



Review Article

TEA: AN IMPORTANT CONSTITUENT OF BIODIVERSITY OF ASSAM, NORTHEAST INDIA

PRADIP BARUAH*

Tocklai Tea Research Institute, Tea Research Association, Jorhat, 785008, Assam, India

*Corresponding Author: Email - pbaruahdr@gmail.com

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Abstract: India is the largest tea producing country and contributes 33% of the global tea production. Much of this tea comes from the biodiversity hotspot region of Assam, northeast India. Tea plantations form an important constituent of biodiversity of Assam and play a major role in conservation of biodiversity. Tea plantations are an amalgamation of cultivated tea species (clones and seeds), shade trees, weeds, birds, pathogens, insects, animals, micro flora etc. A total of 1,074 tea germplasm have been collected so far which indicate the broad base of genetic diversity of tea in Assam. Owing to such diversity, over 60% of the world tea acreage has received its basic planting material, directly or indirectly, from these tea germplasms. Genetic studies also reveal Assam tea to have a distinct genetic lineage from China tea. Besides the cultivated species, wild or semi-wild growing tea plants are also found in the forest areas of Upper Assam and its bordering states. This also clearly indicates that tea has a distinct source of origin in Assam. Additionally, many other species related to tea are found in Assam such as *C. kissi*, *C. caduca*, *C. drupifera* etc. Presently, the tea genetic diversity is getting reduced at a rapid rate due to uprooting of old plantations and replanting with high yielding clones and gradual deforestation for agricultural and industrial production. It is therefore highly desirable to preserve the diverse genetic resources of tea for further improvement of the crop before they are lost forever. Recent genetic study has further strengthened the necessity of exploration and germplasm collection of wild Assam teas whatever may be surviving. New discoveries may be possible on wild tea germplasms which may provide the scientists valuable source for developing better variety of teas with regard to quality, productivity and resistance to various problems of pests and diseases, stress conditions etc.

Keywords: Assam, Biodiversity, Camellia, Conservation, Germplasm, Wild tea

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Introduction

Assam, northeast India is geographically nestled in one of the most biodiversity rich regions of the world and holds immense promise for conservation and sustainable use of its rich biological resources [1]. The climatic conditions and a wide variety in physical features witnessed in Assam has resulted in such diversity of ecological habitats such as grasslands, wetlands, forests and agroecosystems which harbour and sustain a wide range of flora and fauna. The climatic conditions cause prevalence of hot and highly humid weather in this part of country and coupled with heterogenic physiography make possible luxuriant growth of a number of plant communities imparting Assam a distinct identity phyto-geographically, many a species are endemic to this region and it is also the center of origin for commercially important plants including banana, citrus, mango, ber and tea. The array of floristic richness has prompted many scholars to describe Assam as the "Biological Gateway" of North East [2]. Besides having a rich habitat of floral and faunal diversity, Assam is also the place of origin of one of the three cultivated types of tea, the Assam tea plant, *Camellia assamica* (Masters). In fact, Assam is the largest tea producing state in India, producing more than 630-700 million kg of tea annually [3] which contributes to 50% of overall tea production in the country. Globally, Assam has about 10 percent of area under tea cultivation and produces about 13% of the world tea production. The ubiquitous Assam tea is globally renowned for its robust flavor and distinct aroma. Besides earning foreign revenues, tea estates also play a major role in the conservation of biodiversity. In many countries, around 20% of the land within tea estates is covered by natural or planted trees. This ecosystem provides important services such as biodiversity, soil and water conservation, carbon sequestration, crop pollination, pest control etc. [4]. In Assam, tea plantations were introduced by the British which used to grow wild in certain areas of the upper Brahmaputra valley.

Presently, the gene pool of tea found in Assam consists of cultivated species, wild species, weedy relatives, land races, improved clones and breeding lines [1]. Existence of wild tea plants in the forests of Assam has been a subject of much curiosity and collection of such germplasm would greatly assist research on plant improvement by the scientific fraternity. This paper analyzes the present status on the biodiversity of tea based on existing knowledge and highlights the potential and possibilities of exploring the diverse tea germplasm found in Assam, north east India.

Origin and types of tea

It is widely speculated that the place of origin of tea is China. However, absence of wild cultivars in China, even though it has been cultivated for more than 2000 years, puts such speculation in doubt [5]. The situation is different for the Assam and Cambod races of tea. Wild forms of these two races have been found in Manipur, Burma, Thailand, Assam, Mizoram, and the entire Annamite chain from the extreme north of the gulf of Tonkin to South Vietnam and Laos. However, it could not be ascertained if the plants were really wild or relics of migratory tribes inhabiting the region [6]. Based on the origin, three races of tea are to be understood viz., Assam tea plant, *Camellia assamica* (Masters), China tea plant, *Camellia sinensis* L and Cambodiensis, *Camellia assamica* sub sp. *Lasiocalyx* (Planch.MS) [6]. It is believed that Assam tea originated from Indo-Burma region, China tea from South China and Cambodiensis tea from South Vietnam. It is supposed that the three races of tea dispersed to these areas from a common place of origin. Many different theories have been put forward regarding the dispersal of tea plants from its place of origin. Wight opined that tea originated around the point of intersection of latitude 29°N and longitude 98°E, near the source of the river Irrawaddy.

The river Irrawaddy and other rivers such as Yangtze Kiang, Mekong, and Luhit dispersed tea to different areas from its place of origin [6]. According to Kingdom-Ward [7], tea possibly originated in Central Asia further north of the Irrawady basin or even within the Arctic Circle or further south in the Altai, or somewhere in Mongolian plateau. It is possible that China race came from the North by the Pacific seaboard during the glacial shake out and the Assam race took the more direct route from Central Asia to reach the secondary centre near Irrawaddy. If this is so then the China type had one origin and the Assam and the Cambodia type together had another common origin. From the secondary centre, the Assam race moved South-East to Indo-China and South-West to Assam. Bendall observed that the whole genus *Camellia* seems to have evolved in southern China.

Wild Teas in Assam: History and present status

According to Baildon [8] and Hannangan [9], in 1823, a local noble man Maniram Dewan informed Major Robert Bruce of East India Company about tea plants growing wild in Assam and also introduced Bruce to the Singpho tribes who prepared medicinal beverages from these plants [10]. After Robert Bruce's demise, his brother Charles Alexander Bruce collected the tea leaves and seeds and subsequently forwarded the samples to Dr. N. Wallich, Botanist to the East India Company, Calcutta who identified the leaves and seeds as belonging to *Camellia* family but differed from the tea plant of China [11]. Later, Captain F. Jenkins and his assistant Lieutenant Charlton reported the presence of indigenous wild teas from upper Assam which was consumed as infusion by the local Singpho tribes [11]. Some seeds and leaves of these plants were again sent to Dr. Wallich for identification who was finally convinced that it was genuine tea and identical to China. Charles Alexander Bruce, who was promoted as Superintendent was the pioneer of tea industry in Assam. He extensively explored the forests of Assam particularly in the country of the Singphos, on the south side of the Brahmaputra, along and down the river Buri Dihing and found wild tea growing there and at other places like Phakial, Tingri, etc. He made alliance with different tribal chiefs and convinced them to clear forest areas for tea cultivation with the assertion of teaching them the tea cultivation and manufacturing methods and subsequently buying tea from them. In 1839, C.A. Bruce published a pamphlet which contained a map where he showed the extent of his discoveries of wild tea in Assam. In 1855, native tea plants were also discovered in Sylhet and in a number of places along Khasi and Jaintia Hills [12].

At present, true to type original Assam variety is yet to be found. An exploration carried out in 2012 at Margherita region of Tinsukia district to Bordumsa of Arunachal Pradesh, some "wild" teas were discovered in the forests areas [13]. The locals informed that some of those plants had better yield and nearly free from insect and disease infestation. However, it could not be ascertained whether these plants were truly wild or remains of earlier shifting cultivation [5]. These germplasms are presently maintained at Tocklai Tea Research Institute, Jorhat, Assam [14]. However, possibility still remains on discovery of wild tea in remote unexplored areas of upper Assam and Arunachal Pradesh. Recently, wild tea plants were also discovered from forest regions of Ingching Langso and Songlithi Anglong of Karbi Anglong [15]. This is the first time that wild tea has been discovered from Karbi Anglong district. Other possible areas include Khonsa, Mishimi Hills and Tirap district of Arunachal Pradesh, Miao of Arunachal Pradesh and Mon district of Nagaland. There is scope of exploration of these and Indo Myanmar areas in search of wild teas [5].

Purple tea: Tracing its root to Assam

Purple tea offers a totally new type of tea with a unique colour of the beverage and many medicinal benefits. Purple tea contains anthocyanins, which imparts the purple colour to the tea leaves. At present, Kenya is the only country that manufactures purple tea, which fetches three to four times the price of black tea [16]. However, the purple tea clone released in Kenya for commercial cultivation is an Assam variety [17]. In case of Assam, it has the advantage of being the origin of tea with large biodiversity and with the possibility of finding even better plants for purple tea production. Wild purple teas have been recently discovered in Karbi Anglong Hill district of Assam [18]. Such plants are also available in different tea growing areas of Assam, which are commonly known as 'ox blood', because of the

colour. Tocklai Tea Research Institute is presently maintaining a purple tea germplasm. Researchers have to explore this purple tea for their properties and release the best possible plants from these and collections from the wild teas and old tea growing areas, for facilitating commercial production of purple tea, in the near future.

Genetic diversity among the types of tea

Genetic studies of the three main cultivated types of tea viz., China, Assam and Cambod type reveals that these 3 types of tea are likely the result of three independent domestication events from three separate regions across China and India with high levels of genetic diversity among them. Based on structure, PCoA and UPGMA analyses, the cultivars which were evaluated could be clustered into three distinct genetic groups i.e. China tea, Chinese Assam tea and Indian Assam tea. A significant proportion of the studied tea samples were shown to possess genetic admixtures of different tea types suggesting a hybrid origin for these samples, including the Cambod type. The study revealed that Chinese Assam tea is a distinct genetic lineage compared to Assam tea from Assam. The study further concluded that China type tea, Chinese Assam type tea and Indian Assam type tea were likely domesticated independently in Southern China, Southwest Yunnan Province of China, and the Assam of India, respectively [19]. Some tea historians suggested that Assam tea had been introduced from China, but the researchers found that the short breeding history of this tea in Assam made that unlikely. According to them, if the Chinese Assam and Indian Assam teas were from the same origin, they should have been genetically much more similar [20]. These studies further supplement the fact that the Assam type of tea originated from Assam itself and genetically diverse from other types of tea.

Role of tea estates in conserving biodiversity

Tea planters such as E.P. Gee and R.J. Mackenzie made notable contribution in discovering and reporting the biodiversity of wildlife in Assam. Gee authored many articles and research papers on wildlife of India in prestigious journals, and wrote his own account of his wildlife work in the book "Wildlife in India" in 1964. Even the tea garden bungalows established by the British have large collection of various plants, particularly fruit and ornamental ones which are still being preserved. Tea plantations roughly resemble a "single species forest" [21] and a wide range of floral and faunal diversity coexist by a well-defined stratification and/or ecological niche formation. The natural and semi-natural areas of the tea estates offer refuges not just to common organisms but many of Assam's endemic and threatened flora and fauna. Therefore, these estates can contribute immensely to the long-term conservation of Assam's biodiversity. Most tea gardens of the big tea majors in the state are Rainforest Alliance (RA) certified, and have met the social and environmental standards set by the Sustainable Agriculture Network (SAN). SAN standards ensure protection of workers and wildlife, conservation of natural resources and support the financial viability of farms.

Tea estate maps detail tea fields, roads, factories and housing, but often leave gaps marked as 'blanks' or 'estate jungle'. These spaces, along with the streams and rivers (sometimes merely considered 'drains'), are the most interesting and valuable parts of the landscape. It is in these spaces that one finds evergreen forests, regenerating forest and scrub, grasslands, bamboo patches, swamps and water bodies that support diverse wildlife species. Tea companies such as the Apeejay Group has partnered with World Wildlife Fund (WWF) to become involved in wildlife conservation efforts and to minimize human-elephant conflict in their tea estates [22]. In a similar way, a tea farmer, Tenzing Bodosa's plantations along India-Bhutan international border in Assam's Udalguri district has become world's first to get the coveted "Elephant Friendly Certified Tea", an initiative launched by the Wildlife Friendly Enterprise Network (WFEN) and University of Montana, USA to raise fund for Asian elephant conservation [23]. Even water bodies are created for the benefit of elephants. Apart from the water bodies, tea estates also preserve clusters of trees in the gardens where elephants can take shelter. Further, wildlife conservation camps are held in tea estates to convey people that deforestation and hunting is strictly prohibited. Posters are prepared in English and in local language for the tea garden community and for students in the vicinity of the tea gardens to spread awareness about reptiles like snakes.

This helps in conserving the rich fauna that tea gardens have. Chemical-free buffer zones are created in the proximity of streams to further enhance water quality and reduce chemical risks to both fauna and flora. Plant protection chemicals, whether insecticides, weedicides or fungicides, are regulated for use in tea and only Plant Protection Code (PPC) approved chemicals are permitted to be applied in tea. The use of synthetic insecticides is limited in tea and due importance is given on cultural, physical and biological methods of pest control which was absent or negligible before. Due importance is given on conserving the biodiversity within the tea estates. Organic tea plantations can also help in conserving the biodiversity. Organic farming acts as refuge for wild plants, offsetting the loss of biodiversity on conventional farms. Biodiversity analyses also reveal a significantly higher diversity of birds in certified organic tea estates. Even a mixture of organic and non-organic tea plantation in an area can help maintain this biodiversity.

Loss of tea germplasm

The major purpose of germplasm preservation is to preserve rare and endangered species of plants around the globe for future propagation and development; hence germplasm is the foundations of agricultural productions [24]. Loss of the genetic diversity of some of the world's crops has accelerated in recent decades, with many crops becoming increasingly susceptible to diseases, pests, and environmental stresses [25]. This applies in case of tea too. Clones such as the TV series are more popular in major tea estates of Assam, where old seedling teas are being uprooted and replaced with a few of these popular clones [26]. It is leading to decrease in genetic base of tea plantations. It needs to be arrested by preserving interesting bushes in the old, seed grown sections besides planting diverse clones. The opportunity for creating genetic variability in tea through recombination, mutation, polyploidy and tissue culture will be missed if old seed jats are replaced with high yielding clones. In addition, agricultural intensification, changes in land use planning, pests and pathogens, increased human population, land degradation and changes in the environment such as climate change has also contributed to loss in genetic diversity in tea.

Future thrust

The weakening of the agriculture-biodiversity-environment connection has been exacerbated by the training and attitude of professionals engaged in food production and biodiversity conservation. It cannot be overruled that tea plantations also have negative impacts on biodiversity. As research suggest, tea plantations influence biodiversity and is influenced by biodiversity in many ways [27]. Long term monocropping of tea has also led to reduction in biodiversity and nutrient deficient system. However, positive and vibrant changes can be made by adopting different approaches such as intercropping, nitrogen fixing cover crops, vermiculture and organic composting which the tea planters are presently practicing in their estates. Further, increase in number of small tea growers in Assam indicates a potential opportunity to shift away from plantations and towards small farming with benefits to be gained for biodiversity preservation. Small tea growers tend to retain greater biodiversity when producing tea, both through retention of the forest and through intercropping of cash crops and subsistence crops in close proximity [28]. New approaches to protection of species, habitats and genes are essential if agricultural productivity is to be sustained and rural communities are to survive and prosper. Biodiversity conservation goals for a tea estate can be met by protecting and establishing local biodiversity in an integrated pattern within and across the estate. Non cropping or vacant areas can be utilized to provide patches of certain types of habitat, or to form corridors that link protected areas and enable species to maintain genetic interaction between populations that otherwise would be isolated. This will involve protecting remnant native vegetation and/or re-establishing wild species. Safeguarding and restoring these natural remnants will have a greater positive impact on biodiversity conservation. The Food and Agriculture Organisation is taking steps stop the loss of valuable agro-biodiversity through development of methodology for agro-biodiversity assessment and monitoring. Further progress depends on major attitudinal shifts among biodiversity planners and tea planters and agriculture professionals. Many farmers, particularly indigenous farmers, have an

appreciation of their local biodiversity, so for them the adjustment will be less difficult.

Application of review: Study providing information on the present status of biodiversity in tea plantations of Assam, north east India and its future thrust and implications.

Review Category: Biodiversity in tea plantations

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Study area / Sample Collection: Tocklai Tea Research Institute, Tea Research Association, Jorhat, 785008, Assam

Cultivar / Variety name: Tea, *Camellia sinensis* (L.) O. Kuntze

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