had not been a successful method of enticing businessmen.

A mechanism is required to identify collaborations before the start of projects. This must be followed by MOUs that will give confidence to both partners and assurance of exclusivity. Question that is bound to come up is the fairness in using cess funds for undertaking projects with selected partners, because it is only they will get a commercial benefit. Counter argument is two fold. First is that any increase in the use of tea, at least theoretically, must bring in increased demand for the balance and hence it is beneficial to the industry at large and second is the past experience of total wastage of resources in having no commercialisation.

3.7 AGRICULTURAL ECONOMICS DIVISION

Agricultural Economics Division (AgECOND) was to undertake 39 applied research projects, 7 basic research projects and 14 supportive projects in the original Corporate Plan and the subsequent 2003-2004 plan. Of these, 12 applied research projects, two basic research projects and eleven supportive research projects have been undertaken. The balance 27 applied research projects, 5 basic research projects and 03 supportive research projects were not undertaken due to staff shortages in the AgECOND. Some projects are still continuing at the time of the peer review. The total number of projects was 60 out of which 25 have been completed. One can conclude that the performance of the Corporate Plan projects is poor. Shortage of staff is attributed for poor performance and most of the projects were multidisciplinary as clearly identified in the Corporate Plan. The above count of projects is done arithmetically and the share of the AgECOND to each project is not taken into account. The completion of applied research projects where the contribution of the division is higher than 50% is very high. However, some of the work done appears to be excellent and useful to TRI researchers, corporate sector and smallholders. Some studies cover policy aspects as well. A brief coverage of the outcomes of the projects undertaken is indicated below.

Applied Research Projects

(a) Intercropping with rubber in the low country using the experimental data was discussed at an E & E forum. The main findings were that tea yields gradually declined as the shading from rubber increased. In the rubber planted at a spacing 8' x 40' tea yield per push is halved from its monoculture value by the 3rd cycle. It is to be expected that when the spacing of the rubber is increased the yield reduction of tea would be less severe. The experimental data is based on yield per tree and not on unit of land. Further studies are needed.

(b) Crop response to macro-nutrients undertaken and marginal product curves (For N Fertilizer) have been used to identify optimum level of fertilizer to be applied under changing market scenarios. These results have been presented at the E & E forums.

(c) Evaluating and determining ways and means of reversing the factors that influence migration of workers in the tea sector in the low country for outside work have been undertaken and the findings presented at the E & E forum in July 2001. The study found that

in the low country estate sector total workforce is showing a declining trend due to high absenteeism among workers and low rate of young people joining the workforce. Availability of other opportunities outside plantations, changing social attitudes and the increasing level of education are the common factors that contribute to the above situation. "Pulling & Pushing Factors" of worker migration were identified in the study. Higher wages and other non-cash benefits offered by the Tea Smallholders in the low country was the major pulling factor. Under this circumstance "dis-satisfaction with the staff" was found to be the major pushing factor, which encourage workers to go for outside work. Introduction of appropriate machinery for agricultural operations and better incentive systems were suggested as solutions to overcome the problem. Development of outside independent workforce especially for the smallholder sector has been proposed as another solution. This study shows that estates will face serious shortages of workers and increasing demands for higher wages from them. The smallholder sector will face increased cost of production due to higher wage rate for labour they are employing. This problem could be solved if appropriate machinery could be found for major labour intensive operations such as plucking, weeding, pruning and fertilizer application. TRI will have to give high priority for this research in the immediate future. AgECOND also found that attendance based incentives, productivity based cash incentives, social recognition and flexible working hours are the other pull factors.

(d) A study in the up country, mid country and Uva mature tea lands in the estate and smallholder sector was undertaken with three levels of very good, good and poor management classes to identify the level of soil conservation investment, and the factors that determine investment decisions on soil rehabilitation. There is also a study to identify a suitable incentive scheme to encourage tea growers to undertake soil rehabilitation and soil conservation programmes in tea lands, to assess the problem of land degradation and to develop background information for policy formulation. The outcome of this project has been presented at the January 2006 E & E forum. The project findings are limited to soil conservation only. The study found that the actual level of soil conservation in tea lands range from 11% to 22%. Additional investment to improve soil conservation level up to the expected level is in the range of Rs.10, 000/= to Rs.15, 000/= per hectare. The level of soil conservation and the variable cost of tea production have positive impact on productivity of tea lands.

(e) A study on climate change has been undertaken in collaboration with the Meteorology Department. The results of the study shows that temperature is expected to increase 1.0-2.4° C by mid 2100. The productivity of tea grown in lowlands where the present temperature is high will show a decline with climate change, while the plantations in the hill country where the present temperature is low, will show an increase. Hence the tea growers in the low country who comprise the majority will be vulnerable to climate change. These will have implications on the national economy as well.

Although the Corporate Plan identifies some basic research in economics these studies are applied research. Comments on these are as follows.

(f) A study on economics of plucking was undertaken and the cost effectiveness of different methods was worked out and reported in the publication titled "Cost of Tea Cultivation from Nursery to the Field" has been reported. Plucking is one of the higher cost operations in tea cultivation and as such this data is very useful for taking management decisions. Estimation of tea production costs at different elevations in five modules namely tea nursery management, replanting, field production and management, harvesting and tea

manufacturing were undertaken. A manual titled "Cost of Tea Cultivation from Nursery to the Field" has been published. This is a very valuable document for everyone involved in tea production. This is also due to be published in digital format.

Supportive Projects

Tea sector studies

(a) Many useful tea sector studies have been undertaken by the Agricultural Economic Division(AgECOND). The study on optimum replacement age of tea was completed and presented at the E & E in 1999. Break-even analysis for decision making in tea plantation management was studied and results were published. Cost benefit analysis on (i) irrigation/fertigation of tea. (ii) Alternate methods of nematode control and (iii) weed control methods were carried out, but findings are yet to be published. A study on economic impact of green leaf transportation on leaf quality in one of the estates in the mid country was carried out. The study identified a more economically viable system to replace the traditional system. The results of this research are published in the "The Thathu" news letter.

(b) Economics of Blister Blight control study was undertaken and findings reported at E & E forum. These findings should be inserted into TRI Advisory Circular on Blister Blight, so that economic considerations are also covered which is absent in the earlier TRI circulars. Gross Margin calculation in the estate sector and smallholder sector separately for VP and seedling tea have been carried out. A study on the Capital Stock Depreciation in the tea smallholder sector was completed. This revealed that the annual depreciation of the capital stock in the upcountry and low country was Rs.2.83/kg and Rs.1.96/kg of green leaf respectively. A very important study by the Economics Division was the Growth Performance of the tea industry and its Decomposition Analysis. The study covered a 24 year period (1980 to 2004) which was twelve years before privatization and twelve years after. The results of the analysis show that the production, area and yield have changed significantly at rates of 2.3, – 1.0 and 3.6 percent respectively per annum over the period. The growth rates of tea area were at a negative rate of –1.0 during the period of pre nationalizing but it is positive and significantly high during post privatization period. Growth rate of yield is also at a positive growth rate but significantly at a lower rate during post privatization period. These are useful findings to Government policy makers and TRI should prepare policy papers based on these findings.

(c) Ecological and economic analysis of tea based home gardens in mid country was undertaken. This study concluded that having contribution of cash generating crops is economically and ecologically sustainable than tea as a mono cropping in the mid country home gardens

Comments and Suggestions

The AgECOND with very little manpower resources has fulfilled most of the required studies earmarked in the Corporate Plan. The main reason for not undertaking some projects was due to staff constraint. An Agricultural Economist and two Research Assistants have left the TRI since 1995. The approved cadre to the Economics Division is Economist, one Research Officer with PG Training, two Research Assistants, two Experimental Officers and one Technical Assistant. The present staff available is one Senior Research Officer and Technical Assistant. The Experimental Officer is on overseas study leave for three years from 2006 January. The staff shortage is a very serious situation that needs immediate correction. One alternative is to seek outsourcing some studies especially to Universities.

During our interviews with some of the CEOO of the plantation companies and the Tea Smallholding Authorities we were told that TRI should give more emphasis to economics of tea production, policy analysis and other tea related economic studies and to be an active player so that policy makers will understand the issues and make better decisions so that the tea sector in Sri Lanka will be more dynamic.

There is a need for the Tea Research Institute to undertake the following activities in order to meet the above stated objectives.

a. Study of high cost of production and low profitability in the industry.

b. Comparison of energy sources with respect to cultivation and manufacture of tea.

c. Evaluation of the recommendations of the TRI

d. Market trend analysis and identification of consumer needs.

e. Impact assessment of state policies on the tea sector

f. Maintenance of an information system on all matters with respect to tea nationally and internationally.

Suggestions
(a) Strengthen AgECOND to undertake studies identified by stakeholders including market analysis, policy analysis and tea information.

(b) TRI should evolve a mechanism to regularly publish many of the findings of the Agricultural Economics Division that are of much use to the stakeholder.

3.8 ADVISORY & EXTENSION DIVISION

The extension function is exercised mainly by the Advisory and Extension Division (AED) through advisory and extension officers working out of the main TRI station at Talawakelle and the stations at Ratnapura, Deniyaya, Kottawa, Hantane and Passara. Current scientific ideas, findings and innovations arising out of research are disseminated by the AED to the corporate sector and by the TSHDA to the small holder sector. Methodology used is through training programmes lectures, seminars, field days, demonstrations, group discussions and on called field visits.

Regional Scientific Committees (RSC) and Experiments and Extension Forums (E&E) are the main scheduled seminars. The other services provided by the AED are laboratory analysis of soils, plants and other specimens , issuing of planting materials , holding exhibitions and giving advice through correspondence, provision of resource personnel to National Institute of Plantation Management (NIPM) , Tea Small Holdings Development Authority (TSHDA) and directly to Plantation Companies and other groups for training purposes, provision of publication and resource material including guidelines, Advisory Circulars, books and video tapes.

Forward Extension Programmes

As per the Corporate Plan (1999 – 2003), six projects had been identified for implementation for Advisory and Extension Division.

The progress of these projects is given below: -

Project 1 - Adaptive/demonstration trials on fertilizer use, nursery practice, plucking and pruning

It is indeed disappointing to note that out of the four "most important cultural operations" that had been identified viz. fertilizer / nursery practices / plucking and pruning, only the project on fertilizer which commenced in 1999 has been completed and the results communicated at the Experiments and Extension forum. In the absence of adaptive / demonstration trials carried out by the TRI, they have not been able to convince either the corporate sector or the smallholder sector with regards the advantages of the new TRI fertilizer recommendations. In fact, in a survey carried out by the Faculty of Agriculture, University of Peradeniya, the adoption levels of the new TRI fertilizer recommendations have been found to be a mere 7.9% by the Regional Plantations Companies. This report identifies the low practical feasibility of the recommendations made by the TRI as being one of the prime reasons for the low adaptability. This report also identifies individual Plantation Management Company policies being one of the major reasons for the low adaptability.

It is to be expected that the Advisory and Extension Division of the TRI should have undertaken proper adaptive / demonstration trials which would have facilitated a far better adoption rate of the fertilizer recommendations.

The projects under nursery practices, pruning and plucking had been abandoned due to, what is being reported as "lack of human resources".

This situation is indeed very disappointing and unacceptable.

Plucking constitutes almost 40% of the cost of production in tea and these experiments which were commenced in 2001 should have had priority allocation of human resources for adaptive / demonstration trials by the Advisory and Extension Division. The acute shortage of workers in all plantation districts and more so in the low country is severely impacting on productivity and it is imperative that the TRI focuses intensively on research pertaining to plucking.

It is most imperative that research findings must perforce be followed up with adaptive / demonstration trials in order to validate the research and make it credible for stakeholder adoption. It is little wonder that adoption rates of TRI recommendations are generally reported on as poor / low, due to the Advisory and Extension Division not being able to undertake adaptive / demonstration trials.

Project 2 - Information desks are to be established at each Extension Centre involving the latest communication technologies

Ready-reckoner
Though the preparation of a ready reckoner commenced in 1999, it is discouraging to note that only limited copies had been circulated to the stakeholders resulting in very poor use of this chart.

Hotlines
Contact telephone numbers of TRI – Talawakelle, Passara, Kandy and Ratnapura have been merely given in TRI publications.

Wall Charts
The wall charts / posters are still in the process of being prepared. This is indeed most disappointing as pictorial depiction of nutrient deficiencies / pests / diseases etc. is extremely important – more so for the small holders, plantation staff and workers to grasp quickly the nuances that a picture can convey as opposed to voluminous printed material.

Databases/Email/Internet
Regrettably, this project, which commenced in 2003, is reportedly "in progress" with little or no results to record.

The TRI website which was introduced in 2003 is not updated regularly and therefore, is currently not serving the intended purpose.

Email facilities are available at Talawakelle / St. Joachim and Passara (System disorder at Hantane and Kottawa).

Internet facilities are only available at Talawakelle / St. Joachim and Passara.

In today's day and age where access to information and knowledge via email and internet takes a common place, it would have been preferable for all sub stations of the TRI to also have email / internet facilities.

Project 3 - Upgrading Extension Centres with a tea museum and "AV" saloons for accessing AV (audio-visual) publications

AV Saloon / Reading Room
Regrettably, the AV Saloon and the Reading Room projects had been abandoned due to;

a. Lack of human resources
b. Lack of suitable locations

Tea Museum
This project, which commenced in 2001, merely maintains a TRI Section at the Ceylon Tea Museum, Hantane.

Project 4 - Establishment of mother bush areas for supplying planting materials to tea smallholders

It has been reported that 78 ha of mother bushes under the ADB funded project had been established as follows:-

St. Coombs	14 ha
St. Joachim	30 ha
Passara	2 ha
Kottawa	5 ha
Deniyaya	1 ha
TSHDA site	26 ha

Despite this being a priority and a very important project that was funded by the ADB, the feedback obtained by the Peer Review Committee, both from the private sector as well as smallholder sector, has been most disappointing.

The smallholders were complaining of very poor planting material that was being issued from the nurseries with little importance attached to the quality of the VP cuttings that were issued. It is acknowledged that the tea nursery is the "cradle" of the tea industry and it is vitally important that good quality cuttings of superior clones are used for future replanting in the country. The ADB project provides a manual specifying the procedure of issue of good quality cuttings, nursery management standards, etc.

An annual rolling plan was to be drawn up by all parties involved. However, there is a mis-match of quantity in demand and supply. TRI should draw up a programme for certifying of tea nursery plants by TSHDA for smallholder-registered nurseries. To that extent, the TRI has failed to manage "this project effectively and efficiently".

Corporate plan although envisaged, certification of VP nursery plants in nurseries in all tea districts has not been done. This needs to be implemented soon. In addition, good management practices for nursery plant production and new nursery structures need to be introduced.

Project 5 - Monitoring of the agricultural performance of tea plantations and smallholdings

This extremely important and urgent project, which commenced in 2000, had to be abandoned due to lack of human resources. "If the proof in the pudding is in the eating", indeed evaluating performance and adoption rates of the TRI scientific findings must perforce be measured in terms of adoption by stakeholders and impact.

In the absence of a performance evaluation, the entire research thrust in the TRI appears to us to be more an end itself rather than a means to the end. In this case, the end being what has been expressed as the vision of the TRI.

Project 6 - Production of extension materials for the effective dissemination of research findings and observations

Project 6 covers the production of video programmes, overhead slides, leaflets, booklets, posters and stickers.

Although the reported adoption and impact is very high, as perceived by TRI, there seems to be a different opinion by the users.

All these productions are too general, inappropriate language has been used, are not directed to a specific audience and pre-testing has not been done.

In the preparation of these materials, script reading, technical content draft, proof reading and pre-testing should be undertaken so that each of these productions will be more effective. For instance, there are stickers to be put on the windscreens of vehicles, which are not one glance type. These stickers do not serve any purpose. The audience for printed materials varies from Chief Executive Officers, Managers, TSDHA Staff, Estate Workers and Growers. One type of production will not be effective to these varying audiences.

Some of the videos are too long and boring.
If this was done in a professional manner, the videos will be more interesting and the length or time could have been made very short.

2. <u>TRI – End user Meetings</u>
2.1 The Experiments and Extensions (E & E) forums

2.1. a E & E forum Sinhalese medium for Smallholder Sector
From December 1999 to December 2005 14 E & E forums have been held in accordance with the requirement of two per year. Average attendance of participants was 85%.

Interviews with the General Manager, Deputy General Manager, Regional Managers and Assistant Regional Managers of the Tea Small Holdings Development Authority, and President, Secretary and Treasurer of the Sri Lanka Federation of the Tea Small Holdings Development Societies and the Key Officials of the Regional Organizations indicated that the E & E forum is very informative and effective in disseminating the research findings to the smallholder sector. A general request is to increase the No. of E & E Forums to 04 per year.

2.1. b E & E Forum English Medium for Corporate Sector
From January 1999 to January 2005, 13 E & E Forums were held, two per year. It should be noted that in the years 1991, 1992, 1993, 1994 and 1995, three Forums have been held each year and from 1996 onwards it has been brought down to two per year.

The Planters' Association is of the view that the E & E Forum is a useful mechanism in disseminating research information and should be brought up to 3 forums per year.

2.2 The Regional Scientific Committees – RSC Seminars

The 6 RSCs, which are in the tea growing districts, were expected to hold RSC seminars twice a year. The details of the RSC seminars held are tabulated below.

Year	Talawakelle	Hantane	Ratnapura	Passara	Deniyaya	Kottawa	Total
1999	01	02	02	01	-	-	06
2000	01	02	02	-	-	-	05
2001	-	02	01	-	-	01	04
2002	01	01	01	01	01	-	05
2003	01	02	02	02			07
2004	RSC Seminars replaced by 08 Crop Clinics						
2005	RSC Seminars replaced by Crop Clinics						
2006	01	01	01	01		01	05

Interviews with CEOO of RPC's reveal that the Superintendents, Asst Superintendents, factory owners and the proprietary planters in the regions find the RSC seminars very useful in gathering knowledge and information in good agricultural practices. Prior opinion call on subject matter of discussion would be an effective mode of deciding on the needs of the planters.

Both E & E forums and the RSC seminars seem to be successful in terms of attendance, number of meetings and usefulness. However, both corporate sector and smallholder sector observe that both these meetings need more objectivity and goal orientation. The format of the meetings need improvements. The language used by the TRI Researchers is too technical. These meetings should be used to sell TRI publications as well.

Observations are also made about reporting of field problems at these meetings but TRI does not give a feedback of the actions taken at the next meeting. Both sectors stated that diagnoses of field and factory problems as well as conduct of research is the total responsibility of the TRI research staff. The following suggestions are made to improve the usefulness of E & E and RSC.

a. Continue E & E separately for corporate sector and smallholder sector and the latter to be conducted in Sinhala

b. E & E to have an agenda consisting of Review of the Tea Production and problems, Status of current research program of TRI, New technologies or information from TRI and Information on topics requested by participants. The minutes should be written in a manner where responsibility to take action is indicated. The first item on the agenda should be matters arising out of the previous E & E meeting and progress there upon. Research problem census from the RSC should also be tabled. Appropriate convenor must be identified.

c. Two RSCs to be held, one each for the corporate sector and for the smallholder sector.

d. Representatives from the corporate and smallholder sectors shall Chair the meetings. The Convenor will be from the particular region.

e. Appropriate Research Officers shall attend the meetings depending on the problems reported. Advisory and Extension Officers will participate at all meetings

f. The smallholder meetings will be held in Sinhala

RSC should also have an agenda similar to E & E and minutes written in a manner such that officers responsible for certain duties are identified. RSC for smallholders should also include smallholder society office bearers. The RSC should serve as a regional level representation of growers and an interface for research. The research problem identification and adoption of TRI recommendations should receive priority at these meetings. Data on fertilizer application, replanting extents, pruning, tea production and yields, prices, labour supply, tea plant nursery production and certification data should be collected and reviewed so that regional progress and problems are identified by all agencies.

Publications and Extension aids

The corporate plan envisaged a major shift in TRI publication outputs in terms of coverage of subjects, language and clients. Review of the performance indicates that while Corporate Plan goals are met in terms of the above, the usefulness and effectivity are very subjective. The distribution to end-user is found to be defective. Our discussion with the corporate sector and smallholder sector indicated that some of these publications have not been seen by them. The coverage of the subjects could be stated as good, including almost all subjects or technologies in a short time span, except the factory technologies. Majority of publications are on tea crop production technologies and very few are on factory technologies.

It is commendable that TRI started and continue to produce a journal called "Tea-Thathu" directed to tea smallholders in Sinhala. Another significant publication that needs to be highlighted is titled "Cost of Tea cultivation from nursery to field production" in English & Sinhala. This is a comprehensive publication giving information to growers on taking critical decisions for maximizing profits.

In the production of many of the publications the target audience or client has not been taken into consideration. The corporate sector CEOO and Estate Management are separate audiences. The TSHDA staff another category. The estate worker and smallholder another category. Depending on the audience the publication language, presentation, content, length etc, should be different. A general publication will not meet the multiple needs. Almost all publications do not contain economics or costs of inputs. This is due to the fact that TRI Circulars are limited to the technical aspects only.

TRI has produced video films and CDs on many topics. This is commendable. However, the target audience is too general as such its usefulness to the end user limited and its impact is questionable. CDs on all TRI recommendations are yet to be covered.

Adoption of Technology

Fertilizer usage in the corporate sector
Studies conducted by the Agricultural Economics Division have revealed the following.

- Majority (95%) of plantations were applying inorganic fertilizer where as the regular organic fertilizer application is comparatively low (7.9%).

- There were 19 different mixtures for mature tea. Most of the plantations were applying the old TRI mixture, especially the U709 mixture (68%). Other major old TRI mixtures were U877, U270 and U300. These mixtures were used for both VP fields and Seedling fields. Only 7.94% were following the new TRI mature tea mixtures. Considerable amount (23.8%) was following own company mixtures.

Fertilizer usage pattern in Nivithigala AGA division of Ratnapura District.
A survey on fertilizer use of smallholdings in Nivithigala AGA division was conducted. The results revealed that the tea smallholders have deviated from TRI fertilizer recommendations due to the unavailability of appropriate fertilizer mixtures on time in remote areas, financial difficulties and lack of proper knowledge on fertilizer use. These studies also show that TRI new fertilizer recommendation is not being adopted by the corporate sector. This is good feedback to TRI to study why this new fertilizer recommendation is not adopted by both sectors in spite of low cost to the grower.

Current status of Agro-chemical usage in the Tea smallholding sector in Kegalle District.
This study found that smallholders are applying mostly glyphosate to control weeds and they are applying lower dosage and frequencies and are still within safe use range. However, knowledge about agro-chemical usage was found to be a limitation in terms of adoption of recommended practices in the tea smallholders. One can come to the conclusion that dissemination of TRI recommendations to smallholders is very weak. Availability of Agro-chemicals was not found to be a problem.

Other studies.

A case study in Kegalle and Kalutara Districts found that registered tea nurseries are superior to unregistered tea nurseries. Even in the registered tea nurseries the study finding is that the flow of technological information, knowledge and skills to the nursery men is weak.

Studies on factors affecting the spread of Horse Hair Blight Disease in tea smallholdings in the low country, investigations on general yield decline/debilitation and death of tea bushes in the Deniyaya Region and identification and assessing Good Management Practices adopted by growers have been completed. The common finding is that some of the recommended technologies are not practical, the knowledge/information from TRI is not flowing to the growers and yields are stagnant. The study on the role of Leaf Supervisors in reducing knowledge gap among tea smallholders show that Leaf Supervisors play an important role in information/knowledge transfer. But TRI extension services hardly have any linkages with them. This should be rectified.

The studies undertaken for identifying the levels of TRI recommendations and adoption should be institutionalized as TRI – Advisory and Extension Service as an annual data collection, such as areas of TRI clones planted, Fertilizer applications kind, and quantities used, agrochemical applied, pruning, replanting, shade planted, application of organic manures, green manures, disease outbreaks its controls, pest out breaks and its controls etc. These data are to be collected from corporate sector and TSHDA on an annual basis. Then the status of the tea plantations of any given District will be known, along with the adoptions of individual technologies on a time series. Special studies need to be under taken when new innovations/technologies are introduced as was done according to corporate plan so that research will have a quick feedback. And where recommendations can either be modified or new recommendation made. It will also be a feedback to Advisory and Extension to find-out the effectiveness of their own communication methodology, media etc. The reason for non-adoption due to poor communication should be first ascertained before all others. Then the economic soundness, technical feasibility, social acceptance need to be studied. This is a two-step method. In most cases poor communication which result in poor adoption levels, are ignored.

Review of TRI Recommendations

Adoption and Impact

In this review adoption refers to "practice of any technology or innovation recommended by TRI to a grower or growers for a longer period in a significant area of his or her field." Impact refers to "final results arising out of adoption of an innovation or recommendation to the grower and to the tea sector in general terms resulting in growth of the tea industry". In this paper TRI recommendation refers to either TRI guidelines or TRI circulars issued only. The level of adoption in this review is as perceived by TRI and as acknowledged by RPC and smallholder sector during our discussions. There are no data on extents of adoption of TRI recommendations available for studying adoption level. As such our findings are subjective but there is no alternative methodology to assess the adoption level and impact. Following are our observations.

a. Thrust on "Developing High Yielding clones" – TRI circular issued. Adoption level as perceived by TRI is good. As a significant area has not been planted to TRI 3000 and 4000 series clones it is not possible to assess its impact.

b. Thrust on "Developing economically viable rehabilitation systems in up country". TRI S4 circular issued. Adoption level as perceived by TRI is good. Our observation from both corporate sector and smallholder sector is that this recommendation is not economically sound. Cost of rehabilitation and income forgone during the long period of soil rehabilitation is so high that growers are not convinced of the need to do it. Smallholders in the low country say that since nematode is not a problem, why not apply a large dose of organic manure in to planting holes, incorporate a lot of vegetative matter into the soil, remove all old tea bushes completely, make the land disease free and replant. As the replanting incentive given is for less than one acre, the quantities of organic material to be applied could be found as claimed by the TSHDA.

c. Thrust "Developing inter-cropping systems in Mid country smallholder sector". No TRI circulars issued, only guidelines. TRI reports that adoption level is satisfactory. Our observations from the smallholder sector are that this innovation needs more information on economics, cash flow, labour requirements, etc. In their absence adoption of this innovation is very slow.

d. Thrust "Development of harvesting devices to overcome labour shortage." TRI HP2 guidelines issued. TRI reports that adoption level is poor. Our observation in both corporate and smallholder sector is same. There are sporadic success stories on the shear harvesting device. However, what is needed is not the tool recommended by TRI. To overcome labour shortage specially during peak plucking periods both estates and smallholders need a device to increase plucker intake substantially and to be an easy device to operate both to maintain a good plucking table, and enable plucker to walk on any terrain. The shear harvester also needs the new basket. Both these are not acceptable to many pluckers at present. TRI needs to study the problems further and discover a better device very soon.

e. Thrust "Development of weed management strategies in Tea" TRI circulars WMI, WM2 and WM3 issued. TRI reports that adoption level is satisfactory. The corporate sector expresses dissatisfaction of mere removal of some of the previous recommendations due to possibility of residues ending up with made tea. Instead of throwing away of a good herbicide, TRI should research on how to apply it without causing a residual problem. Similar observations were made by smallholders. Both the corporate sector and smallholders want a new herbicide which will be more cost effective, efficient and will not cause any residual problem.

f. Thrust "Development and management of nurseries". TRI circulars issued on nursery management and cleft grafting. TRI reports that adoption level is good for the nursery and poor for cleft grafting innovation. Although TRI perceives that nursery technology adoption is good both corporate sector and smallholder sector express dissatisfaction. Some nurseries still produce poor plants, which can result in poor replanted stands. The colourless polythene is not used in most other nurseries in Sri Lanka. More cost effective and efficient as well as good management practices are needed. Presently concrete posts and coir – shade netting which are heavy and expensive are recommended. Cheap less labour intensive watering methods need to be introduced. Soil pH, humidity, temperature, and shade have to be regularly checked so that ideal growth of nursery plants could be obtained. With regard to cleft grafting, TRI itself perceives that this technology adoption is poor. The method is not sound technically and economically. Smallholder sector observed that TRI should identify the exact areas where cleft grafting tea should be planted. Planting of poly clonal tea will result in higher productivity as a result of cleft grafts being able to overcome inherent soil, and climatic problems which normal VP tea plants cannot.

g. Thrust "Developing regional/site specific fertilizer recommendations for improved productivity and made tea quality". TRI has issued SP1-6 circulars. TRI reports a very poor adoption level and says that this is due to insufficient information, that the recommendation is practically and economically unsound. This recommendation is not being adopted in the smallholder sector in toto.

Corporate sector is also hardly following this, but consider it as a useful exercise. TRI should assist the corporate sector to adopt this innovation.

h. Thrust "Developing regional specific dolomite recommendations for improved productivity and made tea quality". TRI report this recommendation adoption to be good. Both corporate sector and smallholder sector agree with TRI with these recommendations. However a simple pH meter soil testing is requested do that growers can quickly take a decision.

i. Thrust "Developing cost-effective control methods for integrated management of SHB". TRI has issued PM1 and 2 circulars and reports that adoption level is poor and that this recommendation is economically and technologically not sound. The Review Team inquired about economic loss due to shot hole borer and was informed that it was difficult to obtain yield loss data. It is difficult to understand the rationale of doing shot hole borer control research without an idea of the economic loss from this pest.

j. Thrust "Biological control of major pests and diseases of tea with a view to reducing usage of pesticides". TRI circular PM 4, 5, 7 issued. TRI reports a poor adoption by the corporate and smallholder sectors due to insufficient information. Furthermore, the recommendation is neither economically nor technologically sound. Both corporate sector and smallholder sector are not adopting this recommendation.

k. Thrust "Studies on the entomological pests not covered by other projects" TRI circulars PM3 and 6 issued and the TRI reports a satisfactory adoption level but information is insufficient and technologically not sound. The corporate sector as well as the smallholder sector view on this recommendation is that TRI should improve on the weaker aspects of the current recommendation by working with the Estate and the smallholders. Pests such as live-wood termites are becoming serious pests and are on the increase now. Hence this needs to be kept under control before a major damage takes place.

l. Thrust (D-21) (supportive Projects) Leaf disease control. TRI has issued circular DM1 and 3 and reports a good adoption level. There seems to be good adoption as growers see the loss. However, corporate sector wants chemicals recommended that will not cause problems in so far as residue levels in made tea are concerned.

m. Thrust (D 22) (Supportive project) Stem Disease. TRI has issued DM 4, 5 and 6 circulars and reports a very poor adoption level. TRI itself perceives this recommendation has insufficient information, is practically difficult to follow and economically unsound. This is another example of a TRI recommendation that is not acceptable within the TRI it self which shows to what extent TRI recommendations are now failing to convince the growers.

n. Thrust (D24, supportive projects). Root diseases. TRI has issued DM 2 circular and reports a good adoption level. However, it is practically difficult to adopt and economically unsound.

o. Thrust (D 24, Supportive projects) Horse hair Blight. TRI has issued guidelines but no adoption has been reported. However, Galle area reports this as a problem and the TSHDA officers are unable to answer the growers. TRI needs to carryout research to control this disease in the field it self and make recommendations soon.

p. Thrust "Development and management of shade". TRI circular SI 2 issued and reports a good adoption level but the information is insufficient. Both corporate and smallholder sector feel that this TRI recommendation is useful but TRI needs to give more information and convince the growers.

Since the corporate plan initiation in 1999 TRI has undertaken 41 Thrusts, commenced 77 projects and issued 24 circulars and 3 guidelines. No new circulars or guidelines have been issued on Factory Technology and Economics. Economics by nature of the subject will not end up with TRI circulars. However since, 1999 Economics Division Research Projects have come up with very useful information and knowledge to the corporate sector as well as to the smallholder sector. TRI failed to convey these in a timely manner. There are many evaluations of research recommendations by Economics Division which is not known within the TRI itself and not known outside TRI. Even the publication on the cost of production is not well known outside TRI. The recommendations arising out of corporate plan research projects are not been adopted to a level that gives a significant impact to the tea industry. The problems that were there before corporate plan continue to be serious problems as TRI is not able to come up with acceptable technologies and newer problems are getting added up. Furthermore, inability to have any influence on Government policies such as fertilizer subsidy aggravates the situation. The adoption level of new TRI 3000 and 4000 series clones and its impact is too early to be commented and needs a longer period to see the performance. This observation agrees with the views held by the corporate sector and the smallholder sector. Both sectors are very critical of TRI performance during the last 10-15 years. There is no data what so ever to say that a specific recommendation of TRI is so willingly adopted by a large section of growers and that they are benefiting. Added to this tea yields are stagnant and in some areas it is declining.

The effectiveness of TRI extension services on the smallholder sector

A survey was carried out by the Review Team on the effectiveness of the TRI extension services on the smallholder sector by means of a questionnaire that was distributed to senior officers of the TSHDA and the key office bearers of the Federation of Tea Smallholder Societies. The findings of the survey are given in Annexe 4. It is apparent that apart from the E&E Forum where TRI got a good rating, in other important aspects such as relevance of research to the growers, dissemination of research findings, follow-up on recommendations, supply of planting materials and the relationship with growers, the Institute fared poorly.

Improving technology transfer to the corporate sector and smallholder sector.

The poor performance of the AED was due to shortage of staff and resources, poor institutional linkage systems, and lack of clear terms of reference for its operations. The Review Team recommends the following to improve the capacity

and effectiveness in technology transfer to the corporate sector and smallholder sector by the Advisory and Extension Division.

a) Drafting of clear terms of reference to AED and associated institutional setup.

The terms of reference (TOR) of the Advisory and Extension Division should be clearly stated so that all work, tasks and activities will arise out of the TOR without any overlap or gaps or conflicts with other agencies such as the corporate sector and TSHDA. The TOR should include service functions such as analytical service, supply of mother bush cuttings etc. However, the classical TOR stated "as getting useful information to tea growers and then in assisting those people to acquire the necessary knowledge, skills and attitudes to utilize this information (technologies) effectively" should be emphasized. The work activities and products carried out to perform advisory and extension function will fall into (a) information delivery function (b) education delivery function (c) problem solving function.

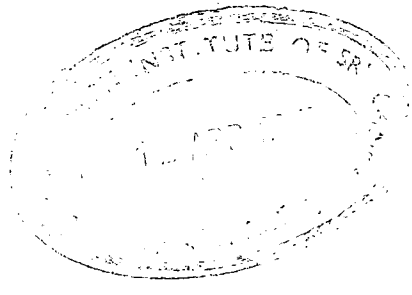
b) The next step should be drawing up the TOR for the Estates and Advisory consultative committee, E & E forum and RSC. These are presently functioning without a clear TOR or no TOR. Frequency of meetings convenor, Chairmen, their responsibilities, agenda, minutes composition of committee etc need to be drafted by the stakeholders. In drafting this TOR the linkage system to the corporate sector and the smallholder sector to allow two-way technology flow should be ensured.

c) Once the TOR of the AED and operational details of E & E, RSC, and E & A etc are finalized the staff requirements of the AED could be worked out. At present the AED staff is grossly inadequate and need a fresh assessment based on the TOR. No definite staff requirement recommendations could be given at this stage. Presently all staff of AED are not issued with job descriptions. New job descriptions based on workloads, area of activity, to whom responsible etc need to be drawn up.

d) In order to carryout the entrusted work, the AED should draw up an annual work plan with budgets etc in consultation with the corporate sector and TSHDA. This work plan should be reviewed at all E & A consultative committee meetings.

e) It is the responsibility of the TRI-AED to carryout a training of trainers programmes for the corporate sector and the TSHDA. The AED should prepare a training curriculum for training of trainers by TRI-AED on all aspects of tea production, manufacture, including economics. This should be in the form of a manual and issued to the stakeholders so that they can identify their training needs and request TRI for TOT. This training manual should also contain a section for growers so that corporate sector and TSHDA could use it as a guide for training their workers and growers. As this is urgently needed TRI may out-source the preparation of this training manual to a recognized professional who is conversant both in tea production and training manual preparation.

f) The TRI-AED staff need to be fully competent in all tea-production technologies especially new recommendations. Presently AED staff does not get an opportunity for any formal training. Regular and continuous training of AED staff at all levels should be done within TRI i.e. "In Service Training". This should include communication methodology, use of media as well. TRI may invite outside resource persons or send AED staff to outside institutions for "non tea-training". "In Service Training" should be drawn into a training curricula and a training manual different to the TOT training manual.



4. HUMAN RESOURCE DEVELOPMENT

The development of human resources in an organization has to be based on its goals, objectives and the challenges that it is likely to face in the future. The capacity of staff in the organization should be developed to meet the continuously changing needs. An assessment of the capacity of the staff within the organization should be first made and capacity building needs identified. It appears that TRI has not undertaken such an exercise.

Development of human resources (HRD) in an organization is important. It increases knowledge levels of the staff, brings about desirable changes in attitude, increases commitment to the job and often leads to career advancement. Therefore, opportunities should be provided for participation of staff in post graduate training, short courses, seminars, workshops and interactive sessions in relevant areas to make the staff more efficient and effective.

At TRI, the Human Resources Development (HRD) component is primarily focused on developing research capability of the research staff by exposing them to post graduate level research oriented degree programmes. The TRI has encouraged the officers to pursue higher studies leading to either a Master's or a Doctoral degree.

The Institute management has identified the following four major categories of training in its Corporate Plan.

a. Post graduate research degree either at Master's or Doctoral level for scientific staff already having a first degree. TRI may meet the expenses.
b. First degree for Technical Assistants, Experimental Officers and Extension Officers. TRI does not normally provide funds for this training
c. Visits and short term training for scientific and administrative staff. TRI may consider funding of such programmes if other sources of funding are not available.
d. Internship training for newly recruited Research Assistants, Experimental Officers and Extension Officers.

It was noted that apart from (a) and (d) above TRI has not adopted a clear policy on training its staff or other activities of HRD for officers of the Institute based on needs assessment. The criteria developed for staff are briefly stated below.

Research Assistants/Senior Research Officers (with a special degree and a class)

1. The Research Assistants will be assisted to undertake training leading to a Master's Degree

2. Those that possess a Master's degree will be encouraged to obtain a PhD degree.

3. Officers will become eligible to pursue Post Doctoral research (Sabbatical Leave) on completion of 5 years in Grade I with PhD

Non graduates (Technical Assistants)

1. Short term technical training in extension methodology

Experimental Officers

1 Confirmed Experimental Officers with minimum of 2 publications may be considered for full pay study leave to follow a Post Graduate Degree

2. Confirmed Experimental Officers without publications may be granted one year no-pay study leave to follow course of study as part of a Post Graduate Degree.

Technical Assistants – Non graduates

1. Proper training program for this category is not available. However, they are allowed to undertake short term training depending on the Institute's needs.

Administrative and Finance Staff

No proper training program has been developed for this category. However, officers are allowed to follow short term training based on the needs of the Institute.

It is clear from the above that TRI has not developed strong criteria for HRD of its staff. The basis for training has been mostly focused towards promotions and not towards improving the effectiveness and quality of the output of the staff. Since there is no clear policy on HRD for different categories of staff, most staff members have shown their dissatisfaction towards how TRI prioritizes training needs and select candidates for training positions. There had been some complaints that the training positions are not being fairly distributed among staff of sub stations.

Funds allocated for HRD:

Though Rs. 975,000 was allocated for local training during 2005, TRI has utilized only Rs.393, 193 (40%) while in 2006 the Institute utilized Rs. 384,113 up to September out of an allocation of Rs. 680,000. This indicates that TRI has not been able to utilize all the funds allocated for local training. It was mainly due to non availability of a HRD plan drawn up for the Institute. However, the Institute has been successful in utilizing most of the funds allocated for foreign training. The allocation for overseas training was Rs. 1 million in 2005 and Rs 2 million in 2006. Major component of funds allocated for foreign training was utilized for post graduate training.

Taking into consideration the present HRD activities at TRI, the review team noted that the management is not following a clear and transparent policy on identifying training programs and selecting candidates to suit the institute's needs. Training needs of HODs, researchers, management staff, administrative staff, finance staff, field staff etc. are not adequately looked after, discussed or planned. Training areas are never discussed in a common forum. Majority of training programs in operation are subject oriented and technical in nature

Proposed HRD programs for TRI staff:

There are many organizations and institutions in Sri Lanka and abroad which offer different HRD programs for different professional groups. Some are well recognized and maintain a good reputation. There are also reputed freelance individuals who conduct seminars, workshops and training programmes for professionals on different subject matter. Further, some of these organizations are prepared to conduct even custom made programmes based on the needs of the stakeholders. TRI has already established links with several organizations, locally as well as internationally, where its staff could be trained on subject matter and technical areas, and has made use of the facilities available in such organizations. Some areas for training that would enhance the efficacy of the staff are given below.

1. Governance and management structure
2. Attitudes, ethics and values for institutional setting
3. Improving administrative efficiency and financial management
4. Leadership and personality development
5. Team building and motivation
6. Role of committees in the institute as channels of communication for management
7. Development of decision making skills
8. Development of negotiating skills
9. Basic tender procedures
10. Dealing with stakeholders, liaison and interaction
11. Codes of practice and guidelines
12. Disciplinary procedures
13. Office procedures for stenographers, personal assistants, computer application assistants etc.
14. Stress management strategies for organizational effectiveness
15. Organizational management in research
16. Prioritization, monitoring and evaluation techniques for agricultural research and development
17. Development of performance indicators for research
18. Technical writing, presentation skills and effective communication for researchers
19. Managing intellectual property in agricultural research

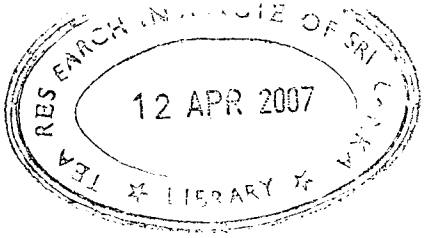
Suggestions

1. The subject of HRD should be placed under a Deputy Director who will implement the programme. This will be in addition to his other duties.

2. Assess the capacity of the staff and identify the gaps. Prioritize the training needs based on the urgency and importance.

3. Identify post graduate, long term, short term and other training needs of the Institute. This could be done by a Committee.

4. Categorize the training needs into different groups such as academic, technical, administrative, management, finance etc.



5. Identify certain compulsory training programs for certain groups such as, '*Decision making and negotiation skills*' for Administrators, '*Improving administrative efficiency and financial management*' for Deputy Directors, '*Funding and financial procedures*' for HODs, '*Disciplinary procedures*' for Administrative staff, '*Basic tender procedures*' for Financial Staff, '*Presentation skill and effective communication*' for Researchers etc.

6. Draw up an annual HRD program with a clear time schedule.

7. Develop acceptable selection criteria

8. Identify the organizations where selected training programs are to be conducted.

9. Maintain transparency in identification and selection of candidates for training.

10. Advertise the training programs identified for each year at TRI and its sub stations.

11. Develop HRD programs to train staff through out their career.

12. Make senior staff with Master's degree also eligible for sabbatical leave.

13. Establish a training center within TRI with necessary facilities to train all categories of staff.

Few observations on the progress of the Corporate Plan

The main objective of the Review, according to the TOR, is to assess the quality, effectiveness, relevance and impact of TRI Research and Development programmes carried out since 1999 under the Corporate Plan. Accordingly, the Review Team focussed its attention on the activities spelt out in the Corporate Plan.

Many of the major activities identified in the CP are of a long-term nature and ongoing at the time of the review. For example, varietal development is scheduled to take nearly 20 years for its completion, while studies on intercropping and fertilizer, to name a few, require up to 10 years. Accordingly, an assessment of the effectiveness and impact of the long duration research activities will not be found in this review. Also, the number of research publications arising from the CP studies, an instrument used in measuring research output, cannot be used as the sole criterion of assessment of the performance of the Corporate Plan since many of the projects are still being carried out.

The Corporate Plan lists 113 Thrust projects, 48 basic research projects and 36 supporting research projects conducted at the headquarters, substations and in growers' fields. The team is of the view that the number of projects is excessive considering the resources available. Many of the projects have been abandoned owing to what is commonly stated as lack of resources, mainly staff shortages. Some have not been completed although the targeted completion dates have passed. Taken as a whole, the Review Team is not satisfied with the progress thus far.

While the universal cry has been the lack of staff, it is interesting to note that there are no vacancies in the cadre of 57 Experimental Officers and only three in the cadre of 18 Technical Assistants. We suspect that part of the problem lies in some divisions and locations having excess staff. In fact at one location, the middle level officers complained that they had very little work. That was their problem. Another problem is that

technicians hired on contract basis quit their jobs with hardly any notice. A third reason is the undertaking of a large number of projects without having the required staff to implement them.

The Annual Reports beginning 2002 have given very sketchy information about the progress of research carried out by the Institute. The reader is therefore unable to get a good grasp of the status of a project. Such reports are not likely to make a positive impression on important readers such as administrators, policy makers, treasury officials, the Central Bank and the parliamentarians to whom the Annual Reports are distributed. The Review Team gathered that more details of research projects are given in another document titled the Technical Report which is also published annually. While the concern to limit the Annual Report to a reasonable size is accepted, the need to keep it comprehensive, clear and useful to the reader cannot be over emphasised.

A major deficiency in implementing the Corporate Plan has been the lack of progress monitoring. The Thrust leaders hardly meet with the project leaders, the HODs are not meeting adequately with their colleagues within the division, and the Director or the Deputy Director is not having formal quarterly or half yearly meetings with the scientists, although many of the aforesaid work in the same building.

It is correct that the researchers are required to submit progress reports at stipulated intervals and do so, but a response to these reports by way of a query, clarification or appreciation, even by telephone, is extremely rare. Annual visits of the Director to the substations for the purpose of reviewing the research projects, meeting the officers and inquiring about their well-being do not appear to be a part of the TRI top management culture.

The Review Team noted that owing to improper statistical designs, valid conclusions could not be made from some of the field experiments. Not adhering to basic principles of biometry in field experiments that take 10 to 15 years for completion can be very costly. Consultation with the Biometrician before laying out an experiment should be considered essential.

5. THE WAY FORWARD

The leadership of the Institute must continually look ahead, identifying the challenges, setting goals and developing strategies to achieve them. The emerging challenges of the industry include:

- Taking the industry forward in the midst of worker shortages and rising energy costs.
- Developing varieties with much higher yield potentials, pest and disease tolerance and assured quality with the use of advanced technologies.
- Increasing the economic life span of replanted tea
- Reducing use of synthetic pesticides to a minimum
- Maintaining soil health and increasing fertilizer use efficiency
- Developing value added products from tea
- Developing the scientific base to help promote tea as a safe and healthy beverage that will lead to its increased consumption worldwide
- Remaining in the forefront in all aspects of research and technology development of the Industry

In order to achieve the set goals, the Institute should have the required funds and facilities, qualified, well-trained and motivated staff, a carefully prepared research plan, meticulous execution of projects, efficient dissemination of research findings, thorough monitoring and evaluation and good governance.

Adequate funding for research

Unlike for research on annual crops, tea requires very long time periods to obtain results from research. Varietal development for example, may take twenty years, and a simple fertilizer field experiment may require ten years for completion. Accordingly, long term funding must be assured for completion of such projects, once started. Much investment is required in procuring costly equipment and maintaining them as the industry has to compete with other tea exporting countries. Furthermore, advanced technologies are required in meeting the ever stringent quality stipulations of some of the major importers.

As one of the strategies of obtaining adequate funding, TRI must build its public image as a key institution influencing the economy and employment in the country. This may be achieved through a number of activities that include participation in exhibitions, delivering public lectures, writing newspaper articles and conducting radio and TV programmes on a regular basis. Current funding for tea research stands at less than half the internationally accepted level of 1% of the value of a commodity. The Government of India presently invests about 1% of AgGDP on agricultural research.

A contented workforce
A contented staff across the entire Institute is required to reach its goals. The main problems of the staff that were brought to the attention of the Review Team include: lack of promotions, low emoluments, lengthy stays at locations with poor educational facilities for the children, inadequate health services, lack of appreciation and inaccessibility to officers of the top management.

Quality scientific staff

As in the past, TRI must continue to recruit the most promising of the passing out graduates and endeavour to send them quickly for postgraduate studies to leading institutions. The young scientists should be given all the facilities, opportunities and encouragement to develop into high calibre professionals.

Having high quality scientists in the organization is also a liability however, because they are in much demand locally and abroad. The Tea Research Board should take all steps to see that these officers get their due emoluments, promotions, and other perks and remain in the Institute. In this regard TRI should permit scientists to take up consultancies during week ends and public holidays so that they enhance their incomes, broaden their outlook, sharpen their skills and contribute to national development. The Institute has been very liberal in this regard having issued a Circular as far back as 1992 allowing this facility.

Human Resource Development
Very high priority should be accorded to the development of human resources. The principle that the skill requirements of all categories are changing and that every officer requires training throughout the career must be accepted.

Although the core business of scientists is the conduct of research, managerial skills are often required in carrying out day to day activities. Scientists have to manage people, run laboratories, work in teams, engage in negotiations, and develop communication skills and many other attributes that are involved with management. TRI scientists can benefit from a course in management training.

TRI should establish an In-Service Training Centre with residential facilities, audio-visual and other equipment and qualified staff. Some of the facilities currently available at the Low Country Station at Ratnapura could be utilized for this purpose.

The laboratories and the library
Although the TRI laboratories are very well equipped to meet most of the needs of the research programme, continuous updating of the equipment is required, particularly in frontier technological development areas such as molecular biology, product development and chemical residue analysis. Furthermore, regional laboratories equipped to analyse soils, plant materials and identifying pests and diseases are required to provide a better service to the stakeholders.

The library provides a good service with its 36 reputed journals obtained from abroad, regular procurement of important text books, acquisition of annual reports of research institutions in tea growing countries and updated tea news from around the world. Furthermore, the TRI library is linked to the CARP library services and is a member of the inter-library network. The present budget of Rs. 5 million is adequate for the present.

TRI must ensure that this important service to its scientific staff is continued. The vacant position of Librarian should be filled soon.

The research agenda

The research agenda must be developed in consultation with the stakeholders and considering the short and long-term interests of the country as well. While the E&E, the RSC, the Crop Clinics and other links with the stakeholders provide opportunities for determining research needs, a formal problem census with the participation of all stake holders once in every four or five years would be useful. Although the vital importance of fuel wood for the tea industry in the years ahead is well recognised, the Institute does not have a sound research programme with respect to forestry. It would be prudent for the TRI to join up with the Forest Department or the universities where scientists are already well experienced on the subject, and initiate collaborative forestry research programmes. Increased attention should be given to the development of diverse products from tea. The research project proposals must be prepared with meticulous care, spelling out their relevance and importance, the chances of success, the costs associated with their execution and the anticipated benefits to stakeholders. A standard format should be prepared for a project proposal, obtaining assistance from CARP if needed. The proposals should be subject to internal and external reviews as appropriate.

Making plans

The time is ripe to initiate the preparation of the Corporate Plan for the period 2008-2012, using the lessons learnt from the preparation and implementation of the previous plan. The Plan must be in conformity with the challenges of the industry, the goals of the Institute and the availability of financial, human and other required resources.

The Agricultural Economics Division will be required to play a major role in the planning process. It must be fully conversant with national policies, well informed on all aspects of tea here and abroad, and be fully aware of the economic sensitivities of the workers, smallholders and the plantation companies. Clearly, the AgECOND has to be significantly strengthened to carry out its future responsibilities effectively.

Annual Work Plans should also be developed that spell out the operational details such as who is doing what, when and how.

Monitoring and evaluating research programmes.

Monitoring needs to be carried out by the management through a mix of mechanisms such as perusal of progress reports with follow-up action, review meetings, visits to the laboratories and fields and getting scientists to make oral presentations at seminars. The absence of monitoring and lack of course corrections on the way, can be very costly in tea research since experiments take a very long time for completion. While the Review Team noted that all the scientists and the top management unanimously declared the critical importance of having an M&E system in place, they have to accept that it is a demanding task. M&E will require additional staff at DDR level, additional time input from HODs and scientists and plenty of paper work. It must also be realised that the formats for M&E will be different at HOD level, Directorate level and Board level.

Monitoring and evaluation of the research and extension programme at the Institute level should be carried out by a well structured quarterly meeting chaired by the Director. A research project monitoring unit must be set up in the office of the Deputy Director.

Monitoring and evaluation of the Thrust and Project levels should also be strengthened, formalized and more frequent.

Monitoring and Evaluation should not be considered a chore by those who monitor and a headache by those being monitored. Rather, it should be considered a very important requirement for the betterment of the Institute, and owned by all.

Interdisciplinary research
The shortcomings of the operational aspects of the interdisciplinary research programmes should be reviewed immediately by an in-house committee consisting of the Director, Deputy Directors, Heads of Divisions and representatives of each Division, and workable procedures to carry out such programmes effectively in the future should be agreed upon by all parties.

Dissemination of research
The acid test of the success of a completed research project in a cess funded research organization such as the TRI is the sum of the actual and potential benefits of the findings to the stakeholders. The process of technology transfer from the researchers to the corporate and smallholder sector is not very effective. If the findings of the researchers cannot be effectively carried out to the stakeholders, the findings themselves are of no avail.

The funds allocated, the facilities provided and the recognition given to the Extension and Advisory Division are inadequate. A strong division must be built that consists of suitably qualified officers who carry out their duties in a professional manner. They have an important role to play in raising the standards of the Industry.

A formal seminar programme at the TRI
TRI scientists make oral presentations frequently at the Annual Sessions of the Sri Lanka Association for the Advancement of Science, the Institute of Chemistry, Institute of Biology and at other highly professional gatherings in all parts of the world. Many of them are accomplished presenters. However, TRI does not have a formal seminar programme. The Review Committee suggests initiating a seminar programme at TRI headquarters on a monthly basis with a mix of TRI and leading scientists from other research institutions taking part. The benefits from such a programme need hardly be elaborated here

Scientific forum of the tea growing countries
The major tea growing countries include India, China, Sri Lanka, Kenya, Indonesia, Bangladesh, Vietnam and Malawi. Although each of these countries has established institutions that are mandated to conduct research on tea, there is very little known interaction between them. The Review Committee proposes that the TRB considers initiating the formation of a forum of scientists of the tea growing countries with the ultimate objective of upgrading the quality of research in them. One activity of this forum would be the holding of a meeting of the scientists annually or once in two years hosted by the countries on a rotational basis. This meeting will provide an opportunity for the scientists to get to know each other, develop fellowship, share knowledge and experience and even lead to better international relations for mutual benefit.

Fixed term assignments for managers at the top

The Review Committee is of the view that senior management positions such as Director, Deputy Director and Heads of Divisions should not be held for more than three years at one time. Management positions require a set of skills that are often not found in hard-core scientists.

A manager has to be a leader, planner, co-ordinator, motivator, problem solver, mediator, decision maker, listener, disciplinarian and a humanitarian. We have seen that many managers of research institutions however, do not possess most of these qualities and after few years in office become biased, autocratic, stale and a burden to the institution. Furthermore, new ideas and new approaches that are often brought into an organization with changes at the top facilitate institutional innovation and change.

The fixed term principle has been practised at the universities where the Vice Chancellor, the Dean and the Head of the Department are appointed on a three year term. That this system is detrimental to development of higher education is not even murmured in the campuses.

6.LIST OF ANNEXURES

Annexure 1. The Terms of Reference

The main objective of the Review is to assess the quality, effectiveness, relevance and impact of TRI Research and Development programmes carried out since 1999 under the Corporate Plan prepared in 1999.

The specific points that need to be looked into by the Review Committee are given below.

1. Whether the Institute has effectively carried out R & D programmes and achieved the set targets of the Corporate Plan

2. Review of TRI recommendations and its adoption and its impact on corporate sector and the smallholder sector.

3. The Institute's capacity and capability and effectiveness in technology transfer to the corporate sector and to the smallholder through Advisory and Extension Division.

4. A critical review of the TRI management structure and its effectiveness in achieving the set targets by formulating an inter-disciplinary approach in the implementation of the set programmes.

5. Critical review of the Institute's capacity to meet the emerging challenges of the industry for

- Mechanisation
- Process technology including energy saving approaches
- Plant Breeding programme
- Diversity of germplasm base and breeding strategies
- Plant protection research programmes in relation to future global restrictions on pesticide residues
- Institute's recommendations on fertilizer and their adoption
- Institute's publications and Scientists' research publications

6. Critical review of the administration and financial management, human resources development and allocation of funds for research

7. Review Committee is expected to submit their recommendations to bring about necessary changes in the research and development programmes to meet the emerging local challenges of the sector.

Annexure 2. Production of made tea in major tea growing countries.

Country	Production (million kg/yr)
India	820
China	800
Kenya	328
Sri Lanka	309
Turkey	205
Indonesia	170
Malawi	50

Source: FAO (2005)

Annexure 3. Cost of Production of made tea in tea exporting countries

Country	Cost of production ($/kg)
Sri Lanka	1.73
India	1.35
Kenya	1.15
Vietnam	0.80

Source: Export Trade, Sri Lanka (2006)

Annexure 4. Extension services of the TRI to the smallholder sector.

	Very poor	Poor	Satis factory	Good	Very good
	%	%	%	%	%
Relevance of research to growers needs	3.9	50.0	26.9	11.5	3.95
Dissemination of research findings	7.7	61.5	23.1	3.9	3.9
Recommendation/Relevance	3.7	23.1	38.5	30.8	3.9
Recommendation effectiveness	0	23.1	38.5	34.6	3.9
Recommendation quality	0	3.9	46.2	42.3	7.7
Recommendation impact	11.5	15.4	50.0	19.2	3.9
Recommendation adoption follow-up	15.4	73.18	7.7	3.9	0
Facilities – AE Service	3.7	53.9	34.6	3.9	3.9
Quality/Lectures/Seminars/Discussions	3.9	11.5	46.2	30.8	7.7
E & E Forums	7.7	11.5	42.3	19.2	15.4
R.S.C. Seminars	11.5	30.8	23.1	26.9	7.7
Quality publication products AV products	0	30.8	15.4	38.5	15.4
Planting material facility	26.9	50.0	19.2	3.9	0
Relationship with growers	3.9	76.9	7.7	11.5	0

Annexure 5. Persons met by the Review Committee.

Dr. Sarath Abeysinghe, Director, TRI and staff
Mr. Nihal Bopearachchi, General Manager, Madulsima Plantations Limited
Mr. K. D Dahanayake, OIC, Regional Station, Kottawa
Mr. Abeynanda Dias, Director (Operations), Namunukula Plantations Limited
Mr. Ananda Fernando, Director (Operations), Maskeliya Plantations Limited
Mr. Suranjan Fernando, OIC, Regional Station, Passara
Mr. Mohan Ganapathy, General Manager, Kelani Valley Plantation Limited
Mr. Malin Goonetilake, Secretary General, Planters' Association of Ceylon
Dr. S S B D G Jayawardena, Chairman, Tea Research Board
Mr. H M S Kahatapitiya, Gouravilla Estate, Upcot
Mr. K G J P Mahindapala, OIC, Regional Station, Deniyaya
Mr. S D Nandasena, Member, Tea Research Board
Mr. R K Nathaniel, Member, Tea Research Board
Mr. T Pinidiya, Manager, Venture Organic Tea Garden, Norwood
Mr. Sunil Poholiyadde, Director (Operations), Maskeliya Plantations Limited
Mr. T Manamperi, Superintendent, Galaboda Estate, Ratnapura
Mr. J M A Ratnayake, Executive Director, RPC Plantation Management Services (Pvt) Limited
Mr. G K Seneviratne, MD/CEO, Kelani Valley Plantation Limited
Mr. Asoka Somaratne, Member, Tea Research Board
Dr. M A Wijeratne, OIC and staff, Low Country Research Station and, Ratnapura
Mr. Athula Wijewardena, Superintendent, Glasgow Estate, Agarapatana
Dr. Kapila Zoysa, OIC and staff, Mid Country Research Station, Hantane
Executive Committee, Private Tea Factory Owners' Association