SCIENCE AND THE TEA INDUSTRY: LESSONS FROM HISTORY

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CERTIFICATE

This is to certify that **Mr. Goutham Sukumaran** pursuing BS-MS at Indian Institute of Science Education and Research, Pune, underwent a two months Summer Fellowship Programme at the Indian Institute of Technology Madras, Chennai, in the Department of Humanities and Social Sciences, under my guidance. This report titled "**Science and the Tea Industry: Lessons from History"** was prepared as a requirement for the completion of the programme.

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ABSTRACT

This report examines the role of science in the development of tea industry in India and some of the lessons that could be derived thereof. Scientific institutions like Botanic Garden, Agricultural and Horticultural Society of India, played important roles in the development of tea industry from its early days. After the period of personal endeavours, organised scientific research commenced with the establishment of scientific departments under Indian Tea Association (ITA) and United Planters' Association of Southern India (UPASI) in 1900 and 1925 respectively. Modern botanical research for tea industry included production of high yielding varieties using modern techniques. Fields like soil chemistry and tea chemistry received attention from the early years itself. Studies on pests and pest control were also indispensable for the industry. Tea plantations were also major sites for medical research. Today, although India is the second largest tea producer in the world, the condition of Indian tea industry is not very rosy. Challenges like stagnant prices, low productivity, high production costs and changes in rainfall patterns require a new grand alliance between science and tea industry. The past may offer some useful pointers in this regard. Also needed is a proactive tapping of the potentials of some of the premier institutions of research and teaching which were not available before independence.

CONTENTS

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1. INTRODUCTION

The history of tea industry is intertwined with the history of the European colonial project. But tea as a beverage has a longer history in its home - China. From China it went out as a commodity to Europe and the rest of the world through the trade routes. Europe had a very long history of trade with the East especially through the silk route which connected the Orient and the Occident. After the decline of the silk route in the 15th century, European powers established alternate sea routes to the East and to the New World. This was also a period of intense cultural and scientific exchanges between the colonies. It is in this context that Europeans first encountered tea, a Chinese beverage. The Dutch started trading tea in Europe and the habit of tea drinking gradually gained popularity. Later the British East India Company became the dominant players in tea trade. But tea as an industry had not yet been born. It happened when the East India Company lost its monopoly over the Chinese tea trade in 1833. It is from around that period that the British actively sought ways and means of growing tea in different parts of India itself.

The Chinese knew about tea from a very long time. The use of tea as a beverage started as early as sixth century. In China, it was a small-scale cultivation where the plant is grown around the houses unlike the large tea plantation seen today. But when tea met the British, its biography changed. The main change in tea production was that of its scale: backyard Chinese cultivations gave way to large tea plantations in British India. Without the help of modern science and technology, this radical transformation would not have been possible. Being the pioneers of Industrial Revolution, the British were keen to mechanise and modernise processes and (conversely) large-scale cultivation enabled them to do it. Thus scale and science went hand in hand.

In order to introduce a foreign plant, one has to study the plant first. Therefore botanists played a crucial role during the initial stages of the industry. Particularly scientific institutions like Calcutta Botanic Garden and Agri-Horticultural Society of India, Calcutta played a central role in the development of the nascent industry. However the role of science does not end with the introduction of the tea plant. Once in its new place, apart from the favourable disposition of the locality's soil by nature, further investigation into its nutrients and the nutrient-needs of the tea plant facilitate greater productivity (especially when one is operating on big/large scales). This demands researches on soil chemistry and development of appropriate fertilisers. Attack from pests is always a problem and it is of a higher magnitude when the scales are high. This in turn necessitates greater understanding of the diseases which might affect the tea plants and their causative agents. Thus researches in mycology, entomology and phytopathology were indispensable for the tea plantations.

But the growth of tea plant in plantations is only the initial part of tea manufacture. Once the leaves are collected, it has to be transported to the factory and has to undergo further manufacturing processes. The manufacturing steps include withering, rolling, fermentation, firing and finally grading and packing. These steps are meant for the physical as well as the chemical transformation of tea leaves to made tea. In order to control and modify the processes, one first needs to understand it. Therefore, research in this domain too was given importance from the initial days of tea cultivation itself. The chemistry of manufacturing is particularly important as the quality of the made tea is determined here.

From its foundation in 1834 till the beginning of the 20th century, scientific enquiries needed for the tea industry were done by experts sent by the Government upon the request of tea bodies like the Indian Tea Association (ITA) with the expense mostly being shared by the government as well as the planters. Soon the need for a scientific department fully devoted to research beneficial to the tea industry was grasped. Personal endeavours on tea research gave way to

organised scientific research. In 1899 ITA appointed its first ever Scientific Officer, Harold H Mann who took charge in 1900.[1] The expense was again divided between the association and governments of Assam and Bengal. The scientific department initially had to work within the limited facilities of the laboratory in the Indian Museum in Calcutta which was functional till 1932. In the meantime, a field research station was opened in the tea growing area of Heeleakah in Assam in 1904. This station had to be shifted in 1911 to Tocklai in Assam itself and was renamed as Tocklai Experimental Station. The institute continues to function as a chief centre for tea research in that region till date.[2]

In South India, organised tea research started under the patronage of United Planters' Association of South India (UPASI). The fiirst Tea Scientific Officer under the scientific department of UPASI was appointed in 1925.[3] The experimental station was situated in Devarshole but in 1966, it was shifted to Valparai village of Anamallais. From their humble origins, both Tocklai Tea Research Institute and Valparai Tea Research Station quickly grew into fully fledged research institutes. Their contributions to the development of tea industry in India is invaluable.

One important factor that enabled the transformation of Chinese craft of tea making into the British system of tea manufacture was the extent of mechanisation. Mechanisation of the process was instrumental in bringing down the production cost with increased efficiency thus making it possible to sustain large plantations profitably. For the British, it was more than mere improvement to the existing system. For them, mechanisation stood as the testimony of triumph of Western science and technology over the traditional knowledge of the East. However, even with considerable mechanisation, the tea industry remained a labour intensive activity. After

[1]William H Ukers, *All About Tea Vol. 1*,The Tea and Coffee Trade Journal Company, New York, 1935, p. 167
[2] Ibid p.167
[3] *Tea Research in S. India under the UPASI Scientific Department*, pp.3-5

failed attempts at utilising natives from various tribes of Assam, the planters' turned to the possibility of exploiting the workforce from the peasants of Central and Eastern India. "Coolies" were recruited and brought to the vast plantations of Assam.[4] These workers were subjected to severe exploitations which came very close to slavery. They lacked proper access to basic infrastructure and healthcare facilities. The dense jungles and swamps of the North East being perfect breeding ground for various insects, the risks of communicable diseases were also extremely high. Diseases like malaria and cholera were rampant among the workers and knowledge from medical research in fields like parasitology was of grave importance. Thus apart from the sciences of botany, entomology and chemistry, medicine also played a very important role in the development of tea industry in India.

Therefore history of tea industry is never complete without considering the contributions of various fields of science and technology in its growth. Through this project, I try to elaborate, within the limitations of time and resources, on the contributions from different fields of science alone (not technology) in the development of tea industry in India, and the lessons they offer.

[4] Jayeeta Sharma, ''Lazy' Natives, Coolie Labour, and the Assam Tea Industry', *Modern Asian Studies*, Vol. 43, No. 6 (Nov., 2009) pp. 1304- 1310

2. BOTANICAL RESEARCH

Successful introduction of any plant to a foreign environment requires careful examinations of various factors influencing the growth of the plant like nutrients, climate, rainfall and humidity among other things. Tea plant was no exception. Considering the immense economic importance of the tea made from the tea plant which was known to grow only in China, the colonial powers were compelled to try their own luck at growing tea plants and mastering the process of tea manufacture. The British naturally turned to their colony India, which had regions geographically as well as climatically similar to that of tea growing provinces of China for experimentations. Such endeavours required specialised knowledge of the botany of the tea plant and that of the locality. Therefore botanical research was indispensable for the development of tea industry.

One of the earliest attempts at growing tea plants outside China was by the Governor General Warren Hasting who sent some Chinese tea seeds to George Bogle, the British diplomat in Bhutan in 1774. This move was in line with the Hastings' view that mere exploitation should yield way to industry (centred on items like cotton, silk and indigo), for the long-term prosperity of the East India Company. However, no further developments were reported from Bhutan.[5] It should be noted that East India Company was not enthusiastic about starting tea cultivation in India as they had the Chinese tea trade monopoly. This approach along with other factors like internal political turbulence halted development of tea industry in India for two to three decades. As indicated earlier, East India Company had active trade relations with Chinese Empire due to the high demand for Chinese products including tea. However the trade was mostly one-sided and the trade imbalance grew. Instead of trying to master the Chinese craft,

[5] Percival Griffiths, *The History of the Indian Tea Industry*, Weidenfeld and Nicolson, London, 1967, p.33

the solution adopted by the Company was to export opium (which then lead to the Opium War between Britain and China). Only when the whole prospect of trade was in danger, did the Company turn its attention to the possibility of growing tea plant in India.

The active participation of botanists in the development of tea industry started in 1819 when David Scot, agent to the Governor-General in Assam asked Dr Nathaniel Wallich, botanist to the East India Company as well as the superintendent of Calcutta Botanical Garden for tea plants and seeds from China.[6] It was intended for an attempt at growing tea plants in India. But the experiment failed as the plants did not survive. Attempts at cultivating Chinese tea plants outside China were not limited to India alone. The British had tried setting up a tea plantation in Malaya, and the Dutch had tried it in their colonies of Java and Dutch Ceylon in the early decades of 19th century but these had limited success.[7]

It is worth mentioning the role of Botanic Garden of Calcutta in the development of science as well as commercial agriculture in British India. The garden established in 1787 was one of the earliest institutes of Western science in India. The founder of the garden Lt Col Robert Kyd was of the opinion that it was not merely for collecting and studying plants "as things of mere curiosity…but for establishing a stock for disseminating such articles as may prove beneficial to the inhabitants, as well of the natives of Great Britain, and which ultimately may tend to the extension of the national commerce and riches".[8] From its beginning itself, the garden worked along the founder's visions. According to George Basalla, the foundation of Botanic Garden was a recognition of the economic importance of the data collected during the early phase of exploration.[9]

[6] Ibid p.36
[7] H A Antrobus, *A History of the Assam Company 1839-1953,* T and A Constable Ltd., Edinburgh, 1957 p.13
[8] Adrian P Thomas, 'The Establishment of Calcutta Botanic Garden: Plant Transfer, Science and the East India Company, 1786-1806', *Journal of the Royal Asiatic Society*, Third Series, Vol. 16, No.2 (Jul., 2006), p.167
[9] George Basalla, The Spread of Western Science, *Science*, New Series, Vol. 156, No.3775 (May 5, 1967) pp. 611-613

In the meantime, Charles Alexander Bruce who was working in Assam during the Burma wars for the East India Company was able to collect tea plants native to Assam from a local chief but Bruce was not the first European to find out the local tea plants. It was his brother, Robert Bruce who found it out for the first time but unfortunately, he died before he could get the plants. The plants collected by C A Bruce were then sent to the Government and to Nathaniel Wallich. However Wallich did not find it to be genuine tea.[10] The same conclusion was reached by the Agricultural and Horticultural Society, Calcutta in 1831 when samples from Assam were sent by Lieutenant Andrew Charlton. A significant shift in tea policy happened when the East India Company monopoly on Chinese tea trade ended in 1833. Considering the economic importance, the Company was resolute in finding an alternate source for the same. Therefore a committee was formed in 1834 to provide guidelines on introduction of tea plant in India and they chose to plant the Chinese variety rather than the Assam one. A representative George James Gordon was sent to China to bring tea plants, seeds as well as planters and he successfuly collected the seeds and brought it to Calcutta. Meanwhile Lieutenant Charlton again sent samples of tea including its leaves and fruits to Dr Wallich of Calcutta Botanical Gardens through his superior Captain F Jenkins and finally Wallich was convinced that Assam plants were indeed genuine tea plant. Thus the committee wrote to Government that "the tea shrub beyond all doubt is indigenous in Upper Assam", and shared the hope that it "will be found capable… of being cultivated with complete success for commercial purposes".[11]

However a scientific commission consisting of Dr Nathaniel Wallich, Dr William Griffith, both botanists from Calcutta and Madras respectively and Dr John McClelland, a geologist favoured import of the Chinese plant instead of native one for plantations. This was not without some amount of discussion and disagreements. Though they all agreed on the fact that Assam plant

[10] Griffiths, *The History of the Indian Tea Industry*, pp.36-37
[11] Harold Mann, *The Early History of the Tea Industry in North-East India*, D L Monro, Calcutta General Printing Co. Ld., NA, Calcutta p.7

was indeed a genuine tree, Wallich favoured cultivating the native variety in plantations whereas Griffith considered Chinese plants superior to the Assam one and his view prevailed.

The areas selected for cultivation were Upper Assam, Nilgiri hills, Kumaon and Dehradun. As per the decision of the commission, Gordon was again sent to China for the same purpose and the practice of tea plant import continued for years. The Calcutta Botanic Garden had bred 42000 saplings from Chinese seeds sent by Gordon during his first venture. Among these, 20,000 were sent to Assam, 20,000 to Kumaon and Dehra Dun and the remaining 2000 were sent to various stations in Madras presidency of Southern India[12], significant portion of which perished during and after its journey. The extent of loss during the journey might seem unnatural and avoidable from today's perspective. The situation can be understood better if we consider the condition of the area: recently annexed territories of North-East[13] at that time. The area consisting primarily of forests, had no proper connectivity with the rest of British India. The young tea plants had to be carried in boats, up the Brahmaputra River to the interiors of Assam: A perilous journey that took almost four months.[14] Keeping this fact in mind, the high loss during the journey seems only natural. After a failed attempt in setting up an experimental tea garden in Sadiya of Assam from Chinese plants transported from Calcutta, one was established at Chabua near Dibrugarh in 1837. Here tea plants of Chinese jat or variety was planted and an interesting phenomenon was observed in the area. The plants cross pollinated extensively with the Assam variety, leading to the production of hybrid variety.

The pivotal role played by the Botanic Garden, Calcutta in the development is evident throughout the early years of Indian tea industry. The journey of the Chinese tea plants in India started inevitably from the Garden and then towards different parts of the country. Another

[12] Ukers, *All about Tea*, pp.140-142
[13] Ceded to British Empire in 1826 by Burmese Empire after the latter's defeat in First Anglo-Burmese war
[14] J Weatherstone, 'Historical Introduction', in K C Wilson and M N Clifford (eds.) *Tea Cultivation to Consumption*, Springer-Science+ Business Media, B.V, North Yorkshire, 1992 p.10

interesting feature to note is that all the expenditure for initial experimentations were borne by the Government.[15] This is in contrast to later scientific developments in the field where the tea industry itself had to bear the major part of the expenditure. The budding industry was soon taken up by merchants and industrialists of the Empire making the tea cultivation a fully-fledged industry. But the following two decades (1840s and 50s) saw the Indian tea industry falling into debt with finances deteriorating year by year. Under these circumstances came the decision which changed the prospects of the tea industry: introduction of the native variety of tea plant instead of the expensive as well as less productive Chinese jat. The advantages of Assam variety over Chinese one includes factors like more vigorous growth and more frequent flushing. Thus Chinese as well as the hybrid jats of tea became commercially irrelevant with the Assam jat being the most commercially important variety.[16] This policy change along with efficient management reforms led the industry to a profitable venture and the tea industry was firmly established from then onwards. But transition from China jat to Assam one was not very smooth. Several features like growth rate, size of the tree and leaves were different in each. The Chinese tea plants grew slower and as a bush in comparison with the Assam variety which showed vigorous growth and more like a tree. Therefore plucking of the latter was not very easy. There was no ready-made solution to be learnt/borrowed from China in this matter as Chinese did not have to face this problem in the first place. The problem eventually was solved by the introduction of the uncommon step of pruning.

After this period, a change in research priorities in the tea industry can be observed. The role of botanists in the industry was diminishing with other areas of research like tea chemistry and plant pathology becoming prominent. This is perhaps due to the fact once firmly established, the need of the industry was to improve the existing system of plantation and manufacture and

[15] Mann, *The Early History*, p.18
[16] Ukers, *All about Tea*, p.142

the above mentioned fields better served those purposes. But this does not mean that botany researches were neglected for ever. The botany department of Tocklai Research Institute was established in 1930.[17] The department under Dr. Wight carried out important works on plant breeding, selection and vegetative propagation towards the end of the second half of 1930s.[18] Plant improvement research in South India under the scientific wing of the United Planters' Association of Southern India commenced in the early 1960s. They have been identifying and developing high yielding cultivars of tea. Various means like grafting and hybridisation were utilised for developing such high yielding and drought resistant plants.

[17] http://www.tocklai.net/activities/departments/physiology-breeding/
[18] Griffiths, *The History of the Indian Tea Industry,* p.450

3. CHEMICAL RESEARCH

Chemistry is one of the most important fields of knowledge as far as tea industry is concerned. From the growth of tea plant to the flavour of the manufactured tea, much is determined by chemical compounds. Therefore, in order to control and improve quality of tea, knowledge and application of chemistry behind every process is highly useful.

One of the earliest aspects of tea plantations subjected to scientific enquiry was the case of fertilisers. Considering the fact that the industry was going through its nascent phase, the topic was highly relevant as the knowledge of chemical composition of the soil is essential for identifying deficient minerals and thereby determining effective manuring Even more importantly, soil chemistry was essential for expanding the cultivation to new areas and to do so, one needs to know whether the plant would grow there or not. During the early stages of the industry, in the absence of scientific data, occurrence of indigenous tea variety was taken as an indicator of whether the Chinese plant would grow or not.[19] Needless to say, such crude methods were inefficient. The need for systematic studies were understood and Surgeon-Major Warden, Professor of Chemistry at the Calcutta Medical College was consulted by Agricultural and Horticultural Society in 1889[20] for advices regarding effective manuring However Warden was unable to spend sufficient time for the research due to his busy schedule, therefore it was decided by the Indian Tea Association to hire a soil chemist solely for this task. Thus M Kelway Bamber, a chemist was appointed by ITA and the Agricultural and Horticultural Society of India in 1891.[21] Works done by Bamber is a milestone in the history of tea research work on soil chemistry during the last decade of 19th century can be considered as the beginning of scientific research in tea industry. Based on the studies carried out in 1891 and 1892, he wrote

[19] David Crole, *Tea A Textbook of Tea Planting and Manufacture*, Crosby Lockwood and Son, London, 1897 p.29
[20] Griffiths, *The History of the Indian Tea Industry*, p.425
[21] Griffiths, *The History of the Indian Tea Industry*, p.426

a book titled'*A Text Book on the Chemistry and Agriculture of Tea Including the Growth and Manufacture'* in 1893. Since there was no scientific wing of Indian Tea Association at that time, the experiments had to be carried out in the limited facilities of chemical laboratory of Medical College, Calcutta.[22] Decreased yield from the plantations, probably due to the partial exhaustion of the soil made the study highly relevant at that time. The objectives of the study included finding affordable and suitable manures, possibility of increasing the yield without manuring, and the effect of manures and soils on the quality of tea.[23] It is interesting to note here a local manifestation of Centre-Periphery relationships in science: between the colonial capital Calcutta and the tea growing districts of North East. The tea industry of Assam and neighbouring areas grew with its economic, administrative and scientific authorities centred in Calcutta.

In his book, Bamber describes different types of soils which support tea plantation and the geographic and ecological processes which might have influenced the nutrition content of the soil. Then he goes on to report of his own studies on soil chemistry. He provides chemical composition (percentage composition of minerals and organic matters) and the mechanical composition (factors like moisture, percentage abundance according to grain size etc.) of soil and subsoil collected from different parts of tea growing areas of North East India. From the analyses, Bamber was able find out the following features about tea soils: the deficiency of lime, positive correlation between nitrogen content and the growth of tea, desirability of soils with porous sub-soils which allow root penetration for tea plantations and the presence of one or more varieties of mica in all soils supporting tea plants.[24] For the study of manuring, nearly thirty gardens were selected in Assam and neighbouring areas spanning different geographic

[22] M Kelway Bamber, *Chemistry And Agriculture Of Tea Including Growth And Manufacture*, Law-Publishing Press, Calcutta, 1893 p.2
[23] Ibid p.82
[24] Ibid, pp.75-76

and climatic conditions. All the plots received same treatment except for the application of manures rape cake, superphosphate and lime.[25] The results indicated increase in yields in various degrees according to the type of the soil and the manure. However, he did not confine his study to soil chemistry. Using different chemical methods, Bamber was able to find out the constituents of tea. He used the method of precipitating tannin, class of compounds responsible for the strength and pungency in tea solution with neutral acetate of lead for estimation of the same.[26]

Another aspect on tea chemistry analysed by Bamber was the chemical changes happening in each stage of manufacture. The chemical composition of fresh green leaf and manufactured tea were found out for determining the overall chemical change happening during the manufacture. Green leaf was dried over sulphuric acid as to prevent further chemical changes and the sample for made-tea was taken after the manufacturing process. Both the samples were extracted with organic solvents like ether, absolute alcohol and caustic soda. The constituents undergoing chemical transformations were analysed separately at each stage of the manufacture.[27] The necessity of research on topics like tea chemistry and chemistry of manufacture being carried out in the colony itself probably arose because of the fact that the whole manufacture had to be done there. This is in contrast to cotton industry, where the raw materials were sent to the metropolis and the finished goods were then sent back to the colony. However, such a model was not possible in the case of tea manufacture as the manufacturing process has to start without much delay after the leaves are plucked. Therefore the British were compelled to grow as well as manufacture tea in India itself.

[25] Ibid, p.95
[26] Ibid, p.156
[27] Ibid, pp.163-164

After the initial years of personal endeavours, the need for well-established centres for scientific research exclusively on tea related issues was fully grasped. Organised scientific research with scientists fully devoted to tea research in deviation to the earlier practice of appointing experts for specific tasks started with the establishment of the establishment of scientific department under Indian Tea Association (ITA). Dr Harold Mann was appointed as the first scientific officer of ITA in 1900.[28] His research areas included soil chemistry and tea chemistry, particularly chemistry behind the tea manufacture. Mann worked extensively on the chemical changes during fermentation, which can be considered as the most important step in the entire manufacturing process. Major chemical changes required for the transformation from green leaf to made-tea happens during this stage. Therefore clear understanding of this stage was essential for improving the quality of made tea. Mann was a student of the prestigious Pasteur Institute, Paris and had worked as a chemist for various Agricultural bodies prior to his appointment in ITA.[29] Mann during his seven years as the chief scientific officer, laid a strong foundation to organised tea research in India. The Heeleakah Tea Research Station was established by the Indian Tea Association upon his suggestion. The following years marked rapid development of the institute with several scientists joining and research expanding to diverse aspects of tea cultivation. The scientific department was funded by subscription fees from the members of ITA based on the area under cultivation and also grants from Assam and Bengal Governments.[30]

In 1935, a committee was formed under Frank Engledow, an agricultural botanist of University of Cambridge to critically enquire upon the working of the Tocklai institute (tea research station was shifted from Heeleakah to Tocklai in 1911) and to suggest possible improvements. Based on the recommendations, a London Advisory Committee comprising of eminent

[28] http://www.tocklai.net/about-tra/history/
[29] Ukers, *All About Tea Vol. 1*, p.168
[30] Ibid, p.167

scientists was formed in 1937 to guide the tea research according to the needs of the industry as well as market. The importance for further research on chemistry of made-tea was emphasised by the committee. Here an interesting phenomenon can be observed: the cooperation between different colonial powers for tea research. Apart from ITA, Tea Associations of Ceylon, Dutch East Indies and South India also shared the cost of the research. With this international collaboration, Dr A E Bradfield was appointed in London for research in chemistry of made-tea in 1939.[31] Therefore the Engledow Commission was an important milestone in the history of tea research. It is worth noting that all the scientists working under ITA were Europeans and the appointment of first Indian in the department happened only as late as 1946. Unsurprisingly political fluctuations of Europe did reflect upon the working of the institute and both the world wars had seriously affected research works at Tocklai. Since independence, the institute is being collectively funded by government bodies like Council of Scientific and Industrial Research (CSIR), Tea Board of India and subscription fees among the members.[32]

Tea research in South India started under the scientific department of United Planters' Association of Southern India (UPASI) when 1925, Dr W S Shaw was appointed as the Tea Scientific Officer in Devarshola Tea Experimental Station.[33] Similar to Tocklai, here also the post was supported by subscription fee collected from members having tea plantations,.based on area under cultivation The UPASI scientific department had active contact with tea researches happening in North East and Shaw was trained in Tocklai Experimental Station for one year.[34] However, the financial situation of the tea industry in South India worsened around 1930s and the assistance to Tocklai station had to be discontinued. Due to the same reason,

[31] Griffiths, *The History of the Indian Tea Industry*, pp. 445- 450
[32] http://www.tocklai.net/about-tra/history/
[33] Ukers, *All About Tea Vol. 1*, p.172
[34] *Tea Research in S. India under the UPASI Scientific Department*, p.3

field works were reduced but it turned out to be a blessing in disguise as far as tea chemistry is concerned. The lack of field work gave the scientists plenty of time to focus on other aspects of tea and naturally, chemistry of tea was extensively studied during this period.[35] Shaw along with assistant scientific officer K B W Jones worked on the chemical transformations occurring to tea leaf at each stage of manufacture. Like Mann, they also focussed on the chemical transformations during the fermentation step. Shaw and Jones worked on the chemistry as well as the possible mechanism of action behind fermentation.

However, the decline of the department started when South Indian Association in London commented that the department was not large enough to carry out experimental works. UPASI also agreed to the view and the role of the department was reduced to advisory services. The decision was followed by the resignation of Shaw and Jones. Soon research on tea chemistry was abandoned and with the appointment of a new chief tea scientific officer in UPASI, focus was shifted to experiments on pruning and manuring.[36]

The department grew in strength as time progressed with researches focussing on various aspects of tea industry including botany, plant pathology, and chemistry. In a strange resemblance to that of Heeleakah Tea Research Station, Devarshola Station also had to be shifted. Unlike the case of Heeleeakah, where the reason for shifting was better logistics management, here it was the miscalculation of a probable expansion of the tea plantation to the Mysore area which did not happen. Therefore the station was shifted to more conveniently situated Government Cinchona Plantations in Valparai of Anamallais in 1961 and was named as Tea Research Station, Cinchona.[37] This is the primary centre for tea research under UPASI with various modern research and analytical facilities. Like that of Tocklai, since

[35] Griffiths, *The History of the Indian Tea Industry*, p.468
[36] Ibid, pp.468-469
[37] *Tea Research in S. India under the UPASI Scientific Department*, p.5

independence, the researches are being carried out with more and more government collaboration. Currently the projects are funded by subscription fee collected from the members of UPASI, Tea Board of India and various government bodies like CSIR sponsoring specific projects.

4. ENTOMOLOGICAL RESEARCH

The importance of documenting and studying the natural enemies of tea plants was acknowledged from the early years of tea industry itself. For an industrial cultivation spanning acres, attack of even a single insect could prove disastrous. Therefore due care was always given to the studies of pests and the possible strategies of its elimination.

One of the earliest comprehensive studies of pests and blights affecting tea plants in India was carried out by a botanist named Sir George Watt. Watt was a well-known botanist, Fellow of the prestigious Linnean Society of London, and was later knighted for his contributions to the study of Indian plants in 1903. He was appointed by the Government of India to visit the Tea Districts and study about tea blights because of the alarming growth of pest infections in the tea plantations observed during the 1880s.[38] The coffee leaf rust attack of 1870s which devastated the coffee plantations of Sri Lanka and South India also might have heightened the need for an expert study. The appointment of Watt for the task of studying pests of tea plant happened after an interesting series of events. Indian Tea Association had intended to ask Bamber to study the pest problem in detail. However, he left the service in 1893 and the Association had to ask for Government help in the matter. Then arrangements were made for the appointment of Cotes from Indian Museum, Calcutta. Unfortunately he resigned before taking up the task. Therefore the responsibility was transferred to George Watt.[39] Watt was a medical graduate from University of Glasgow and came to India to teach Botany in Presidency College, Calcutta. However due to conflicts within the University authorities he could not take up the position and thus ended up joining the Indian Government service.[40] It was during his service as the Reporter to Government of India on Economic Products that he was assigned the

[38] George Watt, *The Pests and Blights of Tea Plant being A Report of Investigations conducted in Assam and to Some Extent Also in Kangra*, Office of the Superintendent, Government Printing India, Calcutta, 1898, p.1
[39] Griffiths, *The History of the Indian Tea Industry*, p.427
[40] R S Chakravarthy, Watt's Dictionary: A Landmark in the Study of the Economic Plants of India, *Economic Botany* Vol.29 No.1 (Jan-Mar, 1975) pp.31-32

task of studying tea pests. Watt extensively toured the tea plantations of North and North-East India from November 1894 to July 1895 carefully examining the insects and pests present. Sources of information for this endeavour included Journals and proceedings of Agri-Horticultural Society of India, publications on the Indian tea industry, annual reports of the Indian Tea Association and newspaper correspondences, apart from the observations he himself made.[41] The report of the study was published by the Government as *The Pests and Blights of Tea Plant* in 1898 in which he listed out the major pests and blights including their history, life cycle and features. It included his broad observations and recommendations on remedial strategies. According to Watt the report was "intended purely and simply as a *popular statement*"[42] and "submitted chiefly in the hope that it may serve as a basis for more satisfactory operations in the future."[43]

Watt in his report stresses the futility of syringing (the process of spraying pesticides) gardens spanning hundreds of acres which resulted in huge labour charges and also had the risk of causing harm to the workers and that of poisoning the manufactured tea in case the insecticide does not wash away with rain. He observed that almost ten or eleven of the pests found were common to both tea and coffee. Watt attributed the presence of common pests for such dissimilar plants to the chemical resemblance of the plants.[44] The strategy he suggested for the pest problem was to improve the plant health by reforms in the selection of seeds, better systems of tillage, more rational pruning and less severity in plucking rather than curing once the plants are infected.[45] Perhaps the greatest contribution of George Watt to the tea industry was that he showed the importance of systematic studies and reforms in cultivation practices.

[41] Watt, *The Pests and Bights of Tea Plant*, p.179
[42] Ibid, p.1
[43] Ibid, p.8
[44] Ibid pp.27-28
[45] Ibid, p.32

Among all the pests and blights of tea plant described in the report, mosquito tea blight was given special importance. Watt describes it as the "most alarming of all Indian Tea pests" . According to the report of the Commissioners appointed by the Government to study the issue, "the loss from this [tea blight] cause in the gardens of one company in 1867 was estimated as high as 50,000 lbs. of Tea".[46]

The disease is caused by the insect *Helopeltis theivora* also known as mosquito blight. The mosquito operates on the leaf by inserting its proboscis to the vascular bundles and sucking out the plant sap which causes the leaf to turn brown. The discoloured part is called as puncture and its size indicates approximate age of the insect. Intensity of attack is not uniform throughout a year. It peaks during the months of August and September and reaches minimum by the end of October.[47]

There were no effective remedies for the tea blight attack which was causing heavy losses to the plantations. Especially the last decade of 19th century was a difficult period for tea industry. There was no increase in yield despite attempts at improvements. Price fell drastically and the disease became more and more rampant. It was in this context, the Indian Tea Association requested for an expert to study the insect. In response to the request, Lionel de Niceville of Indian Museum, Calcutta was appointed in 1901 but he died of malaria immediately after his return from investigations conducted in Terai region. Therefore all his notes were unavailable and Harold H Mann, first Scientific Officer to the Indian Tea Association was appointed for the work. Although a chemist, Mann did not hesitate to take up tasks requiring an understanding various other disciplines of science. Mann's work is the second major scientific research of tea blight after the pioneering work by George Watt. Interestingly, Mann maintained close

[46] Ibid, p.265
[47] Harold H Mann, *The "Mosquito-Blight" of Tea. Investigations during the Season of 1902,* W. Newman & Co., Calcutta, 1902, p.4

connection with Watt during his initial period in ITA and they even toured the tea districts together few times.[48] The study was funded jointly by the Government of Bengal, administration of Assam and the Indian Tea Association.[49] It is should be noted that unlike previous cases where the association wrote to Government requesting for their help in scientific enquiry, this is for the first time association's own scientific department comes into the picture. Mann's initial days as the Scientific Officer were arduous as he lacked any permanent facilities and assistants. He had to perform his experiments in the laboratory in the Calcutta Indian Museum.

In his report, Mann made three suggestions as a strategy against the pest. They are: irrigating in the early months of spring since it was observed that lack of moisture in spring leads to higher pest attack; stimulating the growth of bush as attack is less probable during vigorous growth; covering the egg with a layer of soap before they hatch during the hibernation period so that the larvae would suffocate once it come out. The idea was put to test with treatment of kerosene emulsion and soap emulsion over a small plot. The treatment was effective enough and managed to prevent infection till the peak month of August.[50] The experiment was carried on a larger scale in the following year. This time experiments were done in three gardens and the treatment proved to be an effective strategy at least for postponing the infection.[51]

Organised scientific research in tea industry started rather slowly in South India than in North-East India. This could be attributed to the fact that almost three quarters of land under tea cultivation is in North East India and perhaps also due to the proximity to Calcutta, the capital

[48] Harold H Mann, 'The Indian Tea Industry In Its Scientific Aspects', *Journal of the Royal Society of Arts*, Vol. 79, No. 4089 (APRIL 3rd, 1931), p. 474
[49] Ibid, p. 474
[50] Harold H Mann, *The "Mosquito-Blight" of Tea,* pp.10-13
[51] Harold H Mann, *The "Mosquito-Blight" of Tea Part II. Investigations during the Season of 1903,* W. Newman & Co., Calcutta, 1903, p.18

of British India where various important government and economic institutions were situated. Interestingly, we come across the above mentioned scientists again, when the history of pest control research in South Indian plantations is traced. The Madras Government employed a botanist C A Barber to study the pests and plant diseases found in plantations. But he was unable to take up the task and then the United Planter's Association of Southern India (UPASI) wrote to the Government of India requesting the service of Dr George Watt for the same. Unfortunately, he was not available and arrangement was had been made to appoint Lionel de Niceville of Indian Museum, Calcutta. But as already noted, he died in 1901 of malaria infected during his investigations in Terai - before the work in South India could be commenced. A significant study on pest control was carried out by Dr W.S Shaw, Tea Scientific Officer of UPASI during the second half of 1920s. He was a chemist by profession and his study was mainly concentrated on the chemical methods against the tea blight. In the report of the experiments conducted, published under the name *Observations on Helopeltis (Tea Mosquito Blight) for South Indian Planters* he discusses the ineffectiveness of existing strategies of control like hand picking and application of potash.[52] The need to work more on the possibility of introducing a parasite which uses the *Helopeltis* as host as a strategy against it is also stressed in the report. Spraying of contact insecticides (insecticides which kills insect by direct contact) against the pest has the disadvantages of high expenditure and does not reach all parts of the plant. Therefore the solution would be to a use non-contact insecticide like calcium cyanide. When Calcium cyanide [$Ca(CN)_2$] comes in contact with moisture, gaseous hydrocyanic acid (HCN) is liberated which is responsible for the insecticidal action leaving behind residue of hydrated lime [$Ca(OH)_2$]. Since the insecticidal hydrocyanic acid is in gaseous state, it will spread on its own making it a non-contact pesticide.

[52] W.S Shaw, *Observations on Helopeltis (Tea Mosquito Blight) for South Indian Tea Planters*, Diocesan Press, Madras 1928, pp.29-30

After the initial experimentations with calcium cyanide against Helopeltis in 1926, the experiments were again carried out in a larger scale in Manjumullay estate of central Travancore in September 1927. Calcium cyanide required for the experiment was imported from an American Company.[53] The main objectives of the experiment were finding the efficiency of calcium cyanide as an insecticide, minimum dosage and number of applications required, burning effect of hydrated lime on leaves and the effect on labour and chances of poison ending up in manufactured products.[54] Fifteen plots were divided into three categories: experimental, sprayed but non-experimental and control plot with no treatment. The second category was to minimise the possibility of pests entering the control plots from outside.[55] Efficiency obtained from this study was 79.2% which includes possibility of insects flying from outside and the figure when corrected for this was calculated as around eighty five percent.[56]

The second part of the experiment was aimed at optimisation for the most effective use. In order to find the minimum dosage, a second dusting was carried with a greatly reduced amount of pesticide applied per acre. Surprisingly the decrease failed to affect the efficiency, thus reducing the cost considerably. The minimum interval between two consecutive sprayings was determined to be ten days based on the knowledge of the life cycle of *Helopeltis* and the mechanism of action of the pesticide. Other concerns such as the possibility of poisoning the tea and the adverse effect of hydrated lime on the manufactured tea were ruled out based on the observations from the experiment[57]

The last portion of the report deals with the economic feasibility of calcium cyanide as pesticide. The profit from the calculated increase in yield of twenty one percent compared with

[53] Ibid, pp.35-36
[54] Ibid, p.37
[55] Ibid, pp.48-49
[56] Ibid, p.40
[57] Ibid, pp.41-47

the expenses incurred which includes the cost of material, transportation, application and supervision. However calculations pointed out that the application of calcium cyanide as an insecticide is economically unviable.[58]

From these various endeavours, we see the involvement of various governmental, commercial and scientific agencies in the fight against pest infection in tea plantations. Research in plant pathology and pest control did not stop here. It still remains one of the important areas of research of tea research institutes. However, in the early days of scientific research in tea industry, it was carried out largely by European professionals primarily for the benefit of European tea planters in India.

[58] Ibid, pp.51-52

5. MEDICAL RESEARCH

Medical research was integral to the colonial project. Sustaining and governing colonies spanning large areas of land with subject population in the range of millions would not have been possible without proper healthcare infrastructure. The period of colonialism is also marked by severe outbreaks of diseases. Several non-native diseases were introduced in the period of intense exchange and interaction between different regions of the world as part of colonialism and infections from existing diseases became rampant. Diseases like malaria and cholera were serious threats to the military as well economic interests in the colonies. Therefore, medical research was deemed extremely important and was supported both by the Government as well as wealthy investors in the colonies.[59]

Special importance was given to the study of malaria, a deadly disease distributed around the equatorial regions. European researchers enthusiastically studied malaria- its mode of propagation, vectors and treatments in colonies like Algeria, India and Malaya. Malaria research was considered important because of the impact it had on the economy of the colonies. Tea and rubber plantations of colonies like India and Malaya were highly infected by malaria. Since most of the plantations were cleared forests and surrounded by tropical forests they had perfect breeding sites for the carriers of the disease. The lack of infrastructure and medical facilities for the labourers might have amplified the intensity of attack. Recall that Lionel de Niceville (discussed in the section on 'pest control'), who was appointed by the Government to study the pests of tea plant, died of malaria from his stay in Assam. Malaria was indeed a serious threat to the development of tea industry.

[59] Bhattacharya N, "The Logic of Location: Malaria Research in Colonial India, Darjeeling and Duars, 1900-30," *Medical History*, vol. 55, no. 2 (2011): 183

Like in the case of all major researches related to tea plantations, researches on malarial infections in the plantations of India were also started in the tea growing areas of North-East. In 1924, Sir Malcolm Watson visited (from Malaya) many of the tea plantations of Assam to study the incidence of malaria in the tea plantations. Sir Malcolm Watson was one of the pioneering figures in malaria research. He was involved in the field from his days as a medical student itself and even his doctoral thesis was under the title 'the effect of drainage on malaria'.[60] After his studies he travelled across the British colonies and in 1900 he joined the Malayan Medical Service. He went on to do some of the most important works on malaria control there and after almost 30 years of work in Malaya, he went back to London as the Principal of the Malaria Control department at the Ross Institute for Tropical Diseases, Putney.[61]

His work in Assam was primarily guided by experiences from his time in Malaya. He was able to identify the two vector species and the recorded value of spleen rate (an indicator of the endemicity of malaria) among children indicated intense malaria. He notes the inability of preventive measures like general sanitation, education of the people and quinine to prevent malarial infection as was in the case of Malaya[62]. He attributed the presence of malaria to the geographic features rather than the neglect of sanitation alone. River valleys, swamps, rice fields and wet wastelands were found to be associated with malaria.[63]

[60] http://www.universitystory.gla.ac.uk/biography/?id=WH17440&type=P
[61] Ibid
[62]Malcolm Watson, Observations on Malaria Control, with Special Reference to the Assam Tea Gardens, and Some Remarks on Mian Mir, Lahore Cantonment, *Transactions of the Royal Society of Tropical Medicine and Hygiene*, Vol. XVIII No.4, p.150
[63] Malcolm Watson, 'Observations on Malaria Control', *Transactions of the Royal Society of Tropical Medicine and Hygiene*, Vol. XVIII No.4, p.151

The first half of 20th century was indeed a period of intensive malaria research. C Strickland, Professor of Medical Entomology of School of Tropical Medicine, Calcutta studied malaria on tea estates of Kurseong, Darjeeling in 1923. The institute specially focused on common diseases of tea growing areas such as malaria, cholera and kala azar and the tea industry made significant financial contributions for its running.[64] His research was on the relationship between malaria rate and rainfall in the area. Dr G C Ramsay, Director of the India branch of the Ross Institute also studied about malaria infection in tea plantations of Assam and his work was published as "Assam's Malaria Problem and its Solution" in *The Lancet* in 1929.[65] One key feature that distinguishes malaria research from other researches in tea is the extent of international communication. Researchers in the field, be it in the tea plantations of India or rubber estates of Malaya, were in touch with regular correspondences and discussions. It should be noted that malaria research was not confined to plantations of the East. Malaria control was a matter of life and death, be it in the Panama Canal construction sites or the World War 1 and certainly was taken seriously by authorities.

Yet it should also be noted that "every malaria is a local problem" and malarial condition and the carriers should be studied in each locality without making generalisations from limited data.[66] Knowledge of local carriers among of malaria is essential for adopting efficient strategies against the disease. Otherwise the only available option is the general anti-anopheline strategies which were not very effective. Therefore, in order to study malaria in South Indian tea estates, a malariologist named J E Mesham was asked by Dr Ramsay to open a research centre on behalf of Ross Institute in Southern India and to carry out malarial research there. It is worth noting the involvement of the Ross Institute which was specifically founded to study

[64] Griffiths, *The History of the Indian Tea Industry,* p.357
[65] JE Measham, *The Transmission and Prevention of Malaria on the Tea Estates of the Madras Presidency,* Valparai, 1939 p.8
[66] Ibid, p.15

tropical diseases across British colonies. Measham was provided with the service of a laboratory technician and a specially trained field worker by the institute. J E Measham had worked under Sir Malcolm Watson in Ross Institute.[67] The report of the research which was started around 1933 was published under the title *The Transmission and Prevention of Malaria on the Tea Estates of Madras Presidency* in 1939.

Among the four tea growing areas of South India: Nilgiris, Nilgiri-Wynaad, Wynaad and Anamallais, Measham's research was primarily in the tea estates of Anamallais region of erstwhile central Travancore with his laboratory being set up in the village of Valparai.[68] The survey to identify the local malaria carrier was carried out in two stages. Firstly, the infectivity survey consisting of dissection of adult anopheles and the second was the larval survey to identify the breeding habits of species. Mosquitos were collected from the estates in tubes indicating the source of the catch and further studies were carried out in the laboratory. The specimens were then sent to the Director, Malaria Survey of India.[69] From the survey *Anopheles fluviatilis* was identified as the only malaria vector in Anamallais[70] whereas information regarding breeding sites and conditions favourable for it were obtained from the larval survey. The transmission of malaria in the Anamallais was also found to be confined to the period from February to June since the subsequent monsoon rain and the resulting floods will wash away the breeding waters of the carrier whereas the following colder nights makes the completion of reproductive cycles impossible.

Control measures against malaria were broadly divided into two categories as strategies for control of parasite and that of vector. The former category consists of the treatment of malaria infection as well as prophylactic treatment whereas the strategies for vector control include

[67]Ibid, p.8
[68] Ibid, p.5
[69] Ibid, pp.8-9
[70] Ibid, p.12

cutting down the possible breeding sites such as slowly flowing water. Another important factor in vector control according to him is the treatment of swamps which hosts large number of larvae.

Maesham provides a rough sketch of malaria infections in the tea plantations of South India over the years. The period 1927-1933 during which general antilarval measures were taken showed significantly lower infection rate than of 1926 when only quinine was taken. Measham attributes sudden increase in infection observed after 1933 to other factors like faulty clearing methods which might have made favourable environment for breeding. Control measures against the specific vector species *A. fluviatilis* were started in 1934 and unsurprisingly the period 1934-1937 shows the lowest rate of malaria infection.[71] The same trend was observed in other aspects like death rate, spleen rate and general health of the labourers.

One key feature that distinguishes medical research is that while other researches focussed on improving the production, medical research actually dealt with people who were being exploited for the same. Medical research in tea industry was not confined to malaria. Occurrence and spread of various other diseases including cholera and hookworm among plantation labourers were systematically studied. Cholera had been a serious threat to the life of labourers especially during their transport to gardens of Assam through Brahmaputra. The death rate on the passage from 1871 to 1878 was calculated to be as high as 47.8%.[72]

One of the earliest medical researches around tea industry was done by Surgeon-General A C C De Renzy. He worked primarily on cholera and was one of the earliest to study the high rate of cholera infection among tea labourers during their transportation. Researches about

[71] Ibid, pp. 47-48
[72] A C C De Renzy, 'Cholera Among the Assam Tea Coolies', *The Lancet*, April 11, 1891, p.823

hookworm infection among workers in tea plantations of Madras Presidency showed 83% in the dry regions and 100% infection in wet regions in 1920. The research was carried out as part of the anti-hookworm campaign in Madras presidency with the aid of Rockefeller foundation.[73]

An overall survey of medical facilities in the tea plantations of India was done by Major E Lloyd James of Indian Medical Service for the Government of India in 1947. The decision was taken in the First Tea Plantation Labour Conference (held in New Delhi), aimed at updating the existing system of medical care in the tea plantations from the experiences gained from the world war.[74] Lloyd James travelled extensively across the tea plantations of Assam, North Bengal and South India. This is one of the very few medical researches where tea planters' organisations like Indian Tea Association and United Planters' Association of South India were directly involved. Thorough examination of the condition of labourers, mortality rates of each sections were done. Pathetic condition of the labourers was evident from these statistics. Infant mortality rate of 168.8 and 213 in tea plantations owned by Europeans and Indians respectively in 1947 stands as a testimony to it[75] (compare it with the national average value of 145.6 during the same period)[76]. It is interesting to note that even after almost two decades of research about malaria, this report, published in 1947 describes malaria as one of the most important causes of sickness. Nonetheless, Lyod Jones lauds the preventive measures which did manage to bring about significant reduction in mortality rates. The anti-malaria activities carried out in the plantations is described as "the biggest single campaign against disease anywhere in the world".[77] In the report, comparison of health conditions in tea plantations of Assam, North Bengal and South India shows that the conditions were better in South than the other two which Lloyd James attributes to the relatively higher level of literacy and better infrastructural

[73] 'Anti-Hookworm Campaign in Madras Presidency', *The Lancet*, April 29, 1922, p.865
[74] Griffiths, *The History of the Indian Tea Industry*, p. 359
[75] E Lloyd Jones, *Standards of Medical Care for Tea Plantations in India*, Government of India, Ministry of Labour, 1947 p.5
[76] http://pib.nic.in/feature/feyr98/fe0898/f1808983.html
[77] E Lloyd Jones, *Standards of Medical Care*, p.6

facilities for the labourers.[78] He scrutinised the existing healthcare infrastructure of tea gardens and submitted the recommendations on its improvement along with the calculations of expenditure for the implementation.

From these various measures, one can guage the importance given to medical research especially in economically important areas such as tea industry. Malarial infection in tea plantations seems much more extensively studied than any other aspect of tea industry such as tea chemistry or plant pathology. However, it should be noted that unlike research in such fields, malaria research in tea plantations was part of the broader project of malaria research both within India and across the globe.

[78] Ibid, p.11

6. CONCLUSION

Indian tea industry which started as an experimental colonial enterprise has travelled a long way since then. India is now the second largest tea producing country in the world. The growth of Indian tea industry from its humble origin to the position it is enjoying today is indeed an inspiring success story. However, the situation of the Indian tea industry now is not all too rosy. The industry is going through a crisis, perhaps the worst one in the post-independence period.

The tea industry, was established by the British to cater to the needs of the Western market i.e. it was export oriented. Over the years, the industry managed to pick up a strong domestic market but exports were still important. The dissolution of Soviet Union which was one of the major importers of Indian tea in 1980s, served a severe blow to the industry. The loss of the trusted Soviet market followed by policy blunders from the Tea Board, contributed majorly to the current scenario.[79] Although the industry had seen ups and downs since its inception during the colonial era, the present one is particularly severe. The price of tea is remaining stagnant, this when read along with inflationary pressure itself presents a gloomy picture.[80] Problems are not just confined to price stagnation and market. Plantations are suffering from low yield and high production costs, which worsens the position of the industry in an already tight situation. Aberrations in weather and changes in rainfall patterns are also expected to cause major loss in production.[81] Changes in weather pattern can also lead to increased pest attack, complicating things further. Being a labour intensive activity, plantations which employ more than one million people directly, cannot shy away from their social obligations. Plantation labourers who were subjected to merciless exploitation right from the inception of the tea industry, still are being exploited. The wages are the lowest in the organised sector.[82] It is the responsibility

[79] Pratim Ranjan Bose, Trouble's brewing in India's tea sector, *The Hindu Business Line*, April 20, 2017
[80] Ibid
[81] 'TAI apprehends severe trouble for Tea Industry', *The Economics Times*, May 31, 2016
[82] Mishra, Deepak K. , Sarma, Atul and Upadhyay, Vandana(2011) 'Invisible chains? Crisis in the tea industry and the 'unfreedom' of labour in Assam's tea plantations', *Contemporary South Asia*, 19: 1, p.78

of the industry to spend adequate amount for the benefit of the workers. Therefore cutting down the expenditure for social obligations is also not an option. Thus the tea industry is in a critical situation whereby it cannot backtrack on its traditional obligations and yet at the same time has to face stiff international competition (along with other afore-mentioned challenges). It is here one has to turn again to options which improve the efficiency of the industry. One of the best ways to do it is to look at the past. One clear message that emerges from the past is the crucial role played by science in the growth of the tea industry - particularly in India overtaking the traditional giant China.

One sees from history that there was extensive interaction and collaboration between tea industry and the scientific community. Botanists were as influential as or perhaps even more influential than policymakers of the East India Company in determining the course of the industry during the initial years. The Botanic Garden, Calcutta and professionals associated with it played pivotal roles in the development of the industry. Towards the second half of the 19th century, there were multiple instances of tea planters writing to the Government requesting service of experts for studying specific problems faced by them in the field. George Watt's study of pests and Kelway Bamber's chemical analyses are good examples of the response to such requests.

The importance of science was formally acknowledged when separate scientific departments were created under Indian Tea Association (ITA) and United Planters' Association of Southern India (UPASI) with scientists fully devoted to research in areas related to tea. Establishment of Tea Research Institutes in Tocklai and Valparai under ITA and UPASI respectively was indeed a big boost to the industry. It was not just the planters who benefitted from research carried out in the plantations. Like in the case of malaria and other healthcare research, the whole community - of employers and the workers alike - were benefitted. While these institutes

continue to this day, it is big question as to whether they are equal to the challenges faced by the industry today.

Even with regard to the past, it has to be pointed out that tea research never went beyond the secluded spaces of the institutes mentioned above. Yet, if these institutes with limited resources could support the industry the way they did, we can imagine the scenario if the rich human resource currently available in the country is properly utilised. Greater collaborations with the premier institutes of higher education in science and technology, could bring about profound changes in the tea industry. Given the current circumstances, this precisely is what the industry needs. Some of the problems haunting the industry now like the weather changes and reduced productivity have to be dealt with by original research.

Tea research is not merely for increasing the profit of the planters. The industry which employs more than a million workers directly and indirectly contributes significantly to the Indian economy. Their role in the economy of the North-East states is even more pronounced as most of the plantations are in Assam. Therefore the fate of tea industry is important to all of us. What we need is a vibrant and successful tea industry supported by an even more vibrant scientific community.

BIBLIOGRAPHY

Antrobus, H A. *A History of the Assam Company 1839-1953.* Edinburgh: T and A Constable Ltd, 1957

Arnold, David. 'Plant Capitalism and Company Science: The Indian Career of Nathaniel Wallich'. *Modern Asian Studies*, Vol.42, No.5, Sep.2008, pp.899-928

Bamber, Kelway, *A Text Book on the Chemistry and Agriculture of Tea including The Growth and Manufacture*. Calcutta: Law Publishing Press, 1893

Basalla, George. 'The Spread of Western Science'. *Science,* New Series, Vol. 156, No.3775, May 5, 1967, pp. 611-613

Bhowmik, Sharit. 'Gift for Private Sector'. *Economic and Political Weekly*, Vol.19, No.28, Jul.14, 1984, pp.1070-1073

Brabin, Bernard J. 'Malaria's Contribution to World War One- The Unexpected Adversary'. *Malaria Journal*, 2014, 13:497

Chakravarthy, R.S. 'Watt's Dictionary: A Landmark in the Study of the Economic Plants of India'. *Economic Botany,* Vol. 29, No. 1, Jan.-Mar., 1975, pp. 31-38

Coggeshall, L.T. 'Malaria'. *The American Journal of Nursing,* Vol.46, No.10, Oct. 1946, pp. 673-675

Crole, David. *Tea a Text Book of Tea Planting and Manufacture*. London: Crosby Lockwood and Son, 1897

Griffiths, Percival. *The History of the Indian Tea Industry*. London: Weidenfeld and Nicolson, 1967.

Hazarika, M. '100 Years of Tea Research- A Journey of Pride'. *Science and Culture,* Vol. 77, Nos. 9-10, September-October, 2011, pp. 347- 352

Jones, E. Lloyd. *Standards of Medical Care for Tea Plantations in India.* Government of India Ministry of Labour, 1947

Mann, Harold H. 'The Indian Tea Industry in its Scientific Aspects'. *Journal of the Royal Society of Arts*, Vol.79, No.4089, 3rd April, 1921, pp. 469-483

Mann, Harold H. *The "Mosquito-Blight" of Tea Part II. Investigations during the Season of 1903.* Calcutta: W. Newman & Co, 1903.

Mann, Harold H. *The "Mosquito-Blight" of Tea. Investigations during the Season of 1902*. Calcutta: W. Newman & Co., 1902

Mann, Harold H. The Early of the Tea Industry in North-East India. Calcutta: D.L Munro

Measham, J.E. *The Transmission and Prevention of Malaria on the Tea Estates of the Madras Presidency.* Valparai: 1939

Mishra, Deepak K et al. 'Invisible chains? Crisis in the tea industry and the 'unfreedom' of labour in Assam's tea plantations'. *Contemporary South Asia*, March 2011

Misra, Bhubanes. 'Quality, Investment and International Competitiveness: Indian Tea Industry, 1880-1910'. *Economic and Political Weekly*, Vol.22, No.6, Feb.7, 1987, pp.230-238

Obituary of Sir Malcolm Watson. *The British Medical Journal,* Vol.1, No. 4957, Jan.7, 1956, pp. 52-53

Ratcliff, Jessica. 'The East India Company, the Company's Museum, and the Political Economy of Natural History in the Early Nineteenth Century'. *Isis,* Vol. 107, No. 3, Sept. 2016, pp. 495- 517

Renzy, A.C.C De. Cholera among the Assam Tea Coolies. *The Lancet*, April 11, 1891, pp. 823-824

Sadir, M. 'The Tea Industry in Assam'. *Journal of the Royal Society of Arts*, Vol.61, No. 3177, October 10, 1913, pp. 1022-1023

Savur, Manorama. 'Labour and Productivity in the Tea Industry'. *Economic and Political Weekly*, Vol.8, No.11, Mar.17, 1973, pp.551-559

Sharma, Jayeeta. ''Lazy' Natives, Coolie Labour, and the Assam Tea Industry', *Modern Asian Studies*, Vol.43, No.6, Nov. 2009, pp. 1287-1234

Shaw, W.S. *Observations on Helopeltis (Tea Mosquito Blight) for South Indian Planters*. Madras: Diocesan Press, 1928

Stern, Alexandra Minna. The Public Health Service in the Panama Canal: A Forgotten Chapter of U.S Public Health'. *Public Health Reports (1974-)*, Vol.120, No.6, Nov.-Dec. 2005, pp.675-679

Strickland, C. 'Malaria on Ambootia Tea Estate near Kurseong and the Success of some Anti-Malaria Operation'. *Indian Medical Gazette*, Mar. 1924, pp. 119-121

Tea Research in S. India under the UPASI Scientific Department.

Thomas, Adrian P. 'the Establishment of Calcutta Botanic Garden: Plant Transfer, Science and the East India Company, 1786-1806'. *Journal of the Royal Asiatic Society* Third Series, Vol. 16, No. 2, Jul. 2006, pp. 165-177.

Turnbull, David. 'The Push for a Malaria Vaccine'. *Social Studies of Science*, Vol.19, No.2, May 1989, pp.283-300

Ukers, William. *All about Tea Vol. 1*. New York: The Tea and Coffee Trade Journal Company, 1935

Watson, E.A. 'The Tea Industry in India'. *Journal of the Royal Society of Arts,* Vol.84, No. 4346, 6th March, 1936, pp. 445-465

Watson, Malcolm. 'Observations on Malaria Control, with Special Reference to the Assam Tea Gardens, and Some Remarks on Mian Mir, Lahore Cantonment'. *Transactions of the Royal Society of Tropical Medicine and Hygiene,* Vol. XVIII, No. 4, pp. 147- 161

Watt, George. *The Pests and Blights of the Tea Plant Being a Report of Investigations Conducted In Assam and To Some Extent Also In Kangra*. Calcutta: 1898

Whittaker, Arnold. 'The Development of the Tea Industry in India and Pakistan'. *Journal of the Royal Society of Arts*, Vol.97, No. 4800, 29th July, 1949, pp. 678-687

Weatherstone, J. 'Historical Introduction', in K C Wilson and M N Clifford (eds.) *Tea Cultivation to Consumption*, Springer-Science+ Business Media, B.V, North Yorkshire, 1992 pp. 1-23

Anti-Hookworm Campaign in Madras Presidency. *The Lancet,* April 29, 1922, p. 865