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Present Status and Future Prospects of Tea production and Research on Varietal Improvement in Bangladesh

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ABSTRACT

Tea is one of the most important non-alcoholic beverage in the world and has been gaining further popularity as an important 'health drink' in view of its inferable medicinal value. In Bangladesh, commercially tea was cultivated since 1854 by establishing first tea garden Malnicherra Tea Estate in Sylhet. From 1947 to 2020, tea growing area, production and per hectare yield were increased 127.71%, 370.53% and 137.96% respectively. The major reasons behind the increasing tea productivity are extension of tea growing areas as well as cultivation of the tea clones (BT clones) released by Bangladesh Tea Research Institute (BTRI). Till now BTRI released 23 clones and 5 biclones, having average per hectare yield of 3461.67 kg. In the world, tea production, consumption and exportation have increased significantly. Unlike world condition, there is a negative relation between tea production and export in Bangladesh. From 1980 to 2020 the quantity of tea exports was decreased by 92.99%. This situation emphasizes the need for exploring alternative means by the tea industries of increasing profits from tea cultivation and tea export. As a result, researches on tea varietal improvement is needed for rapid economic growth and development of tea industry as well as to encourage tea plantation business to go ahead with more production to meet our own demand along with quality tea to flourish tea business in Bangladesh.

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Introduction

Tea (*Camellia sinensis*) is a widely consumed oldest non-alcoholic beverage over the world, next to water and adored by all age groups (Hicks, 2009). Due to specific requirements of climate and soil, tea cultivation is confined only to certain specific regions of the world. Majority of the tea producing countries are located in the continent of Asia where China, India, Sri Lanka are the major producers. African tea growing countries are located mostly around the tropical regions where Kenya, Malawi, Rwanda, Tanzania, Uganda are major producers. Apart from these regions, some quantities of tea are also being produced in South America (Argentina, Brazil and others), the Near East (Iran and Turkey) and the CIS (Russia and Georgia) (Basu et al., 2010).

In Bangladesh, commercially tea was cultivated since 1854 by establishing first tea garden Malnicherra Tea Estate in Sylhet. In 1947, total tea cultivated area was 28,734 ha, production was 18.36 million kg and yield was 656 kg per hectare; whereas in 2020, tea area was 62,168.46 ha, production was 86.39 million kg and yield was 1561 kg per hectare (BTB, 2021). From 1947 to 2020, tea growing area, production and per hectare yield were increased by 127.71%, 370.53% and 137.96%, respectively. The major reasons behind this increasing tea productivity are extension of tea growing areas as well as cultivation of Bangladesh Tea series tea clones (BT clones) which were released by Bangladesh Tea Research Institute (BTRI). Till now BTRI released 23 clones and 5 biclones, having average per hectare yield of 3461.67 kg (BTRI, 2020).

In recent years, In the world, tea production, consumption and exportation have increased significantly. In 2017, total tea production accounted for 5697.98 million kg, of which approximately 35% was exported, worth USD 8 billion (IGT, 2018). In 2018 world tea production was 5856.41 million kg which was 45.73% increased tea production higher than 2009 (BTB, 2020). World tea exports increased annually by 1.4 percent over the last

decade to reach 1.75 million tonnes in 2016 (FAO, 2021). The massive expansion is also a result of increased consumer health consciousness and the rapid development of tea beverages in the country characterized by a longstanding tradition of drinking tea.

Unlike world condition, there is a negative relation between tea production and export in Bangladesh. During the period 1980, the quantity of tea exports was about 30.98 million kg, whereas during 2020, the amount reduced to only 2.17 million kg, decreased by 92.99%. This situation emphasizes the need for increasing productivity as well as for exploring alternative means by the tea industries of increasing profits from tea cultivation and tea export. In Bangladesh, thus there is a dire need to focus attention on varietal improvements covering quality and high productivity of tea to meet up consumers demand and to increase profit margin for tea planters. The following account reviews the present status and future prospects of the tea industry in Bangladesh as well as researches on varietal development by BTRI to compete with other tea producing countries in the international markets.

Materials and Methods

This article is mainly a review paper, hence all sorts of data are collected from secondary sources. Data were obtained from different kinds of journals, research articles, statistics from Bangladesh Tea Board, Bangladesh Tea Research Institute, International Tea Committee etc. However, some decision and conclusion were made from the analysis of these secondary data. Data were analysed by Microsoft Word Excel version 2019. The correlation coefficient was used to interpret the relationship based on its value (Gogtay et al., 2017).

Results and Discussion

Tea and Worldwide its Distribution

'Tea' means the plant *Camellia Sinensis (L) O.* Kuntze as well as all varieties of the product known commercially as tea made from the leaves of the plant *Camellia Sinesis (L) O*. Kuntze including green tea (Tea Board, 2019). Tea is a cash crop as well as also an export item all over the world. Different kinds of teas are manufactured in different countries based on taste, habit and culture of people. Normally, tea can be categorized into three groups: green tea (unfermented), Oolong tea (partially fermented) and black tea (fully fermented) based on tea processing (Arefin et al., 2020).

Tea is one of the most important cash crops worldwide, playing a significant role in rural development, poverty reduction and food security in developing countries. It is planted in 58 countries in the five continents, the majority being in Asia and Africa. The total area of land under tea cultivation is 4.37 million ha, with an annual production of 5.30 million tons in 2015 (ITC, 2016).

Today, Tea Horizon of modern world is seen to extend from the latitude 43° N (Georgia, USSR) to 27°S (Corrientes, Argentina). Most of tea growing countries like China, Japan, Formosa, Java, Sumatra, Sri Lanka, India, Bangladesh, etc. lie however, within a restricted range of 43°N of latitude from 6°S in Java to 35°N in Japan, and 60° of longitude from 80° to 140° E. The home of tea is assumed to be within the comparatively small, fan-shaped area between the Naga, Manipuri and Lushai Hills along the Assam/Burmah frontier in the west, through to China as far as the Che-Kiang province in the east, and from this line generally south through the hills to Burmah and Thailand to Vietnam (Figure 1). The east-west axis, as indicated is about 2400 km (1500 miles) long, extending from longitude 95° to 120°E. The north-south axis covers about 1920 km, (1200 miles) starting from the northern part of Burmah, latitude 29°N, passing through Yunnan, Tongkin, Thailand, Laos and on to Assam, reaching latitude 11° N (Sana, 1989).

Figure 1. World Tea Horizon

Basic Requirement for Tea Cultivation

Tea originated in southwestern China, at the centre of the Yunnan and Guizhou plateaus, a junction of tropical and subtropical areas. This region is characterised by a warm climate, abundant rainfall, high humidity and sufficiently diffused light. Under such conditions, tea plants have gradually evolved specific characteristics of adaptation to warm, moist weather, diffused light and acidic soils (Ranjitkar et al., 2016 and Zhao et al., 2021). Pronounced changes in temperature, precipitation, relative humidity, rainy days and annual sunlight hours will not only directly affect tea yield and quality, but will also change other basic parameters necessary for its growth and development, such as soil pH, water content, organic matter, nutrient availability, pest and disease management, ecological systems around tea gardens and eventually tea processing. The basic environmental requirements for tea growth and development are listed in Table 1 (Han et al., 2018).

Present Status of World Tea

World Tea Production

From the data of last 10 years, it is found that total world production of tea has been increased to about 36% (Table 2). The tremendous advance in this regard was achieved by China which is about 83.96% increase in production in 2020 in contrast with 2011. Tea production of Bangladesh was increased 31.08% from 2011 (ITC, 2021).

Figure 2 exhibits the percentage share of world tea production by major tea producing countries in 2020. China produces about 48% of total world tea, whereas India produces about 20% of total world production. Bangladesh contributes only 1.0% of world production (ITC, 2021).

World Tea Consumption

The consumption of world tea by the producing countries from 2011 to 2020 is shown/ given in the Table 3. Like production, China also consumes largest amount of tea every year. In 2020, 2450 million kg tea was consumed by China and this consumption trend was is increasing greatly during last 10 years which is almost 92.15%. India occupies second position in world consumption as they have a large population. Although Kenya and Sri Lanka produces about cumulatively 13% of world tea (Figure 2) but their consumption is very low. Besides consumption of tea by Kenya has been increased by about 109.15%, whereas decreased in Japan, Taiwan and South Africa during last 10 years (ITC, 2021).

World Tea Exports

World tea sector showed an increasing trend among production, consumption and production. Table 4 exhibits the world exports of tea and Figure 3 shows the percentage share of world exports by leading exporting countries. It is found that, total world export of tea has been increased to about only 3.46% within last ten years. Kenya is the leading exporting country, responsible for 28.43% of total global exports. China being the leading tea producing country, in case of export, they occupied the 2nd position in 2020 by sharing 19.11% of total world exports. Sri Lanka and India contributed about 14.39% and 11.17% respectively of world exports in 2020 (ITC, 2021).

Bangladesh Tea: History and Present Status

Tea plantation in Bengal region was developed concurrently with that in the north eastern part of India during the early nineteenth century (LaFavre, 2013). In 1855, the Assam indigenous tea plant was established in Chandghani Hills of Sylhet. Near about the same time, wild tea was found among Khasiand Jainta Hills. The first commercial tea plantation was established in 1857 in at Malnicherra in Sylhet (Nasir et al., 2011).

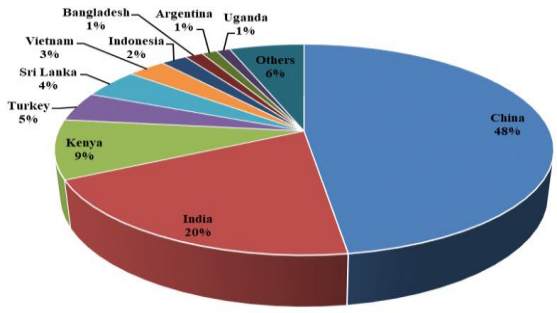

Figure 2. Percentage Share of World Tea Production in 2020

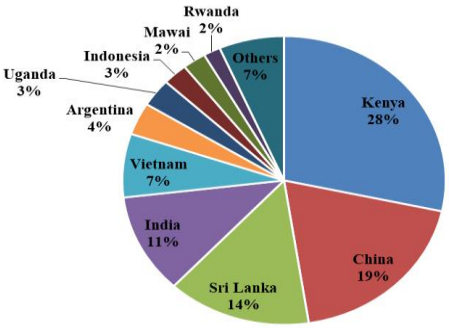

Figure 3. Percentage Share of World Tea Export in 2020

Table 1. Basic Requirement for Tea cultivation World-wide

Climate parameter	Extreme lowest	Normal range	Optimum
Temperature (°C)	−20 (var. sinensis),−8 (var. assamica)	13–26	18–23
Annual accumulated temperature (≥10°C)	3000	4000–8000	6000–7000
Annual precipitation (mm)	500	800–2500	1500–2000
Annual relative humidity (%)	60	70–90	80–85
Soil moisture (% of water holding capacity)	50	60–95	70–90
Soil pH (in water suspension)	3.0	3.5–6.5	4.5–5.5

Table 2. World Tea Production (in Million Kg) of Last 10 Years

Country	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	I/D
China	1623.21	1789.75	1924.46	2095.72	2249.00	2404.95	2496.41	2610.39	2799.38	2986.02	83.96
India	1115.72	1126.33	1200.41	1207.31	1208.66	1267.36	1321.76	1338.63	1390.08	1257.53	12.71
Kenya	377.91	369.56	432.45	445.11	399.21	473.01	439.86	493.00	458.85	569.54	50.71
Turkey	246.12	230.56	235.21	246.46	258.54	253.31	255.40	280.00	267.80	280.00	13.77
Sri Lanka	328.63	328.40	340.03	338.03	328.96	292.57	307.72	304.01	300.13	278.49	-15.26
Vietnam	178.00	174.03	180.33	175.00	170.00	180.00	175.00	185.00	190.00	186.00	4.49
Indonesia	150.78	137.77	145.46	144.37	132.62	137.02	134.00	131.00	128.80	126.00	-16.43
Bangladesh	65.91	62.16	66.26	64.48	67.38	85.05	78.95	82.13	96.07	86.39	31.08
Argentina	92.89	82.81	80.42	82.31	82.00	84.00	82.00	80.00	77.00	73.00	-21.41
Uganda	54.18	57.94	60.97	65.37	58.59	55.74	53.89	71.55	70.34	66.39	22.54
Others	355.81	352.43	354.61	364.11	349.62	360.74	373.40	390.48	382.69	359.59	1.06
Total	4589.17	4711.73	5020.60	5228.27	5304.58	5593.74	5718.39	5966.19	6161.15	6268.95	36.60

I/D: % increase/decrease

Table 3. World Tea Consumption (in Million Kg) of Last 10 Years

Country	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	I/D
China	1275.00	1437.00	1532.00	1657.00	1796.00	1969.00	2041.00	2141.00	2276.00	2450.00	92.16
India	872.00	891.00	906.00	927.00	948.00	965.00	1059.00	1084.00	1109.00	1062.00	21.79
Turkey	242.40	226.30	230.20	241.80	253.00	247.20	250.20	256.40	268.40	270.00	11.39
Japan	121.65	121.23	117.80	111.76	108.32	102.15	104.49	104.98	165.17	92.00	-24.37
Bangladesh	58.50	61.19	64.00	67.17	77.57	81.64	85.93	90.45	95.20	87.00	48.72
Vietnam	33.00	30.00	31.50	28.00	33.00	3.70	40.00	43.00	45.00	46.00	39.39
Taiwan	44.45	41.68	41.47	43.14	39.88	35.21	36.37	36.83	36.82	36.00	-19.01
Kenya	20.02	22.74	26.55	32.18	29.37	29.75	37.63	37.95	40.47	41.87	109.15
Sri Lanka	27.85	27.13	27.50	27.78	28.44	28.76	28.90	29.21	29.38	29.54	6.07
Sth. Africa	22.30	22.00	20.00	20.30	20.00	20.50	21.00	17.60	18.40	19.00	-14.80

I/D: % increase/decrease

Table 4. World Tea Export (in Million Kg) of Last 10 Years

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	I/D
Kenya	421.27	430.21	494.35	499.38	443.46	480.33	415.72	474.86	496.76	518.92	23.18
China	322.58	321.79	332.42	301.46	324.96	328.69	355.26	364.71	366.55	348.82	8.13
Sri Lanka	301.27	306.04	309.20	317.89	301.32	280.87	278.20	271.78	289.59	262.73	-12.79
India	213.17	206.19	215.54	204.70	225.23	218.39	247.02	261.35	247.80	203.89	-4.36
Vietnam	130.00	144.03	141.02	132.00	133.60	142.00	146.44	130.00	134.91	130.00	0.00
Argentina	86.20	76.84	74.37	76.11	76.03	78.18	74.92	72.62	75.32	65.98	-23.46
Uganda	46.15	52.27	57.49	57.19	54.79	50.19	47.01	60.88	60.65	56.83	23.14
Indonesia	75.45	70.07	70.84	66.40	61.92	51.46	64.19	49.03	43.11	45.27	-40.01
Mawai	44.89	41.83	37.10	39.77	30.88	29.29	29.29	34.82	32.85	42.73	-4.81
Rwanda	22.96	22.45	22.34	21.68	24.79	25.42	26.24	30.95	31.16	31.00	35.03
Others	100.02	103.15	105.43	109.85	118.91	118.63	113.59	111.67	126.29	118.90	18.88
Total	1763.96	1774.87	1860.10	1826.43	1795.88	1803.45	1797.87	1862.66	1904.98	1825.06	3.46

I/D: % increase/decrease

Table 5 and Figure 4 represents tea cultivated area (ha), production (million kg), per hectare yield (kg), consumption (million kg), export (million kg) and export value from 1947 to 2020 in Bangladesh (BTB, 2021, Mondal et al., 2021 and Ahmad et al., 2013). From 1947 to 2020, tea growing area, production and per hectare yield were increased by 127.71%, 370.53% and 137.96%, respectively. But, interestingly, the tea export was decreased to 92.99% since last 40 years (from 1980 to 2020). The main reason was the rapid consumption rate which was increased with the increase of population and tea production. It was found that, there were strong relationship between tea growing area and both production as well as yield. The Correlation Coefficient, r value is 0.94 and 0.92, explaining as a strong positive correlation between tea growing area and both production as well as yield. Similarly, the production strongly affect the consumption, r value = +0.95. But strong negative correlation was found between tea production and export, r value = -0.71 which indicates production was increased but export was decreased over time.

Recently, small holding tea cultivation was increased in Northern region and Chattogram hill areas of Bangladesh. The idea of establishing small holding tea cultivation in Bangladesh is rather new and first introduced in the Tea Policy of 1984-85 (Ahmed, 2014). Thereafter, a few tea professionals of the country took certain positive steps to promote small holding tea cultivation at Tetulia in Panchagarh district by forming a company, namely Tetulia Tea Company Limited (TTCL) which was a private initiative (TTCL, 2000 and Ahmed et al., 2015). At present, there are 167 tea estates in our country having total land of 114.54 thousand hectare. But tea cultivable land is only 62.16 thousand hectare. Again, tea cultivated land under small tea holding is about 3.26 thousand hectare which is increasing day by day. So, now, tea has been cultivated in 65.42 thousand hectare where remaining lands are unusable for tea cultivation. But the land which can be cultivated by tea in near future is only 2.53 hectare (BTB, 2020).

Methods of Varietal Development of Tea in Bangladesh

Our present yield per hectare is quite low compared to other tea growing countries of the world (Aziz et al., 2020). One of the major reasons is around 35% of our tea growing area is covered with seedling plants with over 60 years old plant which are of lower productivity (PDU, 2015). The increase in internal consumption causes decrease of exportable surplus with a slow rate of increase in production, which in turn causes to decline in export of tea. The increasing cost of production as well as adverse climatic conditions have led to marginal economic return to the tea industry. In these circumstances the industry needs to replant and extend new tea areas with improved planting materials of higher yield and good quality (Dutta and Alam, 2001). So, developing and cultivating new high yielding tea varieties can be helpful to eradicate poverty by creating sustainable employment opportunities for marginal land owners as well as for landless mass population and optimum commercial utilization of fallow land in a land hungry country like Bangladesh (Hossain et al., 2017).

Table 5. Tea Area, Production, Yield, Consumption, Export and Export Value from 1947-2020 in Bangladesh

Year	Area ('000 ha)	Production (Million Kg)	Per hectare yield (Kg)	Consumption (Million Kg)	Export (Million Kg)	Export Value (M. BDT)
1947	28.73	18.36	656	-	-	-
1970	42.69	28.00	735	5.77	-	-
1980	43.52	40.04	916	9.06	30.98	-
1990	47.34	45.89	1009	14.21	26.45	-
2001	50.04	53.15	1136	36.95	12.92	894.99
2002	50.80	53.62	1141	41.5	13.65	939.93
2003	50.70	58.3	1150	37.44	12.18	915.07
2004	52.09	56	1219	43.33	13.11	934.04
2005	53.28	60.14	1291	43.3	9.01	742.62
2006	52.82	53.41	1146	40.51	4.79	469.59
2007	53.72	58.19	1236	46.27	10.56	899.01
2008	54.11	58.66	1238	52.12	8.39	976.95
2009	55.83	59.99	1238	53.74	3.16	433.5
2010	56.71	60.04	1221	57.63	0.91	176.68
2011	54.40	59.13	1118	58.5	1.48	213.51
2012	54.50	62.52	1236	61.19	1.56	222.28
2013	57.76	66.26	1280	64	0.54	133.04
2014	59.61	63.88	1239	67.17	2.66	281.72
2015	58.81	67.38	1270	77.57	0.54	105.13
2016	60.8	85.05	1587	81.64	0.62	140.56
2017	62.52	78.95	1470	85.93	2.56	377.29
2018	63.13	82.13	1529	90.45	0.65	203.93
2019	63.26	96.07	1769	95.2	0.6	194.26
2020	65.42	86.39	1564	91.97 (Expected)	2.17	347.14

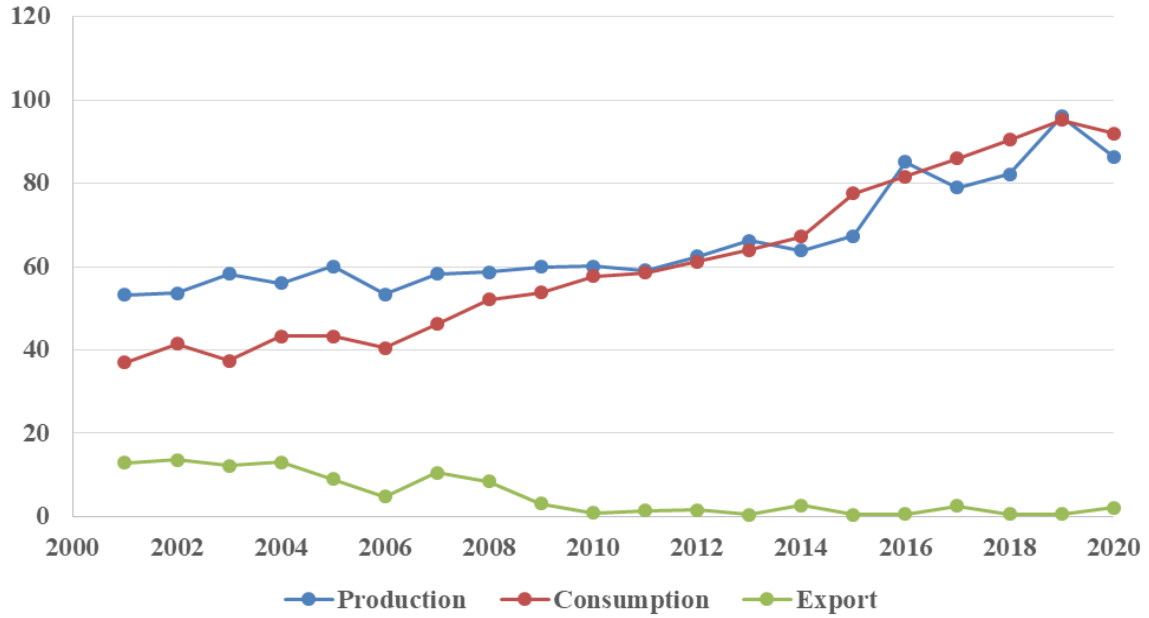

Figure 4. Tea Production, Consumption and Export of last 20 years in Bangladesh

The evolution of tea varietal improvement and genetical stock for Bangladesh tea may be collated to four major phases of stagnancy and development of the industry which are given below:

- Decade of fifties of post-partition stagnancy and slow growth,
- Decade of sixties of mandatory extension and development,
- Decade of seventies of Bangladesh post-liberation period of planning for rebuilding activities,
- Decade of eighties of actual utilization of research innovations for development of the tea industry (Alam, 1994)

Improved planting materials with desirable characteristics can be developed either by the use of existing natural variability or by the creation of new genetic variability through hybridization or other methods of non-conventional breeding like polyploidy, mutation and tissue culture. The conventional methods of tea improvement are i) introduction, ii) selection, and ii) hybridization. Bangladesh tea has been benefited by the introduction of improved materials from elsewhere. Selection and hybridization programme of any institute are aimed on local requirement and local adaptation. Initiation of clonal selection programme in 1959 marked the beginning of tea improvement in Bangladesh. Controlled hybridization programme was initiated at the institute in

the mid-1960s with a view to fulfilling the growing need to develop improved seed varieties suitable for Bangladesh. Other non-conventional approaches of tea breeding are also pursued at the institute but with a little success (Dutta, 2002). Tea varietal development methods Varietal development methods of tea at BTRI are briefly described below:

Clonal Selection

Clonal selection method is a useful and very common method of developing improved planting materials of tea in all tea growing countries. Age of section, yield, seed source etc. should be considered first while under taking a selection programme. Then preliminary selection of mother bush is done on the basis of certain morphological characters such as plant type, frame and size of the bush, branching habit, density of plucking points, leaf size, leaf colour, texture, incidence of pest diseases etc. Thereafter assessment of yield and quality of individual bush followed by its rooting ability is made. Once this screening is done, field trial to compare yield and quality is carried out against standard clone(s) of Bangladesh (Alam, 2002).

A major portion of the yield of a seedling field is contributed by a relatively smaller number of tea bushes. In tea 10 per cent of the bushes produced only 2 per cent of the total crop and about 0.5 per cent of the bushes produce the balance crop because of their superior genetic ability and crop yield of individual bush in a field may vary up to 500 per cent between the lowest and the highest yielding bushes (Wight et al., 1963). On an average one out of 40,000 bushes in a seedling population will be outstanding in yield and quality (Wight, 1956).

Hybridization

Tea is predominantly a self-sterile as well as an out breeding crop. There are two fold objectives in a tea breeding programme, production of generative clones which would give uniform seedling progenies and also further selection of vegetative clones there form. A seed population, being a combination of many genetically distinct units fit into a wider range of environments than the clones. Seedling thrive better than clones in tillahs and hot slopes and are more adaptive to drought condition. For establishment of biclonal and polyclonal seedbaries, ideal generative clones are to be selected first for these purposes, constituent generative clones are studied for cross compatibility, so that they produce uniform seedling of good yield and quality potential.

With an objective of evolving planting materials with high yield and quality potential BTRI has put its priorities on clonal selection and hybridization programme since its inception. As an outcome of these studies, the institute so far released twenty three (23) vegetative clones and five (05) Bi-clone Seed Stock in the BT-series to the industry (Table 6).

Table 6. BTRI released Clone/ Bi-Clone Seedling

Clone/ Bi-Clone Seedling	Release Year	Yield (Kg/Ha) At Mature Stage	Quality*	Category**
BT1	1966	3298	AA	Standard
BT2	1975	3627	AA	Standard
BT3	1975	3431	AA	Standard
BT4	1981	2581	E	Quality
BT5	1987	2811	AA	Standard
BT6	1987	2916	E	Quality
BT7	1991	2790	AA	Standard
BT8	1992	3316	AA	Standard
BT9	1994	3784	AA	Standard
BT10	1995	4600	AA	Yield
BT11	1999	3713	AA	Standard
BT12	2000	4018	AA	Yield
BT13	2000	3203	AA	Standard
BT14	2002	3450	AA	Standard
BT15	2002	3735	E	Quality
BT16	2005	3604	AA	Standard
BT17	2006	3897	AA	Standard
BT18	2010	3777	AA	Standard
BT19	2016	3877	AA*F	Standard
BT20	2016	3685	E	Quality
BT21	2018	3447	AA	Standard
BT22	2021	3304.15	E	Quality
BT23	2021	3341.75	AA	Standard (DT)
BTS1	1985	3217	AA	---------
BTS2	1985	3110	AA	---------
BTS3	2001	3381	AA	---------
BTS4	2001	3303	AA	---------
BTS5	2019	3709.9	AA	--------
Average Yield (Kg/Ha) At Mature Stage=		3461.67		

Note: * Quality category based on Tea Quality score: E = Excellent (≤34 out of 50), AA = Above Average (32≤ to <34 out of 50), A = Average (30≤ to <32 out of 50), BA = Below Average (<30 out of 50) (Bezbaruah HP and Dutta AC, 1977), ** Clonal category based on Yield Quality: Yield clone: Yield of ≥ 4000 Kg/hac. with Above average or Average Cup Quality, Standard clone: Yield of 3000 - <4000 Kg/hac. with Above Average or Average Cup Quality, Quality clone: Yield of 2500 - <3000 Kg/hac. with Excellent Cup Quality (Amma S., 1974; Bezbaruah HP and Dutta AC, 1977; Wachira, 1994)

Polyploidy

Most of the cultivated tea plants are diploids having two sets of basic chromosomes (2x=30). But the occurrence of natural triploids and tetraploids has also been reported in many tea-growing countries. Although quality of triploids and tetraploids are reported to be inferior to the diploids but they are generally more vigorous and good rooter (Sharma and Bezbaruah, 1984). Polyploidy can be artificially induced by chromosomal mutations and hybridizations. Large scale cultivation of triploids and tetraploids have not been reported so far perhaps due to low quality, but a few triploid clones in India (Upasi-3. Upasi-20 and TV29) are found to be high yielder with over all overall quality. Polyploid breeding once was tried at BTRI. A natural tetraploid tea plant was isolated and a number of crosses were tried between diploids and tetraploid. Crosses were found successful only in a few cases and some plants were obtained but elite plants with desirable attributes are yet to achieve (Rashid et al. 1985).

Mutation

The reports on the use of mutation breeding in tea are scanty. This technique can be used to increase genetic variation for possible use in the evolution of better planting materials. At BTRI attempts to produce mutants by irradiation of cuttings and seeds have not yielded significant results so far. Hybridization with irradiated pollens was also tried but with no appreciable success (Rashid and Alam, 1976).

Tissue Culture

In vitro micropropagation can be considered as useful attempt to solve unavailability of sufficient planting materials for tea plantation. This technique can be an ideal choice for the circumvention of conventional multiplication system (Mondal et al., 2004) and commercially, it can be effectively utilized for introducing improved clones in a relatively short period of time (Sharma et al., 1999). Haque and his team (2002) tried to initiate shoot regeneration from shoot tip culture of some BT (Bangladesh Tea) clones as the initial work of BTRI. Recently Boonerjee and her team (2013) has developed the complete regeneration protocol for the rapid propagation of some clones of tea plant using shoot tip and nodal segment explants.

Strategies of Popularization of New Varieties and Technologies

Tea industry is notified regularly regarding the intensive research and knowledge of sustainable technologies. Technology transfer as well as popularization of new varieties are carried out with the help of advisory visits, research sub-committee meeting, yearly annual course, seminar, workshop, annual report, journal, circular, notification, letter, pamphlet, tea tasting session, email, website and electronic media.

Future Research Thrust

- Tea crop improvement as well as saving tea cultivation from adverse condition due to climate change by developing high yielding & quality, drought and disease-pest resistant variety through preliminary selection & long term yield and quality trial, breeding, biotechnology. For upgrading the present crop improvement a guideline for future is presented in Figure 5.

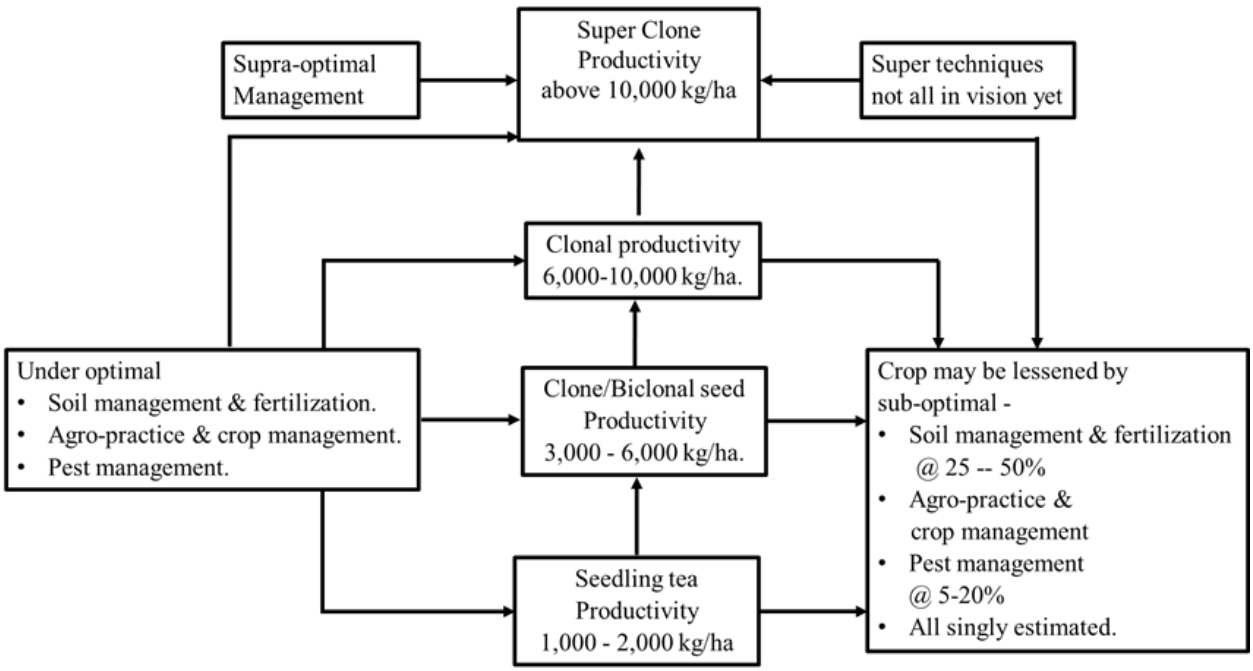

Figure 5. Proposed Crop Improvement Program for Higher Productivity of Tea in Bangladesh (Alam, 2002).

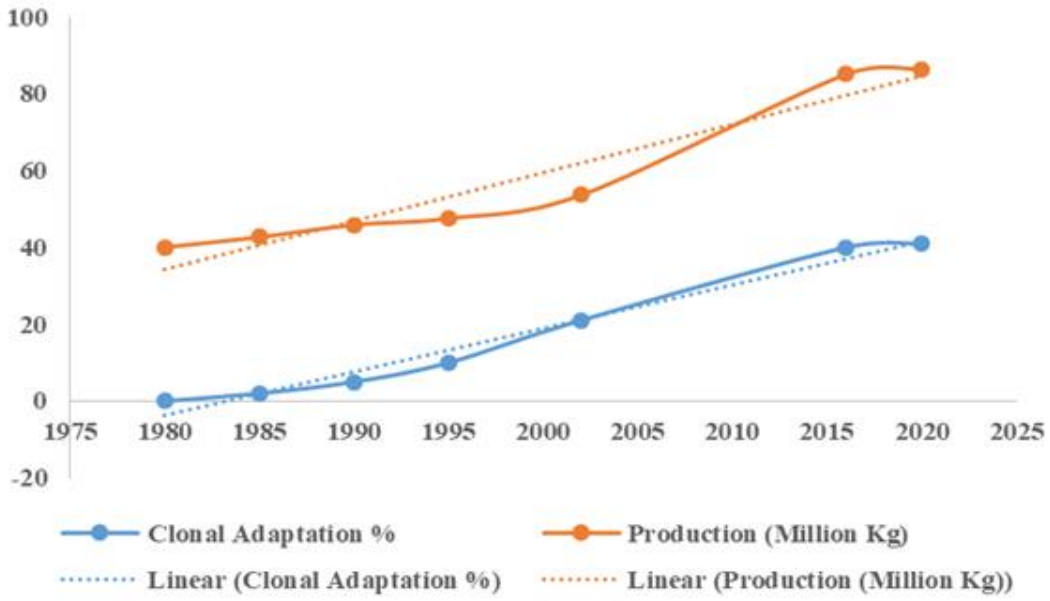

Figure 6. Increasing Rate of Clonal Adaptation and Tea Production of Bangladesh (1980-2020)

Table 7. Action plan for Developing/ Less Developed Tea Estates as well as Small Holding Tea

A. Action plan for Developing Tea Estates				
	2016-2025		2016-2030	
Plans	Activities	Result	Activities	Result
Infilling of tea vacant area by 165 lac saplings	Infilling of vacant area by 140 lac tea saplings to reduce tea vacancy 7.00%	Production will increase 3.2 million kg	Infilling of vacant area by total 140+25=165 lac tea saplings to reduce tea vacancy 5.00%	Production will increase 4.8 million kg
Replanting/ Block Infilling of total 10,000 ha	Replanting/ Block Infilling of total 8,274 ha	Production will increase 20 million kg	Replanting/ Block Infilling of total 8,274+1726=10,000 ha	Production will increase 20+10=30 million kg
Extension of Tea in new 5,868 ha area	Tea Extension in new 3,868 ha area	Production will increase 10 million kg	Tea Extension in total 3,868+2000=5,868 ha area	Production will increase 10+05=15 million kg
B. Action plan for Less Developed/ Sick Tea Estates				
	2016-2025		2016-2030	
Plans	Activities	Result	Activities	Result
Infilling of tea vacant area by 90 lac saplings	Infilling of vacant area by 70 lac tea saplings to reduce tea vacancy 7.00%	Production will increase 0.18 million kg	Infilling of vacant area by total 70+20=90 lac tea saplings to reduce tea vacancy 5.00%	Production will increase 2.7 million kg
Replanting/ Block Infilling of total 320 ha	Replanting/ Block Infilling of total 300 ha	Production will increase 0.30 million kg	Replanting/ Block Infilling of total 300+20=320 ha	Production will increase 0.30+0.02=0.32 million kg
Extension of Tea in new 1,000 ha area	Tea Extension in new 800 ha area	Production will increase 1.92 million kg	Tea Extension in total 800+200=1,000 ha area	Production will increase 1.92+0.48=2.40 million kg
C. Action plan for Small Holding Tea				
	2016-2025		2016-2030	
Plans	Activities	Result	Activities	Result
Extension of Tea in new 4,000 ha area	Tea Extension in new 3500 ha area	Production will increase 8.4 million kg	Tea Extension in total 3500+500=5,000 ha area	Production will increase 8.4+1.2=9.60 million kg

Role of Improved Planting Materials in Upgrading Tea Industry

Bangladesh tea has to give emphasis on its improved production and quality as well. Intensive plantation with elite clones and seed stocks is one of the options to achieve the goal of the tea industries of Bangladesh. But, due to unavailability of new land for extension planting, the existing tea plantation areas need to be enriched with high yield and quality clones. By vacancy infilling and new planting in uprooted old areas with improved clones can promote the tea production towards the desired goal along with the old tea estates economically viable. So the tea planters need to give emphasis on the improved cultivars as per the requirement of the industry (Palni et al., 1999).

Bangladesh Tea 1 (BT1) was the first vegetative clone of BTRI which was released in 1966. During liberation war at 1971, tea industry was at a great loss and production was drastically affected. After 1971, to increase productivity and quality of Bangladesh Tea, use of BTRI released clones was gradually increased. From the figure 6, it was observed that the clonal adaptation and tea production was increased from early 1980. In 1994, a study calculated that 90% of total tea area was occupied by seedlings and the rest was clones of which maximum were the garden clones with a little of introduced clones (Alam, 1994). In the later study of 2001, an improvement was noticed on clone plantation. In that study 58.72% of total tea area was examined of which 21.02% was absolute clonal with 3.6% bi and polyclonal seedling and rest were general seedlings (Alam 2002). From another study it is revealed that, the average seedling area is 54.34% whereas the clone area is 41.64% of the total tea plantation area (Boonerjee, 2016). An experiment was conducted recently by Statistics Division of BTRI, where the adoption percentages of both

BT and TV clones in the 144 tea estates of different valleys has been explored. From the experiment it was found that, about 41.64% land of total tea area of the 7 valleys is occupied by clonal plantation with the average production of 1607.48 kg/ha. The use of Bangladesh Clones and Indian TV Clones were 45.05% and 40.20% respectively (BTRI, 2020). It was observed from figure 6 that, there is a significant correlation between rate of clonal adaptation and tea production of Bangladesh. The Correlation Coefficient, r value is +0.98, explaining as a strong positive correlation.

Target of Development: Projection upto 2030

In the strategy of vision 2030 of Bangladesh Tea Board, a projection has been made to increase the total production upto hundred and forty million kg made tea by 2030 which will meet up the domestic consumption as well as re-start the export of our tea (Ahmed et al., 2015). To achieve the goal for the tea industries of Bangladesh, intensive plantation with improved clones and seed stocks is one of the best options. But, due to non-accessibility of new land for the extension of tea cultivation, the existing plantation areas need to be enriched with high yield and quality clones as well as with improved seed-stock. By vacancy infilling and new planting in uprooted old areas with improved clones as well as with improved seed-stock can promote the tea production towards the desired goal along with the old tea estates economically viable. In 2016, Bangladesh Tea Board has made an action plan 'Unnoyoner Pathonoksha: Bangladesh Cha Shilpo', to boost up tea production to 140 million kg by 2030 (BTB, 2016). Some strategy strategies for of this action plan is given in Table 7.

Conclusion

Tea is a long established plantation crop of enormous economic importance to Bangladesh meeting the entire domestic demand of this cheapest health beverage. Now it is one of the largest agro-based industries in the country. But currently, Bangladesh tea industry is now facing a lot of problems. Bangladesh tea has gradually virtually lost all the established global markets because of its domestic consumption as well as other factors. At present our country's tea own consumption is more than our production and hence, tea exporting country has been converted as tea importing country long back. To overcome this situation a comprehensive long term development plan for the sustainable tea industry in Bangladesh based on a rigorous, scientific and detailed research is strongly recommended. Along with the development plans, researches on tea varietal improvement is needed for higher productivity and better quality of tea to flourish tea business in Bangladesh.

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