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# Tea & Tocklai

A Century of Excellence in Tea Research

## ***TRA Tocklai***

The Tea Research Association is the largest and the oldest tea-research entity in the world. It is a pioneer in the research and development of tea and an innovator in providing extension services to the industry. It has ten branches with its registered office at Kolkata.

- RESEARCH
- TECHNOLOGY
- INNOVATION
- KNOWLEDGE
- TRAINING

Tea research in India dates back to 1891, when a Joint Committee of the Indian Tea Association (ITA) and the Agricultural and Horticultural Society of Bengal appointed Mr. M. Kelway Bamber, a Chemist. Till then, all important contributions towards the growth of the tea industry were the results of the untiring personal efforts of a few pioneers who had to struggle against heavy odds. Mr. Bamber initiated work on the chemistry of tea, soils and manures, in an effort to understand the chemical basis of tea quality. He published the findings of this work in his book *The Chemistry and Agriculture of Tea- Including Growth and Manufacture* in 1893. The ITA then assigned Dr. George Watt, Entomologist, Govt. of India the task of investigating the subject of Tea Blight and the potential of the plant *Adhatoda vasica* as an insecticide against tea pests.

Dr. Watt extensively toured the tea areas of Assam and Naga hills in 1895 and was convinced that the investigations could only be accomplished by conducting a series of long term studies. He published his findings in the book *The Pests and Blights of the Tea Plant* in 1898. Dr. Watt impressed upon the planters the need for proper cultivation of the tea plant, as well as protection from pests and diseases. He dealt with all aspects of tea cultivation such as plucking, pruning, manuring, drainage and even advised pipe drainage. Following his report, the ITA proposed the appointment of a Scientific Officer for research on chemistry, cultivation and manufacture of tea. According to Dr. Watt, the proposed investigations were to include - 1) studies on the influence of environmental factors like soil, climate, moisture, topography of the land, shade, proximity to jungles etc. on the character of the tea leaf, 2) chemical aspects of tea plants in relation to disease resistance, manure requirement, yield and quality improvement and 3) all stages of manufacture and their relation to field operations. For this, Dr. Watt suggested that the concerned scientist should have a strong background in Botany and Chemistry and should be supported by a local laboratory, in addition to the Central Laboratory in the Calcutta Museum. However, the proposal could not be put into immediate effect for want of funds. In 1899, the ITA, with financial support from the Governments of Assam and Bengal, appointed Dr. Harold H. Mann as the Scientific Officer. His joining in the year 1900 heralded a new era in scientific research on tea in northeast India.



Dr. Harold. H. Mann

Dr. Mann started work in the laboratory of the Government Reporter on Economic Products in the Calcutta museum. His work became so impressive that both planters and Agency Houses appreciated it and made a concerted effort to augment research for the benefit of the industry. In 1902, on the advice of the ITA, Dr. Mann prepared a project for expansion, keeping the Calcutta laboratory as the headquarters. He suggested that an experimental station should be established in the central part of the tea districts, preferably in or around Jorhat, as it was well connected by rail and river, the primary means of communication at the time.

## Establishment of Tocklai

Organised research on tea in India began in 1911, with the establishment of Tocklai Experimental Station in the loop of the rivulet Tocklai at Jorhat. The site was provided by the Jorehaut Tea Company Ltd. The governments of Assam and West Bengal, along with the tea industry, shared the expenditure for its establishment. For the greater interest of tea research, a parent organization called the Tea Research Association was formed in 1964 to take over the management of Tocklai Experimental Station and its outstations. Since then, this research station, popularly known as Tocklai, has come a long way and is today regarded as the oldest and the largest tea research institute in the world. Tocklai carries out and promotes research on all aspects of tea cultivation and processing, with the principal objective of improving overall productivity and quality. In 2014, Tocklai Experimental Station was renamed as Tocklai Tea Research Institute.

## Objectives of the Tea Research Association

- To carry out and promote research and other scientific work pertaining to the cultivation, production and processing of tea.
- To provide advisory services to registered members.
- To conduct training on various aspects of tea cultivation and processing.
- To produce literature on various aspects of tea cultivation and processing.

## Management

The management of the Association is vested with the Council of Management, which consists of the Chairman, the Vice-chairman and fifteen members, elected by the ordinary members of the Association, four representatives of the Government of India, including the Director (Research) Tea Board, the Chairman Tea Board, the Financial Adviser and the Chief Accounts Officer, Tea Board, one representative nominated by the Indian Tea Association (ITA), the immediate past Chairman of the council, co-opted as a member, three representatives co-opted by the council from small gardens (up to 200 hectares), the Director of TRA and the Secretary, TRA.

The Director, TRA and the Secretary TRA are principle officers of the association. All scientific and non-scientific positions are employed by the association.

## Funding

Tocklai was funded by the Tea Industry from 1911 to 1963. Towards the end of 1963, when sourcing funds for research activities had become difficult, it approached the Government of India to fund a part of its activities. In 1964, the Government of India agreed to fund a part of Tocklai's research activities. Thereafter, the Tea Research Association (TRA) was established as a co-operative research enterprise, which subsumed all research units of the industry in different locations, including Tocklai and was funded by the major companies of the tea industry and the Council of Scientific and Industrial Research (CSIR), on specific heads. The TRA was adopted as one of the CSIR Group of Laboratories and was approved under Sec. 35 (1) (ii) of the Income Tax Act, which allows

contributions to the Association for weighted deduction from taxable income of the donors. From 1st April 1990, TRA was linked to the Department of Commerce, Ministry of Commerce & Industry, Govt of India and the Tea Board of India for grants-in-aid. The Department of Commerce funded TRA on an agreed formula as per the CSIR till 2001 and thereafter at 49% funding on approved heads. From the year 2004, the Department of Commerce funded TRA at 80% of the expenditure on Salaries, PF, Gratuity, Medical and Training. Since the 12th Plan (2012-2017) and the Medium Term Framework (2017-2020), the funding has been approved at 49% on Salaries, PF, Gratuity, Medical & Training and 31% through research projects with an overall cap.

As of 1st April 2018, 66% of the budget is met out of the funds from the tea industry subscription/internal fund generation and 34% of the funds are from the Department of Commerce through the Tea Board of India.

## Focus Areas

- Sustainability
- Climate change adaptation
- Development of stress tolerant cultivars with high quality
- Improvement of tea quality and production of speciality teas
- Mechanization of field practices
- Reduction in costs
- Risk assessment
- Drip irrigation & fertigation
- Artificial Intelligence
- Robotics in Agriculture
- Ecological pest & disease management
- Mitigating Regulatory & emerging challenges
- Leveraging International Networks
- Analytical support
- Diversification
- Advisory Support & Training
- Training for small growers
- Tea literature
- IOT
- Data analytics



## The Tocklai Campus

Tocklai is located at a distance of 2 km from Jorhat town. The technical campus covers an area of 39.86 acres and features several highlights for anyone who visits the Institute.

### The Heritage Guest House



Tocklai's 90 year old guest house is a classic specimen of the colonial-era architecture. Built in the year 1929, its construction and craftsmanship have stood the test of time. The guest house offers its guests several modern amenities, along with an old-world charm that is unique to it. The iconic guest house has had the privilege of hosting several eminent guests, the likes of whom include Prince Phillip, the Duke of Edinburgh (1961), Dr. Manmohan Singh (1983), Dr. A.P.J. Abdul Kalam (2011), Nobel Laureate Dr. V. Ramakrishnan (2012) and many others.

## The Directorate



The new Directorate building is a sprawling structure that forms the centrepiece of all activities at Tocklai. Built in the year 2011, it houses the Tocklai Directorate, the Administration department, the Advisory department, the Accounts department, the Central Library, the Climate Research Laboratory and the Statistics department.

## The Central Research Facility



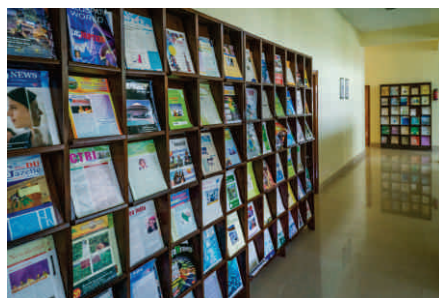
The Central Research Facility, occasionally referred to as the New Research Building, was constructed in the year 1999. It houses the major research departments of Biochemistry, Plant Physiology & Breeding, Biotechnology, Soils, Entomology and Mycology & Microbiology. A major chunk of Tocklai's research work is carried out in the departmental laboratories situated in this building.





## The Tocklai Library

The Tocklai Library came into existence with the inception of scientific research on tea in 1900, when several books and journals were procured and retained in the individual departments. With the growth of the station, however, a central library came into being, which was finally housed in the main office building in 1947.



In 1962, the library was listed in the IASLIC Directory of Special and Research Libraries in India. Today, it is one of the best special libraries in India. Its stock comprises books, journals and other technical literature. The library currently holds more than 6700 books and 15000 bound volumes of scientific and research journals. Technical literature, bulletins, pamphlets, memoranda, annual reports of other research laboratories, conference proceedings, reprints, reviews, trade journals, maps etc. also form a part of the library holdings.

The library, rich in special and rare collections, renders its services to the scientific personnel of the Institute. Research scholars, scientists, students and academicians from different parts of the country and abroad frequently visit the Library.



## The Model Tea Factory

The Model Tea Factory at Tocklai is a complete representative black tea manufacturing unit, equipped with all the facilities and flexibilities of a commercial factory. It houses the latest generation of tea processing machinery, coupled with the utmost level of mechanization. The factory was established at Tocklai under the Tea Automation Project. Tocklai has commissioned the very best of industrial tea manufacturing machinery in the Model Tea Factory. The machinery features around 90 sensors of various types to monitor a variety of process parameters.



## The Tocklai Auditorium



The Tocklai Auditorium was constructed in 2011. It has a seating capacity of 350 people. The state-of-the-art auditorium features high end audio-visual and lighting equipment for presentations and seminars. The auditorium hosted the technical sessions of the World Tea Science Congress held in the year 2011 at Tocklai.



## Activities

Since inception, the Tea Research Association has ably served the Indian tea industry and has become synonymous with research on tea. It has unfurled several technological innovations that have benefited the industry from time to time. The phenomenal increase in the production of tea in northeast India, from 234 million kg in 1951 to 797 million kg in 2012, clearly underlines the impact of R&D activities on tea production. Tocklai carries out and promotes research on all aspects of tea cultivation and processing, with the principal objective of improving overall productivity and quality. Research on tea manufacturing is another major focus of the Association.

TRA has an efficient advisory service operating from Jorhat, Dibrugarh, Tezpur, Cachar, Agartala, Darjeeling, Dooars and Terai. Tocklai has research departments that deal with all important tea domains viz. Plant Physiology & Plant Improvement, Tea Soils, Agronomy, Entomology, Mycology & Microbiology, Biotechnology, Biochemistry, Analytical Services, Tea Processing & Manufacturing and Agricultural Economics & Statistics. Some of the focus areas of the Association are highlighted in the next few pages.



## Plant Improvement

Tea plant improvement is one of the most important areas of research for Tocklai. For the growth and development of the Indian tea industry, Tocklai has been producing a large number of cultivars, which are being used by tea plantations from a long time. The popularity of clones gained

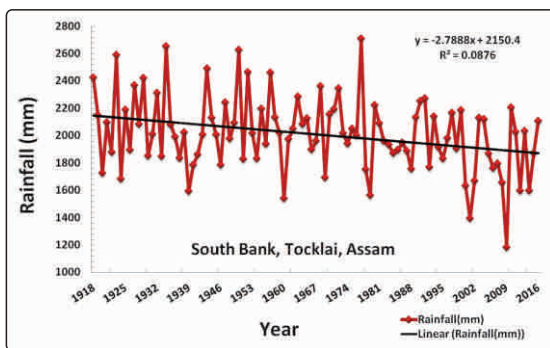


momentum in tea cultivation since the standardization of vegetative propagation and the release of the three clones - TV1, TV2 and TV3 by Tocklai in 1949. Since then, Tocklai has persisted with its efforts to develop improved planting materials through selection and breeding. Tocklai has so far released 33 TV clones for commercial cultivation, apart from 153 garden series clones. Moreover, 27 out of these 153 garden series clones were released exclusively for planting in Darjeeling hills. All in all, Tocklai has thus far released 186 clones and 16 seed varieties to the tea industry for commercial planting. Collection, conservation and utilization of tea genotypes or germplasm have continued as essential activities for Tocklai since inception. As a result, Tocklai today possesses a large germplasm collection, which is utilized for continuous tea breeding activities.

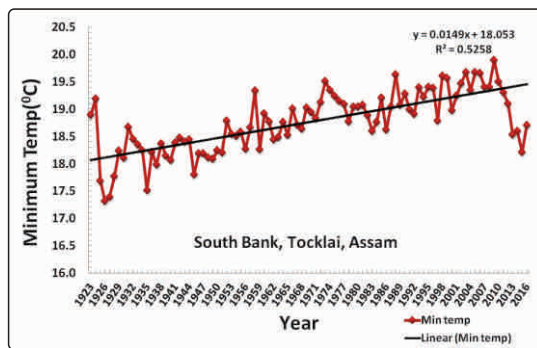
## Climate Change Adaptation

To develop a climate resilient tea production system, a project was initiated at Tocklai to study the impact, vulnerability and adaptation of tea to climate change. This is a part of the network project launched by ICAR across India to study the overall impact, vulnerability and adaptation of Indian agriculture to climate change. The major findings of the project so far are:

- Long-term weather data records of TRA suggest a decline in rainfall and an increase in temperatures.
- There is an increase in the frequency of extreme events (e.g. high rainfall, resulting in floods and low rainfall, resulting in drought-like situations).
- Extreme weather events have been found to trigger some biotic stresses (e.g. increase in the incidence of pests and diseases), as conditions have increasingly become conducive to such stresses.



Total Annual Rainfall, 1919-2016 (South Bank, Assam)



Minimum Annual Average Temperature (1923-2016),  
Tocklai

- Initial results of controlled field experiments have indicated that organic tea or an organically integrated tea production system is more climate resilient than the conventional system. An Open Top Chambers (OTC) facility has been commissioned at Tocklai to study the growth and behaviour of tea plants at elevated carbon dioxide and temperature situations. All the TRA-released clones are subjected to elevated CO<sub>2</sub> and temperature conditions in the OTCs, besides simulating artificial water stress (both high and low) conditions. Individual and combined stress of all the components of abiotic stress are administered and the physiological changes, production potential as well as the quality of tea are monitored. The level of stress (e.g. CO<sub>2</sub> and temperature elevation) is created based on the future climate scenarios, simulated using the PRECIS (Providing Regional Climates for Impact Studies) model developed at the Hadley Centre, UK. Testing all the clones under these simulated climate scenarios allows researchers to conclude the vulnerability of the clones and to figure out as to which of these clones is likely to survive and produce economically with reasonable quality. Further, it is being speculated that tea, being a C<sub>3</sub> plant, may show higher productivity at elevated CO<sub>2</sub> conditions, but it is not yet known as to how the plant will behave when CO<sub>2</sub> and temperature levels shoot up and water stocks are either limited or in excess in the soil, while other meteorological parameters are in the extreme range. This project will eventually answer some of these questions and suggest adaptive measures.



Open Top Chamber experiment at Tocklai

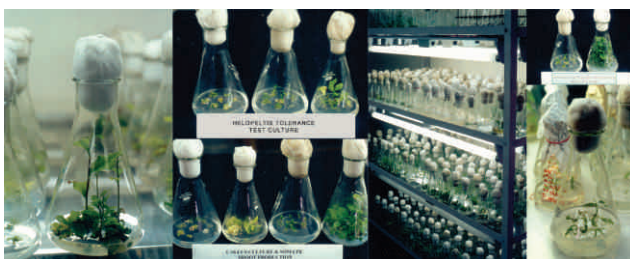


## Biotechnology

Biotechnological research on tea is rather young, having only started in 1980. A lot of work has since been done on micro-propagation, somatic embryogenesis, protoplast culture, anther culture etc. Development of different types of molecular markers and characterization of the large germplasm collection, using DNA finger printing techniques, have been successfully done. Gene expression profiling and identification of candidate genes have also been carried out.



### From flask to hardened tea plant



## Tissue Culture

## Agronomy

Through a large number of experiments, Tocklai has determined the optimum plant population per hectare and has standardized the pre-planting operations. Bringing up of young tea, from planting to the first frame formation pruning, is another area where clear-cut recommendations have been released to the



## Mechanised Harvesting

tea industry. The productivity of tea gardens is closely related to the efficient and complete harvesting of pluckable shoots. Harvesting, therefore, assumes paramount significance in the economy of tea estates. Harvesting is a highly labour-intensive operation which usually engages about 60-70% of the workforce belonging to a particular estate. Hand plucking is the norm in the gardens of northeast India, but the shortage of experienced workers during the high cropping season continues to adversely affect harvesting operations. To overcome this, Tocklai has been conducting several experiments on mechanization of field operations like pruning and harvesting. Initial studies have shown that pruning and harvesting machines can be successfully employed in tea gardens. This can not only improve the productivity of the estates, but also improve the earnings

of the workers. In northeast India, the bushes remain in a dormant stage for about three months during winter. Tocklai has studied in detail the physiology of bushes in relation to winter dormancy, photosynthesis and tea shoot development. Consequently, it is now possible to put forward firm recommendations to the industry on pruning and harvesting. Nutrients like nitrogen, potassium, phosphorus, sulphur and zinc play a major role in the health and productivity of the bushes. Tocklai has already developed an Integrated Nutrient Management system, involving the use of organic manures, vermicompost, biofertilizers and synthetic fertilizers. Recent experiments have shown that the use of synthetic fertilizers can be reduced by 20-25% when organic manures and bio-fertilizers are used in sufficient quantities.

## Soil and Water Management

Tea soils have undergone considerable degradation over the years. Since the massive rejuvenation of soil under a perennial crop like tea is only possible after uprooting of old tea fields, soil rehabilitation before replanting an old tea field is thus an extremely important event for ensuring sustainability of tea plantations in this region. The benefits of soil rehabilitation have been extensively studied by Tocklai.



*Strands of deep-rooted Guatemala grass in an uprooted old tea field*

Water management is another critical area of operation in the estates. In this context, it is worth mentioning the noteworthy work done by Tocklai on drainage. While flooding and water-logging



*Rain water harvesting*

remain major problems in the Brahmaputra valley, soil erosion and landslides are the main problems in Barak valley and Darjeeling. In the plantations located at the Himalayan foothills and the Terai area, flooding, gully formation and river erosion are the major causes of concern. Tocklai has used remote sensing techniques on a GIS platform for covering large plantation areas of major watershed basins.

## Pest and Disease Management

Tea plantations in northeast India are severely affected by several pests and diseases. Tea mosquito bugs, loopers, slug caterpillars, thrips, greenflies and termites are the major pests of tea, while black rot, blister blight and red rust are the important diseases. Tocklai has recommended tea plantations to adopt an integrated pest management strategy to reduce the use of synthetic pesticides and to move towards non-chemical pest management. Tocklai has released certain biological control agents and fungal antagonists on a commercial scale for the control for pests and diseases. Research is being done on the sex pheromones of the tea mosquito and the looper. Biological control agents of termites and loopers are being studied and these will be available shortly.



*Insect pests of tea getting stuck on yellow polythene sheets coated with HMPSA*



*Helopeltis infestation in tea leaves*

Plant growth promoting rhizobacteria is another subject of research. The use of these beneficial microbes enhances the resistance of tea plants against pests and also increases productivity. Tocklai has achieved some useful results in this regard, which are being tested on a commercial scale. Estates have been advised to only use those pesticides that are recommended by Tocklai, based on extensive field testing and residue studies. It has been proved that the tea brew contains very little residue and is therefore safe for consumption.

## Organic Tea

Organic tea is yet another area where Tocklai has been conducting long-term experiments. Through a series of investigations, Tocklai has developed a package of practices for organic tea in northeast India and this package is now available to the tea gardens. Vermiculture is another subject of contemporary interest and here too Tocklai has researched and published the method for vermicomposting in tea gardens.



## Tea Processing and Manufacturing



Tocklai puts immense thrust on the improvement of tea processing techniques to boost the quality of produced tea. It achieves this through experiments on packaging and storage of tea, application of various technologies for the optimisation of space, power and labour in factories, tasting of commercial tea samples, testing of commercial products used in factories and processing and assessment of experimental tea samples. Tocklai also assumes an advisory role for the Tea Industry on aspects such as factory layout, design specifications of machinery and other intricacies of tea processing. The Model Tea Factory (MTF), located within the premises of Tocklai Tea Research Institute, is a complete representative black tea manufacturing unit, equipped with all the facilities and flexibilities of a commercial factory. It houses state-of-the-art tea processing machines, allowing the highest level of mechanisation. Each of these machines has been augmented with various sensors and additional control features. Advanced networking technologies, along with computerised distributed data acquisition and measurement systems, have been used for online monitoring and real-time data logging.

List of machines designed/ developed by Tocklai and used by the industry:

- Rotorvane
- Continuous Tray Drier
- Rotorvane Attachment



- Rotorvane Cone Attachment
- Rotorvane Improved
- Borbora Continuous Leaf Conditioner
- Baruah Continuous Roller
- Baruah Continuous Roller Improved
- Tea Breaker Cum Stalk Separator
- Green leaf Storage System
- Electronic Monitoring and Control System for Withering.
- Modified Open Trough for Withering.

## Biochemistry

Tocklai has conducted detailed investigations on the biochemistry of tea and has documented the physico-chemical changes taking place during manufacturing. Tocklai has also developed machinery for tea processing. While India adheres to the global standard of ISO 3720 for tea, many countries are yet to adopt this standard. The Biochemistry department, in collaboration with the TPMA department, advises the industry on various aspects of tea processing in relation to quality improvement. Some notable contributions of the department:

- Chemical basis of tea quality
- Flavour index for Darjeeling clones
- Factors regulating Darjeeling Flavour
- Tocklai Fermentation Test
- Brightness Enhancement in Darjeeling Tea
- Pigment Profile as a tool for assessing quality
- TF and TR as indices for quality



## Analytical Services

Tocklai undertakes analysis of soils, soil amendments and other agricultural inputs like synthetic fertilizers, organic manures, micro-nutrients, pesticide residues and heavy metals. Samples received from tea estates are analysed promptly and the reports are sent on priority, allowing them to carry out agricultural operations on time. The Analytical Laboratory is accredited by the National Accreditation Bureau for Testing and Calibrating Laboratories (NABL), under ISO 17025. Under the 11th plan, a new Pesticide Residue Laboratory,



entitled **TLabs** was established at Kolkata to assist the industry in conforming to the required norms associated with tea production. The TLabs at Kolkata is equipped with state-of-the-art equipment like triple quadrupole LC-MS/MS and ion trap GC-MS/MS that run 24x7. The testing is carried out by a team of experienced residue chemists in adherence to the Quality Management Systems (QMS).

## Transfer of Technology/Advisory Services

An efficient extension system enables TRA to transfer the technology developed by the scientists in the lab to the gardens. The Advisory Officers of TRA conduct regular visits to the gardens and advise the management on all aspects of tea cultivation. Tocklai also conducts regular training programmes for garden executives and small tea growers. The General Tea Training Programme is very popular among young people pursuing a career in Tea. The quick and efficient transfer of technology to the field and factory is the secret behind the success of Tocklai. The research organization maintains constant interaction with the tea industry, which is faced with several challenges like increased production costs, aging tea bushes, competition from other beverages etc. It is an undisputed fact that TRA's extension services have contributed significantly to the growth of the Indian tea industry.

## Training for Small Tea Growers

Small tea growers have emerged as major contributors to India's total annual tea production. As part of Tocklai's efforts to empower them, a dedicated Training & Research Centre for small growers will be shortly established at Tocklai, in collaboration with the Govt. of Assam. This Training & Research Centre will cater to all R&D needs of small growers. The centre will facilitate residential training on basic as well as advanced topics on tea production, tea quality, organic tea and diversified/speciality teas, among others. The research components proposed for this centre are also designed to tackle the various challenges faced by the industry, including those put forth by climate change.

As part of this initiative, a number of field training cum demonstration programmes have already been carried out by using the existing infrastructure at Tocklai, Dikom and Thakurbari centres of TRA.

## Tea Literature

Tocklai's knowledge base on tea is reflected in the sheer amount of tea literature that it has produced over the years. The biannual journal *Two and a Bud* is a major publication. TRA's newsletter *Tocklai News* regularly publishes notes and articles that are of practical importance to planters. Advisory bulletins, advisory leaflets, special bulletins and occasional scientific papers are also published by Tocklai on regular and topical basis. The Annual

Scientific Reports give a detailed account of the research and advisory work carried out by the Association. Several books on different aspects of tea science, including those on tea manufacturing and tea tasting, have also been published. Publications like the *Tea Encyclopaedia and Science & Practice in Tea Culture* have acquired cult status in the industry.

Some of Tocklai's best-selling publications were recently converted into Ebooks for easy accessibility. An online bookstore was subsequently introduced on TRA's website **[www.tocklai.org](http://www.tocklai.org)** to make these Ebooks readily available to interested readers. TRA's member gardens are eligible to purchase these Ebooks at subsidised rates.





## Externally Funded Projects

### **Funding Agency: Tea Board of India (11<sup>th</sup> Plan)**

- Development of alternative strategies for management of the tea mosquito bug and blister blight disease in tea plantations of northeast India.
- Studies on the biochemical aspects of tea processing in CTC as well as green tea manufacture.
- Studies on drought in tea areas of Dooars and Terai with focus on soil properties, physiology and yield with a view to schedule irrigation in a cost effective way.
- Molecular basis of stress like biochemical changes during processing of tea shoots and their relation to the quality of made tea.
- Development of methodologies of food-grade secondary metabolites from tea and upscaling the methods for commercial purposes.
- Establishment of a chain of quality testing laboratories and strengthening of existing analytical facilities at the regional centres of Tocklai.
- Sustaining soil productivity – some strategies.
- Biotic and abiotic stress analysis for development of stable quality genotypes.
- Studies on heavy metals.
- Establishing a pesticide-residue testing laboratory.
- Current pest problems of tea in North Bengal and their possible management strategies.



### **Funding Agency: Tea Board of India (12<sup>th</sup> Plan)**

- Development of new clones through integration of conventional and non-conventional methods of breeding for productivity, quality and stress tolerance.
- Development of machines for tea harvesting and mechanization of cultural operations.
- Approaches on enhancing the quality of tea and the capacity of existing tea processing machineries.

### **Funding Agency: National Tea Research Foundation (NTRF)**

- Extraction, identification, quantification and utilization of endogenous growth hormones in tea.
- Selection, collection and preservation of tea germplasm from North Bengal area for development of improved planting materials for Dooars, Terai and Darjeeling.
- Selection and evaluation of new planting materials from existing seed population of tea, suitable for Dooars, Terai and Darjeeling agro-climatic conditions.
- Studies on VAM symbiosis and rhizosphere microflora and effect of their interactions on growth and nutrition of tea plant.
- Developing soil solubility criteria for replanting based on soil health parameters.
- Developing a package of practices for the management of compact tea soils by modifying soil physical environment.
- Studies on Municipal Solid Waste Management (MSWM) and its standardization for use in tea plantations.
- Status and response of micro-nutrients (Zinc, Boron and Manganese) in texturally different tea soil of Assam.
- Integrated management of *Helopeltis theivora* Waterhouse Project.
- Biocontrol of tea pests using indigenous natural enemies.
- Pesticide Residue in Tea.
- Pesticide Residue in tea for setting MRLs (Phase II).
- Utilization and implementation of native microbial bio-agents for control of termite pests in tea plantations of northeast India.
- Susceptibility change in the tea mosquito bug, *Helopeltis theivora*, in northeast India.
- Developing of low input weed control programme to reduce chemical load in tea soils.
- Studies on biotypes of *Helopeltis theivora* (Hemiptera : Miriade) in northeast India.
- Bio-intensive integrated management of looper caterpillar pests (Geometridae: Lepidoptera) of tea (*Camellia sinensis* L.) in northeast India, with special emphasis on entomopathogenic viruses.
- Studies on red rust and fusarium die-back : increasing concern for tea growers in northeast India.
- Extraction, identification and quantification of volatile flavour constituents (VFC) in TRA-released Darjeeling clones and standardization of process variables in Darjeeling tea with special reference to VFC (Joint project with DTRDC).
- Biochemical investigations on the quality of made tea in North Bengal.
- Impregnation of oxygen during fermentation of CTC tea.
- Modification of SEPTU micronizer for converting green tea leaves into granulated black tea.
- Standardization and optimization of processing conditions for manufacturing Oolong tea under northeast Indian conditions.

- Development of clones for production of purple tea by the grower of northeast India.
- Studies on the impact of elevated carbon dioxide and temperature on carbon sequestration potential of different tea cultivars and solid organic carbon.
- Evaluating potential of high potassium containing minerals as alternative potassium fertilizers for tea cultivation under agro-climatic conditions of northeast India.
- Impact analysis of changing weather elements and associated tea production variability in the major tea-growing regions of Assam.
- Survey and documentation of soil arthropod fauna in conventional, organic and bio-rational tea plantations of Assam, India : an agroecological approach.
- Sensitivity of the tea looper, *Hyposidra talaca* (Walker), to commonly used insecticides and developing integrated resistance management (IRM) strategy for the pest in tea plantations of Assam.
- A study on the trend of productivity of tea in Assam, assessment of yield gap, yield potential and forecasting.
- Studies on the prospects of microbial biocides and upscaling of commercial production units of Tocklai Tea Research Institute (Scheme No. 4.7).

#### **Funding Agency: Sulphate of Potash Information Board (SOPIB), USA**

- Comparative efficacy of Sulphate and Muriate of potash

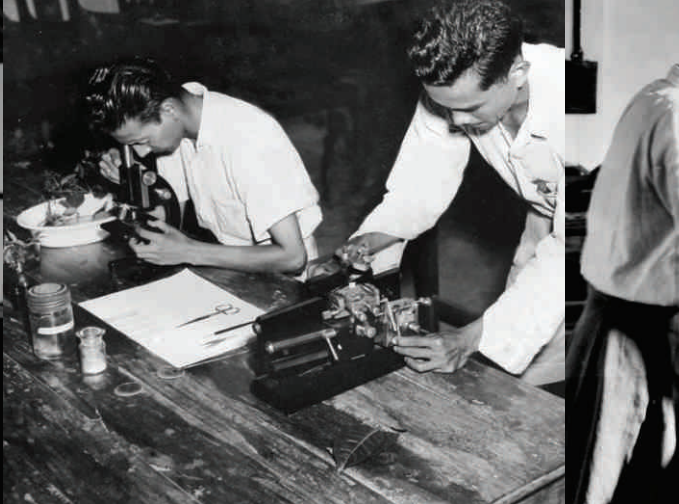
#### **Funding Agency: FAO**

- Organic Tea

## **The Collaborative Projects**

Institutes under collaboration		Projects
1.	University of California, Davis	Work on issues relating to tea germplasm, climate change or tea quality
2.	Unilever-CABI	A move towards a more sustainable approach to pest management in tea
3.	DST-SYST	Evaluation of acaricidal susceptibility of <i>Oligonychus coffeae</i> and developing an integrated resistance management strategy for the pests of tea in Assam

4.	CSIR	NIMITLI Project
5.	DBT-Tea Board	Biotechnological tools
6.	DTRC	Volatile Flavour constituents of Darjeeling teas
7.	CEERI, Pillani	Electronic monitoring and control of fermentation
8.	MIT, ER&DCI, Kolkata	Tea Automation Project
9.	CEERI, Pillani	Fluffing in withering trough
10.	CMERI, Durgapur	<ul style="list-style-type: none"> <li>• Rated Feed unit (rotorvane)</li> <li>• New leaf macerating machine (Alternative to CTC)</li> <li>• Sharpening of CTC rollers in pairs</li> <li>• Microwave drying of tea</li> </ul>
11.	Southampton University under UK-India Education Research Initiative (UKIERI )	Climate-smartening Assam's tea plantation landscapes: defining socio-ecological 'safe spaces' for future sustainability
12.	(DST) Indo-South Africa Project	Effect of trace elements on yield and quality parameters of tea ( <i>Camellia sinensis</i> L. and <i>Athrixia phylicoides</i> DC.)
13.	UK-Tea & Infusion Association (UKTIA)	Studies on Anthraquinone
14.	Ethical Tea Partnership (ETP)	TRA ETP Joint Work on Small Growers Training & Development/ Climate Change
15.	Unilever/ ETP	Small holder empowerment
16.	Solidaridad / ITA	Small holder development
17.	Kawasaki, Kiko, Japan	Tea Mechanisation at Borblela
18.	Ochiai Cutlery Co. Japan	Tea Mechanisation at Nagrakata
19.	Agnext Technologies	Artificial Intelligence/ IOT/ Chat Bots



## ACHIEVEMENTS

### Major achievements upto 1950

- Introduction of annual prune
- Improved pest control measures
- Drainage
- Clonal propagation of tea from single nodal cuttings
- Importance of legume as shade
- Release of TV1, TV2 and TV3

### Major achievements (1960-69)

- Release of TV10, TV11, TV12, TV13, TV14, TV15, TV16 and TV17
- Release of a biclonal seed stock (under Stock 378) in the breeding scheme Nanda Devi for Darjeeling.
- Balanced NPK manuring
- Introduction of longer pruning cycle
- Leguminous shade tree
- Planting pattern and plant density
- Recommendation of herbicides

### Major achievements (1980-89)

- Release of biclonal seed stocks 379, 462, 463, 464 and 491.
- Release of TV25, TV26, TV27 and TV28.
- Release of 30 garden series clones, 15 for the Dooars & Terai and 15 for Darjeeling.
- Plant growth regulators for crop productivity
- Introduction of tissue culture in tea
- Introduction of polyploidy clones
- Irrigation and drainage
- Improved pest control methods through IPM

### Major achievements (1950-59)

- Release of TV4, TV5, TV6, TV7, TV8 and TV9.
- Introduction of herbicides
- Standardisation of tipping level at 5 leaves
- A new species of Camellia (*Camellia irrawadiensis*) was discovered at Tocklai, resembling teas in leaf appearance and can be easily crossed with tea.

### Major achievements (1970-79)

- Release of TV18, TV19, TV20, TV21, TV22, TV23 and TV24, along with three biclonal seed stocks 449, 450 and 397.
- Introduction of micronutrients
- Potash application basis
- Drainage improvement
- Young tea management
- Better pest control methods

### Major achievements (1990-99)

- Release of a triploid clone TV29 and eight garden clones
- Development of a new method for filling of nursery sleeves
- Biopesticides, Trichoderma, Package for Helopeltis control
- Drip irrigation
- Tissue culture technique
- New biclonal seeds and clones
- Establishment of pesticide residue testing laboratory
- Establishment of laboratory for heavy metal testing
- Conservation of tea germplasm.





## ACHIEVEMENTS

### Major achievements (2000-2009)

- Release of tea cultivars, Lengree 51 and Lengree 56 for drought affected areas.
- Development of new cultivars under TV series. TV31 was released after multi-locational trials
- Introduction of a new *Anadenanthera peregrina*, a new leguminous shade tree.
- Comparison of remote sensing imageries for five pilot areas with topographic map of 1912-13.
- Development of a new enriched vermicompost technology.
- Introduction of the VAM technology for tea nurseries.
- *Beauveria Bassiana*, an entomopathogenic fungus developed for control of *Helopeltis*.
- Establishment of the Model Tea Factory at Tocklai for process optimisation.
- Categorisation of clones based on withering and fermentation.
- Development of the Modified rolling table for Darjeeling.
- Development of a process for producing the tea tablet.
- Development of a process for producing soft drinks based on tea by-products.

### Major achievements (2010 onwards)

- Standardisation in installation of low cost sticky traps to control thrips and jassids.
- Development of low cost light traps to control red slug and loopers.
- Integrated management of tea loopers.
- Release of two new clones (TTTRI I and TTTRI II) and one new seed stock (TS560) for Darjeeling. TTTRI I is drought tolerant, while TTTRI II is moderately tolerant to drought.
- Submission of 10,200 Expressed Sequence Tags (EST) of drought, herbivory and blister blight to NCBI
- Amplified Fragment Length Polymorphism (AFLP) based genetic diversity assessment of 123 commercially important tea germplasms of India.
- Development of Neem Kernel Aqueous Extraction technology for pest management.
- Development of ovipositional barriers for looper pest management.
- Development of coloured sticky traps for thrips, green loopers and whitefly.
- Development and release of nutrient management packages for organically grown young tea and mature tea, under conversion.
- Establishment of a Training & Research Centre for Small Tea Growers.
- Establishment of a Tea Tourism Hub at Tocklai.

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