American Journal of Plant Biology
2023; 8(4): 97-105
http://www.sciencepublishinggroup.com/j/ajpb
doi: 10.11648/j.ajpb.20230804.14
ISSN: 2578-8329 (Print); ISSN: 2578-8337 (Online)

Review Article

Status of Tea *[Camellia sinensis (L.) O. Kuntze]* Industry; Research Attainments, and Future Scenarios in Ethiopia: A Review

Mohammedsani Zakir*, Melaku Addisu, Desalegn Alemayehu, Dawit Merga, Lemi Beksisa

Department of Coffee and Tea Breeding and Genetics, Jimma Agricultural Research Center, Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia

Email address:
mohammedsani641@gmail.com (Mohammedsani Zakir)
*Corresponding author

To cite this article:
Mohammedsani Zakir, Melaku Addisu, Desalegn Alemayehu, Dawit Merga, Lemi Beksisa. (2023). Status of Tea *[Camellia sinensis (L.) O. Kuntze]* Industry; Research Attainments, and Future Scenarios in Ethiopia: A Review. *American Journal of Plant Biology*, *8*(4), 97-105. https://doi.org/10.11648/j.ajpb.20230804.14

Received: October 4, 2023; **Accepted**: November 8, 2023; **Published**: December 6, 2023

Abstract: Tea is one of the most popular cash crop and lowest cost beverages in the world, and consumed more than three billion cups daily worldwide. It is a new crop to Ethiopia which introduced in the early 19th century. The main objectives of government commencement to a tea industry were to be self-sufficient in domestic consumption and save the foreign exchange spent for importing, to supply for export market by increasing the production and quality through time and, to create employment opportunity particularly for youth and women who involved in the sector. Currently, fourteen tea clones are available in the country of which ten clones are extensively cultivated while the others are under maintenance for genetic improvement purposes. As future focus area of tea research at Jimma Agricultural Research Center, the improvement of tea yield, cup quality, and resistance to pests are among the prominent breeding programs. This could be achieved through the use of conventional and molecular techniques which are the best methods of obtaining genetic variation, and new varieties. From the research efforts made so far, the characterization of thirteen tea clones for desirable morphological traits and important biochemical parameters have been undertaken under contrasting environments, and potential tea clones that could be utilized in various breeding objectives have been determined. The future prospects of tea breeding and genetics include, genetic enhancement via developing open pollinated progeny and purposive crossing manually, and application of molecular marker assisted technique to effectively conduct early-stage appraisal. Generally, integrated classical with molecular breeding is highly recommended in the future tea research in order to cope up the current technology demand and generate climate smart varieties.

Keywords: Achievements, *Camellia sinensis*, Clone, Ethiopia, Research, Utilization

1. Introduction

Tea (*Camellia sinensis* L.) is perennial evergreen bushes crops which can be propagate by seed and vegetative parts. Tea center of origin is South East Asia; but due to its wide adaptability it is growing under diverse agro-ecologies throughout the world. After water, tea is believed to be the most widely consumed beverage in the world that has a very long, global history of production and consumption. Some degree of tea production is recorded in 62 countries today, although the top 10 countries account for about 93% of tea grown. Tea is now produced in 62 countries globally [1]. These include 18 countries in Africa, 22 in Asia, 2 in North America, 11 in South and Central America, and 9 in Europe and Eurasia [2].

Tea was first planted in East Africa in 1900 at Entebbe in Uganda. African tea-producing countries are located mostly around the tropical regions; from these, Kenya, Malawi, Rwanda, Tanzania and Uganda are major producers. Kenya is the number one producer in Africa and third in the world with a production of 570,000 tonnes in 2020 with a 50% increase over the last 10 years. With production below 7,000 tonnes in 2020, the six remaining tea producing countries are Ethiopia, Mozambique, Cameroon, Democratic Republic of Congo, South Africa and Mauritius [3].

Tea is one of the most important cash crops of many countries, including Ethiopia. Currently, tea is the most widely consumed stimulant beverage followed by coffee which accounts 46% of the world's beverage market [4]. It services as morning drink for nearly two-third of the world population. For stimulant purpose, the young shoots parts (leaves and leaf buds) of the tea plant are harvested and processed using various methods. It is consumed as white, yellow, green, oolong and black tea depending on the type of processing techniques [5].

Until very recently, the cultivation of tea in Ethiopia has been restricted to the expansion of large-scale private farms (Tea plantations of Gummaro, Wushwush, Chewaka and Verdanta Harvest). However, presently, the small-scale tea out-growers are rapidly growing-up in vicinities of the existing large tea plantations found in Southwest Ethiopia which is great opportunity to provide sufficient input for tea industry. Now, the government has established a new Coffee and Tea Development and Marketing Authority (CTDMA) to coordinate the overall interventions along value chains and to meet the GTP-II targets and beyond benefits from the two commodities. The ever-increasing tea domestic consumption and demand in global markets is another chance for tea growers for sustainable production and supply of highquality tea products. Likewise, continuous harvesting of tea leaves has vital role to supply raw materials to local factories and new integrated agro-industry parks and villages in the country.

Despite its economic significance and the favorable environmental conditions for the production of quality tea in Ethiopian, the improvement of tea production and productivity has been hindered by technology limitation and the direct adoption of all production packages from abroad mainly due to weak and infant tea research in the country. Accordingly, there is lack of technologies to boost production and productivity, scarcity of tea germplasm for further improvement, and availability of limited number of processing industry and raw materials with in the country. Therefore; this article was organized and prepared with the intension to identify and articulate research achievements, opportunities, challenges and the research outlook in Ethiopian tea industry.

2. Tea Industry in Ethiopia

Tea introduced in Ethiopia for the first time in 1927 by Father George Holland, is relatively a new crop having a recent venture of commercial production. The germinated seeds were planted near the Italian Catholic Mission station in Bonga, as well as in Dembidollo in the province of Wollega. At Gore area (Gumaro), about 15000 seeds were brought from Southern India through the communication of Father Holland and Kenyazmach Majid with British Counsell General. The experimental tea plot seed at Jimma Melko was received from Kenya, which was a mixture of Assam and Betjan types with a few other specimens [6].

The main government objectives to start-up the tea industry was to be self-sufficient in domestic consumption and save the foreign exchange spent for importing tea, to supply for export market by increasing the production and quality of tea through time and, to create employment opportunity for the citizens [7]. In Ethiopia, tea is produced by four private tea plantations viz. Wushwush and Gumaro (Ethio Agri-Ceft P.L.C), Chewaka (East Africa P.L.C) and Verdanta P.L.C in Southwestern, Oromia and Gambella regions of the country. Moreover, out-growers have produced and supplied green tea leaves to the three estates. Currently, the three estates hold a total area of 2660 ha and out-growers hold 437 ha for tea production. In the last five years (2011/12 to 2015/16), the three estates supplied a total of 4570.78 tons export and 34,126.1 tons of tea for domestic market. Tea industry in Ethiopia has provided income and employment opportunities to 575 out-growers, 7139 temporary per annum and 1157 permanent workers at tea estates [4].

3. Tea Research Achievements

3.1. Breeding and Genetics

In research efforts made so far, the characterization of thirteen tea clones for desirable morphological traits and important biochemical parameters have been undertaken under contrasting environments (Jimma and Gera) of which different groups of potential tea clones that could be utilized in various breeding objectives have been determined. The existing tea clones were clustered in to four groups based on their dissimilarity in morphological (Table 1) and biochemical (Table 2) traits.

Table 1. *Combined distribution of tea clones -based on D^2 analysis of morphological traits at Jimma and Gera.*

Cluster number	no of clones	percent(%)	Clones
1	5	38.46	31/11, L6, Mlk1, S-15/10 and BB-35
2	4	30.77	11/4, 11/56, Chai and B9
3	3	23.07	6/8, FNF and Mlk2
4	1	7.79	SR-18

Source: [8].

Cluster I exhibited the highest mean value for leaf size, leaf width, leaf length and shoot length. In addition, it showed medium score for the traits such as, mature leaf petiole length, internode length and hundred shoot weights. Cluster II differentiated by highest number of days from medium pruning to first harvest, height to first branch, mature leaf petiole length, and internode length. However, tea clones grouped under this cluster showed medium value for stem diameter, leaf length, leaf size, leaf ratio, shoot length and number of shoots. Cluster III characterized by highest values for stem diameter, number of shoots, canopy diameter and fresh tea leaf yield per tree. Finally, cluster IV identified by highest leaf serration density, leaf ratio and hundred shoot weights. On the other hand, the single clone categorized under, this cluster also identified by medium value for leaf width, canopy diameter and fresh tea leaf yield per plant (Table 1).

Generally the lowest values for each clusters were indicated as follow, cluster I for leaf serration density, leaf ratio, number of shoot and canopy diameter, whereas for cluster II for hundred shoot weight and fresh tea leaf yield per plant. However, the cluster III identified by lowest values for number of days from medium pruning to first harvest, leaf length, leaf width and leaf size, thus cluster III clones characterized by early generation from medium pruning. Finally cluster IV identified by lowest value for height to first branch, stem diameter, mature leaf petiole length, internode length and shoot length.

Table 2. *Combined distribution of tea clones -based on D^2 analysis of biochemical traits at Jimma and Gera.*

Cluster number	no. of clones	percent (%)	Clones
1	6	46.15	Chai, FNF, 31/11, 11/56, Mlk1, and SR-18
2	5	38.46	BB-35,6/8, L6, Mlk2 and S-15/10
3	1	7.69	11/4
4	1	7.69	B9

Source: Mohammedsani, 2019.

Cluster I exhibited the highest for photosynthetic efficiency. In addition, it showed medium score for the traits such as, chlorophyll content, total polyphenol, total anti-oxidant and beta-carotene and lowest in ascorbic acid. Cluster II differentiated by highest total polyphenol and ascorbic acid. However, tea clones grouped under this cluster showed medium value for chlorophyll content and photosynthetic efficiency. Cluster III characterized by highest fresh leaf moisture content and chlorophyll content but showed medium value for total polyphenol, total anti-oxidant, beta-carotene, ascorbic acid and photosynthetic efficiency. Finally, cluster IV identified by highest value of total anti-oxidant and beta-carotene. This cluster also identified by medium value for fresh leaf moisture content and ascorbic acid. Generally the lowest values for each clusters were indicated as follow, cluster I for ascorbic acid, whereas cluster II for fresh leaf moisture content, total anti-oxidant and beta-carotene. However, cluster III identified by almost high and medium values for the traits considered. Finally cluster IV differentiated by lowest value for chlorophyll content, total polyphenol and photosynthetic efficiency.

3.2. Tea Weed

A weed flora survey was conducted at Wushwush and Gumaro tea plantations in 2019 and 2020 cropping seasons, respectively. The surrounding out growers farms also surveyed around Wushwush tea plantation. A total of 31 different weed species in 13 families and 32 weed species in 13 families were identified for Wushwush and Gumaro, respectively (Table 3). At Wushwush the survey result revealed 19 broad leaf weeds (61.3%), 5 sedges (16.2%), 5 (16.2%), and 2 parasitic weed spices (6.5%).

Table 3. *Number of families and number of weed species within each family at Wushwush and the surrounding tea out growers.*

Family	Number of species	Percent species
Asteraceae	6	20.7
Poaceae	5	17.3
Cypereceae	5	13.8
Solanaceae	4	10.4
Amaranteceae	2	6.9
Commelinaceae	1	3.5
Polygonaceae	1	3.5
Convolulaceae	2	3.5
Apiaceae	1	3.5
Portulacaceae	1	3.5
Plantaginaceae	1	3.5
Malvaceae	1	3.5
Boraginaceae	1	3.5
Total	31	100.0

Source: [9].

Similarly, at Gumaro 32 weed species were identified in 13 families where the broad leaf weeds were 23, sedges 4 and grasses 5 accounting 71.9%, 12.5% and 15.6%, respectively (Table 4). Based on relative frequency, abundance and dominance values, the most prevalent and abundant weed species at Wushwush were *Ageratum conyzoides, Hydrocotyleamericana, Commelinabengahalensis, Galinsogaparviflora and Cyperuscyperiodes* with 24.5, 23.0, 16.5, 7.9 and 4.8 dominance value, respectively. Similarly, at Gummaro based on frequency, abundance and dominance values, the most prevalent and abundant weed species were *Hydrocotyle Americana, Ageratum conyzoides, Commelinabenghalensis and polygonumnepalense. S*imilarity index result was more than 71% suggesting that the tea weed flora composition at Wushwush and Gumaro was similar. [9].

Table 4. *Number of families and number of weed species within each family at Gummaro.*

Family	No. of weed spp.	% of number weeds
Acanthaceae	1	3.1
Poaceae	5	15.6
Cypereceae	4	12.5
Solanaceae	3	9.4
Amaranteceae	2	6.2

Family	No. of weed spp.	% of number weeds
Commelinaceae	2	6.2
Polygonaceae	2	6.2
Convolvulaceae	1	3.1
Araliaceae	1	3.1
Plantaginaceae	1	3.1
Aizoaceae	1	3.1
Asteraceae	8	25.0
Residaceae	1	3.1
Total	32	100.0

Source: [9].

3.3. Insect Pests

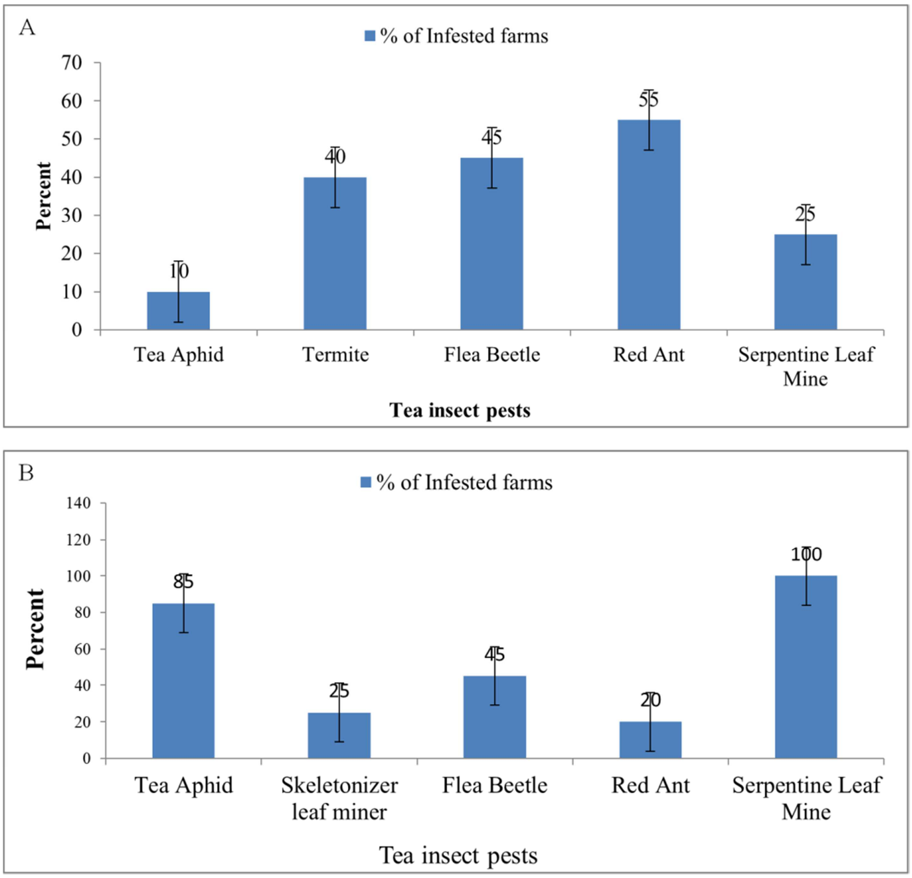
Different insect pests were observed feeding various plant parts of tea in field. Among them, tea aphid and termite were considered as major pests. The percent of farm infestation of by aphids was 85% at East Africa, 40% at Gumaro, 50% at Jimma research center. Tea aphid, termite, flea beetle, red ant, serpentine leaf miner, tea leaf skeletonizer, soft brown scale, orange scale, metallic leaf beetles, grasshoppers were among frequently recorded during the survey (Table 5).

***Table 5.** Lists of insect pests of tea, plant parts they damage and farms frequently recorded in SW Ethiopia.*

Common name	Order	Family	Scientific name	Plant part attached
Tea aphid	Homoptera	Aphididae	*Toxopteraaurantii* (Boyer de Fonsc.)	Leaf & bud
Termite	Isoptera	Termitidae	*Microtermesobesi,* Holmgren	Stem & root
Metallic leaf beetle	Coleopetra	Lagridae	*Lagriavillosa*Fabricius	Leaf eater
Red Ant	Hymenoptera	Formicidae	*Oecophylla*spp	Bud & leaf
Soft brown scale	Heteroptera	Coccidae	*Coccushesperidum* (L.)	Leaf & stem
Orange scale	Heteroptera	Diaspidae	*Chrysomphalusdictyospermi* (Morgan)	Leaf & stem
Tea grasshopper	Orthoptera	Acrididae	*Catantopsmelanostictus*Schaum	Leaf

Source: [10]

Tea aphids and termite, among others, were considered as the major insect pests of tea while the rests were of miner importance on the nature and type of damage and infestations. Flea beetle was infested higher percent at Wushwush and East Africa plantation (45%). Red ant recorded seriously at Wushwush (55%) and Gumaro and its surrounding tea farms (50%). On the other hand, about 25 and 100% of the assessed tea farms of East Africa and its surrounding were infested by the leaf miners (serpentine) where as 60 and 40% at Gumaro including its surrounding respectively (Figure 1A and B).



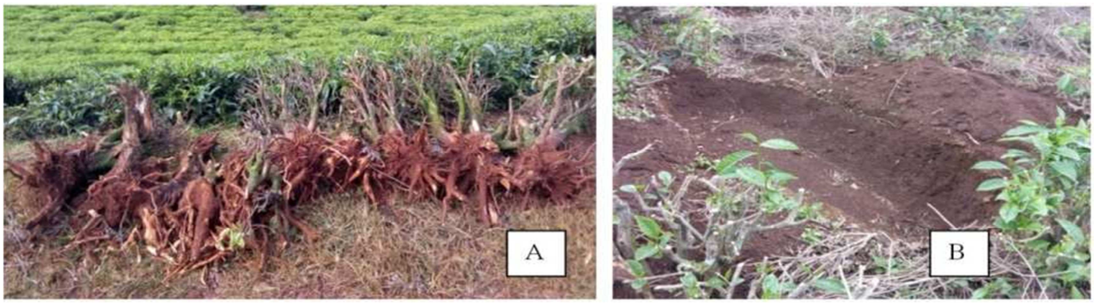
Source: [10]

***Figure 1.** Farm infested percent at Wushwush (A) and East Africa including their out-growers (B).*

3.4. Tea Diseases

Field surveys on tea diseases were carried out across three tea estate farms (Wushwush, Chewaka and Gumaro) and tea out growers surrounding them in Kafa, Sheka and Ilu Ababora zones in Southwest Ethiopia during the 2019 season. Causative pathogens of the diseases were identified using cultural and morphological features. The average Fusarium wilt incidence varied from (0 to 20%), Black rot (7-15%), Bird's eye spot (4-15%), Brown blight (2-5%) and Grey blight (0.5-5%) while mean disease severity of Black rot, Eye spot, Brown blight and Grey blight ranged from 4-11%, 3-9%, 1-5% and 0.5-5%, respectively (Table 6) [11].. Fusarium wilt, black rot disease and eye spot diseases of tea directly related to tea yield loss.

Fusarium wilt disease of tea caused by fusarium oxysporum occurred in almost all tea farms rotting the tea roots, while other diseases like brown blight, grey blight, bird's eye spot, thread blight (black rot) and algal leaf spot caused by *Colletotrichumcamelliae*, *Pestalotiopsistheae*, *Cercosporatheae*, *Corticium koleroga* and *Cephaleurosvirescens*, respectively attacked different parts of the coffee plant in the field [11, 12]. Fusarium wilt of tea was prevalent in southwest Ethiopia as evidenced from the tea bushes uprooted as infected by the disease (Figure 2A) and tea fields on which tea bushes infected by the disease were uprooted at the study areas (Figure 2 B).



Source: [11]

Figure 2. *A) Tea bushes Uprooted as infected by root rot disease at Gummaro tea plantation B) Tea field on which Tea bushes infected by root rot disease were uprooted at Wushwush tea plantation.*

During the field survey, it was observed that the big tea plantations and the out growers' gardens at Wushwush, Gumaro, and Chewaka areas were mostly affected by Fusarium wilt of tea disease which attacked about 19.75% of total tea bushes assessed. The disease was the primary disease of tea bushes at all tea-growing areas of Southwest Ethiopia, which causes death of healthy tissues or bushes even under the best conditions. Tea bushes of all ages were susceptible to this disease. The disease is most damaging if orchards are established in old tea plantations or newly cleared forest sites but not observed in tea gardens of out-growers previously planted with annual crops and appears to be related to the plantation's history.

Source: [11]

Figure 3. *A) Patches of tea bushes affected by Fusarium wilt of tea B) Turning of tea leaves to yellow and weakened tea bush C) Longitudinal cracking of tea stem at collar D) Creamy white mycelia on tea stem.*

Symptomological identification of fusarium that affected bushes occur in patches (Figure 3A), usually around old tree stumps, but sometimes isolated bushes are affected. Plants become weaker and their leaves begin to turn yellow and finally wilt and defoliate, eventually leading to death of the plant (Figure 3B). Longitudinal cracks were usually present on the collar above the soil level but also on the tap root and lateral roots (Figure 3C). Scrapping of the bark at the collar region revealed sheets of creamy white mycelia (Figure 3D) and the wood had a strong mushroom like-smell.

The pathogenicity tests for the Fusarium wilt causing pathogen isolates were performed under greenhouse condition at Jimma Agricultural Research Center. Pure cultures of each fungal isolates growing on PDA medium were used as inoculum. Plates were incubated for 10-15 days at 22-25°C. Inoculum suspensions were prepared by mixing the contents of six agar plates (9cm diameter) with 600 ml of sterile distilled water in a blender for 3 minutes at high speed. Plant material for pathogenicity tests were obtained from Wushwush nursery. Young rooted cuttings (6 months old, clones BB-35, 1156, 6-8 and 11-4) were inoculated as follows: roots were carefully cleaned under tap water and submerged for five minutes into the inoculum suspension. Then, they were transplanted in plastic pots (12 cm diameter x 9 cm high, one plant per pot) containing 600 ml of previously autoclaved soil (Top soil:sub-soil, 3:1) plus 50 ml of inoculum. Five inoculated plants per fungal isolate plus five control ones were placed in the greenhouse (10-30°C, 40-95% RH) and watered twice a week. Severity of aerial symptoms was periodically assessed for each plant on a 0-4 scale, according to the percentage of foliage with yellowing or necrosis: (0 = 0%, 1 = 1-33%, 2 = 34-66%, 3 = 67-100%, 4 = dead plant). At the end of each experiment (after three months), root rot was assessed by using 0-4 scale.

Table 6. *Tea diseases identified and their intensity in Southwestern Ethiopia.*

Location (Farm Name)	Farm Type	Disease type by intensity								
		Root rot	Black rot (%)		Brown blight (%)		Grey blight (%)		Bird's eye spot (%)	
			Incidence	Severity	Incidence	Severity	Incidence	Severity	Incidence	Severity
Wushwush	Big Plantation	19.33	11.77	8.20	1.51	0.90	0.78	0.49	10.00	6.00
Wushwush	Out growers garden	20.17	15.28	10.87	3.84	2.73	5.36	3.91	7.00	5.50
Chewaka	Big Plantation	16.67	7.00	4.23	2.10	1.50	4.85	3.87	8.70	5.97
Chewaka	Out growers garden	17.33	8.97	5.77	6.53	4.92	2.82	2.07	4.08	2.68
Gumaro	Big Plantation	9.67	8.00	6.00	2.77	1.88	0.48	0.38	15.18	8.82
Gumaro	Out growers garden	0.00	12.27	8.54	2.05	1.28	2.92	1.90	8.30	6.75

Source: [11].

4. Socio-Economics of Tea

The socio-economic team has conducted survey with the objectives; to assess production and marketing constraints that limit out growers from improving tea production, productivity and supply, to identify opportunities that out growers benefited from tea production and marketing and suggest feasible and practicable research intervention options that are believed to address tea out-growers major constraints of out-growers in tea production, productivity and quality were prioritized using Relative Severity Index (RSI) approach. Accordingly, the major constraints were high price of fertilizer and labor especially for plucking as well as inputs were not timely supplied to out growers. These in turn result in high cost of production to produce tea. As the crop need intensive management, out-growers unable to supply the required inputs to produce optimal level of outputs and keep quality of green leaves supply. This was due to lack of capital and limited resources with the rise of living. Moreover, prolonged dry season or drought, high weed infestation and lack of government extension services were the main constraints in tea production. Tea out growers have opportunities in generating continuous year round cash income, low risk of theft and wild animal damage and generate high cash income related to annual crops. Moreover, it created job opportunities for rural community which reduced migration of rural to urban to seek job (Table 7). Out-growers considered the crop as insurance as they become older and as asset which can be inherited to family in next generation [13].

Table 7. *Major constraints related to Inputs in the study areas.*

Variables	Scale				Total weighted scale	Relative Severity Index (RSI)	Rank
	Constraint (weight=5)		Not constraint (weight=1)				
	Freq	Weighted scale	Freq	Weighted scale			
price of fertilizer not known	20	100	100	100	200	0.32	4
High price of input	51	255	69	69	324	0.54	1
Timely availability of inputs	24	120	96	96	216	0.36	2
Shortage of inputs	20	100	100	100	200	0.33	3
Road access to transport inputs	7	35	113	113	148	0.25	5

Source: [13].

Out growers plucked tea leaves for 9 months per year. They plucked on average for nearly 6 months in main season and 3 months in dry season. In main season, high yield, short frequency of plucking and plucked mainly export standard. Farm gate price of green leaves was 5 ETB/kg for export standard and 3.5 ETB/kg for local standard. The cost of plucking green leaves was ETB 1.50 for export standard and ETB 1.0 for local standard during 2019/20 (Table 8).

Tea plot management is a very tedious and labor intensive than any other crop. If farmers ignore their tea plots, they totally lose income. It requires timely plot management such as weeding, pruning/stumping (every 4 years), plucking (year round). Family labor lack skill and cannot cover plucking on time. Therefore, most of them use hired labor particularly for plucking. However, they are unable to hire labor due to lack of capital. As a result, they did not produce in required quantity and quality.

Table 8. *Constraints identified during the survey.*

Constraint related to production	Constraint (weight=5)		Not constraint (weight=1)		Total weighted scale	Relative Severity Index (RSI)	Rank
	Freq	Weighted scale	Freq	Weighted scale			
High cost of production	30	150	90	90	240	0.40	2
Drought	23	115	97	97	212	0.35	4
Lack of capital	25	125	95	95	220	0.37	3
Need high labor and capital	32	160	88	88	248	0.41	1
Weed	11	55	109	109	164	0.27	5
Erosion	7	35	113	113	148	0.25	6
Termite	7	35	113	113	148	0.25	6

Source: [13].

The major constraints were high price of fertilizer and labor especially for plucking as well as inputs were not timely supplied to out growers. These in turn result in high cost of production to produce tea. As the crop need intensive management, out-growers unable to supply the required inputs to produce optimal level of outputs and keep quality of green leaves supply. This was due to lack of capital and limited resources with the rise of living.

5. Opportunities of Tea Industries and Research

Favorable agro-ecologies and potential lands for tea production in the country, enabling policy environments to support private companies and out-growers in tea development, establishment of ECTDMA to effectively coordinate coffee and tea sub-sectors, existence of experienced tea development PLC, government plan to establish integrated agro-industrial parks, availability of several research and training institutes in tea growing areas, establishment of Agricultural Development Partners Liasory Council at all levels, availability of introduced research technologies in tea, experience on interdisciplinary research approach in other crops (coffee), increasing interest by smallholders and large scale to expand tea plantation at open fields, keen interests of tea estates and farmers for future collaborative research works. Availability of internationally high genetic diversity resources of tea is another opportunity for tea business. High demand for improved varieties mainly due to the growing emergence of tea out-growers and expansion of commercial plantations, continual need of breeding for adverse biotic and abiotic factors such as climate change adaptation, resistance to emerging diseases and pests. Availability of introduced agronomic recommendations at the tea estates, availability of some laboratory facilities, and trained researchers and newly designed research activities to conduct physiological studies in tea production are the existing reality in tea research. The other chance is experience on application of crop modeling tools to predict scenarios and support climate-smart approach on other commodities. Experience on use of mineral fertilizers and construction of fertilizer factories in tea growing belt, government plan to develop soil-analysis for suitability mapping, awareness on management of natural resources foster tea industry in the country. Also, a very good collaborations and synergies created among different stakeholders on crop protection experiences, encouraging policy on crop protection and minimizing the use of agro-chemical are momentous in boosting Tea production without quality adulteration and expanding the industry. The growing interest of out-growers and cooperatives, increased export and local consumption demands and increased possibilities of product diversification such as green tea, black tea, spiced tea, and orthodox tea provide tea production expansion. Year round harvesting and continuous income source, minimum price fluctuations at farm gate relative to other crops and its role in providing employment opportunity attracts investors, small stakeholders and government attentions. Established out-growers association around tea factories and existence of Agricultural Development Partners Linkage Advisory Council (ADPLAC) are significant factors the sustainability of tea industry in Ethiopia. Also, Ethiopian high land tea considered consideration as one of the best East African teas that could fetch premium prices in the world market [7] and the availability of plenty labor forces in the country [4] give opportunity for tea business expansion in the country.

6. Challenges of Tea Research

Multitude of problems have been posing sever threat to tea production and industry development; these are, less attention to the tea sub-sector, lack of land use planning, limitation of well-developed capacity and inadequacy of linkages among stakeholders and availability of conflict of interest. The problem of low yield, which is mainly emanate from lack of technology recommendations suiting to Ethiopian condition and the use of adopted research technologies from other countries particularly from Kenya are among the challenges. Limitation of tea genetic resources for further improvement; thus, less than 15 tea clones from introductions made so far [4].

6.1. Mini-Manufacture

Mini-manufacture which is limited by the age of the bushes when adequate leaf can be harvested and number of cultivars that can be mini-manufactured and tasted by expert tea tasters per season. There are also high electricity costs involved. Being a final confirmatory quality assessment, only short-listed potentially high quality selections should undergo this test. This can only be achieved when rapid, inexpensive screening methods are in place to eliminate poor quality genotypes in the early stages of selection (Zakir, 2017).

6.2. Cost of Biochemical Assessment, Tools and Luck of Qualified Tea Cuppers

The current biochemical methods are expensive due to the need for special equipment and expertise. The limited funding to most research organizations makes it impossible to analyze all samples going through breeding and selection process. For example, the fresh leaf catechins can be measured in a single two and a bud shoot, but cost about USD 101 per sample. The flavognost costs only about USD 8 per sample but can only be done after mini-manufacture that costs USD 50 per sample, plus 50g fresh shoots costing another USD 10, for a total cost of USD 68. The catechin test is quite attractive due to the possibility of doing this test early in the selection process. There was not trained tea cupper to indicate taste quality of the tea germplasm to just screen the materials from the plot based.

6.3. Climate Change

The impacts of climate change on tea production are the following: drying of the soils causing reduced water content in the tea, decreasing yields and negative impacts on quality; become opportunistic for appearance of new pests and diseases; changes the suitability of existing tea growing areas; sun scorch damage decreasing yields and lowering tea quality; reduced resilience of tea crops; uncertainty with application of fertilizers, high application of pesticides in some countries; increase in extreme weather events such as droughts, hail storms, floods, frosts, extreme rainfall and landslides [14, 15].

7. Future Strategy or Prospects of Tea Research

7.1. Breeding and Genetics

7.1.1. Enhancing Genetic Tea Resource

In addition to introducing from abroad, tea genetic enhancement is possible by control hybridization and open pollination. Breeding for yield and green/black tea quality, breeding for pest resistance/tolerance, breeding for environmental/a biotic stresses, breeding for high levels of biochemical traits and molecular characterization are points that need attention and priority solution. The genetic characteristics of the tea plant are still poorly understood and it causes significant negative effects to tea breeding. Thereby, the well skilled experts in techniques and approaches of modern molecular biology should be employed to enhance the genetic of important agronomic traits, quality, metabolism and stress resistance. This helps to develop conversional and modern tea breeding guide lines which encourage Tea genetic improvement and generating improved technologies.

7.1.2. Molecular Marker Assisted Technique

Informative DNA markers are used to construct high density genetic linkage map, to locate the quantitative trait locus (QTL) of important agronomic traits, quality and resistance, showing bright prospects in tea breeding via marker assisted selection particularly for early-stage appraisal.

7.2. Improved Tea Agronomic Practices

Improved tea agronomic practices like spacing, fertilizer rates, time of fertilizer application, time of hard pruning, harvesting methods, intercropping of tea with legume at early growth should be conducted to enhance the tea yield.

7.3. Post-Harvest and Quality Management Practices

Describing the benefit and drawback of each tea processing methods, establishment of tea cupping laboratory and training the cuppers, analysis of total polyphenol, total catechins, total antocyanins, theanine, theaflavins fraction, antioxidants activities in Ethiopian tea and screening the genotype for tea seed oil.

7.4. Developing Management Practices of Tea Pests

Management of diseases, insect and weed for proper tea production and providing the quality tea for export and fetch good foreign exchange. This can be through, diagnosis of diseases in plant materials; identifications of pests' problem in tea plant materials, conducting research on host-plant resistance, on different pests (mites, mosquito bug), production of fungi antagonistic to armillaria species responsible to a root rot disease of tea and evaluation of pesticides for their efficacy before their use in the whole field.

7.5. Socio-Economics

Assessment of clients needs technology innovation, evaluation of technologies, packaging of technology and dissemination process provision of feedbacks between clients, contribution to development of policies for a sustainable and profitable tea production and industry.

8. Summary and Conclusion

Tea is one of the most popular and lowest cost beverages in the world, and consumed by a wide range of age groups in all levels of society with more than three billion cups daily worldwide. Tea out growers in Ethiopia have opportunities in generating continuous year round cash income, low risk of theft and wild animal damage and generate high cash income related to annual crops. Moreover, it created job opportunities for rural community. The principal problem of low yield emanates from lack of technology recommendations that suiting to Ethiopian condition. In order to develop promising cultivars, breeding strategies, which combine high yield, good cup quality and resistance to biotic and a biotic stresses need to be implemented to boost productivity and to reduce the cost of production. The challenges like mini-manufacture, cost assessment, climate change, insect pest, weed and diseases, labor, soil erosion and tea picking machine are mainly affecting tea industry including in Ethiopia. In the future, the tea research must emphasize on tea genetics and breeding such as genetic enhancement for further breeding purposes, and capacitating researchers in molecular marker assisted technique to effectively conduct early-stage appraisal and similar procedures should be integrated in the future tea research in order to cope up with the currently existing environmental phenomena.

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] American Specialty Tea Alliance. 2018. List of tea producing countries in the world. http://specialtyteaalliance.org/world-of-tea/tea-producing-countries (accessed August 16, 2018).

[2] Paula Bramel and Liang Chen, 2019. A Global Strategy for the Conservation and Use of Tea Genetic Resources Technical Report; Pp 1-57.

[3] https://www.teaandcoffee.net/feature/29834/africas-contribution-to-global-tea-production-escalates/, 2020.

[4] EIAR, 2017. Ethiopian Institute of Agricultural Research, National Tea Commodity Research Strategy (2016–2030), January 2017.

[5] Sharma, V. K., A. Bhattacharya, A. Kumar, and H. K. Sharma, 2007. Health benefits of tea consumption. Trop. J. Pharm. Res., 6: 785-792.

[6] Coultas W. H. W, 1968. A Report on the Investigation and Possibility of Establishing A Tea Industry in Ethiopia; pp 1-96.

[7] Ministry of Coffee and Tea Development (MCTD), 2001. Ministry of Agriculture and Rural Development. Addis Ababa, Ethiopia.

[8] Mohammedsani Zakir, 2019. Morphological and Biochemical Characterization of Tea (Camellia sinensis (L.) O. Kuntze) Clones in Southwestern Ethiopia. A Thesis Submitted to the School of Graduate Studies Jimma University College of Agriculture and Veterinary Medicine Jimma University: 43-46 pp.

[9] Tigist Bidira, Tamiru Shimales, Melaku Adissu, Tadesse Eshetu, 2021. Weed Species Dominance and Abundance in Tea (Camellia sinensis L.) Plantation of Southwest Ethiopia. American Journal of Plant Biology. 6 (4): 89-94.

[10] Sisay Kidanu, Wakjira Getachew, Tamiru Shimelis, Mohammedsani Zakir, 2020. Survey of Tea (Camellia Sinensis L.) Insect Pests in Southwest Ethiopia. ”International Journal of Research Studies in Agricultural Sciences (IJRSAS) 6(10): 23-29.

[11] Nagassa Dechassa, Gabissa Gidissa, Legese Hagos, Mohammedsani Zakir, Lemi Beksisa, Melaku Adisu, 2020. Survey of Tea (Camellia sinensis) Diseases in Southwestern Ethiopia; American Journal of BioScience; 8(6): 139-149.

[12] Otieno W., 1997. Epidemiology and management of hypoxylon wood rot of tea. Tea. 18: 175-83.

[13] Beza Erko Erge, Melaku Addisu Bifa, Megdelawit Temesgen, Efrem Asfaw, Rehima Musema, 2021. Assessment of Constraints and Opportunities of Tea Out-Growers in SouthWest Ethiopia International Journal of Agricultural Economics; 6(4): 151-161.

[14] Mohammedsani Zakir, 2017. Review on Tea (Camellia sinensis) Research Achievements, Challenges and Future Prospective Including Ethiopian Status; International Journal of Forestry and Horticulture (IJFH): 3(4): 27-39.

[15] MCCTS, 2014. Mitigating Climate Change in Tea Sector, International Trade Centre 2014.