Camellia Sinensis - Tea

Monograph - Agricultural Sciences

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Chapter 1: Introduction:

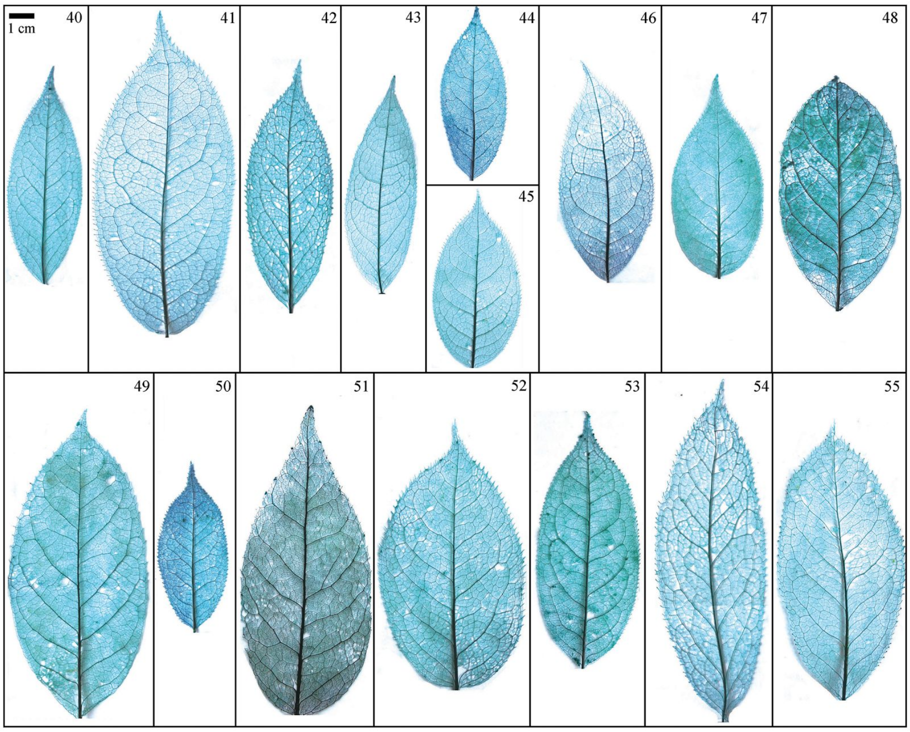
Tea is probably of the most popular beverages in the world and is consumed by millions of people every day. In continents like Asia, and in different cultures around the world, tea plays a vital role in the everyday lives of people who not only see it as a normal beverage but as a social mechanism to integrate their culture. Tea not only has become a worldwide known beverage, but a symbol of different cultures around the globe. It is very important to consider everything that is behind tea and tea production, referring to the factors that build *C.Sinensis* and how this crop impacts the world. In this monograph, readers can find detailed and complete research about *C.Sinensis*, and addresses its ecology, biology, propagation and management, as well as its emerging products and markets. In the ecology chapter, readers can find details not only about the crop's distribution, but it's affinities, origin, fossil record, environmental factor, etc. The biology chapter relates directly to the crop's chromosome complement, as well as its life cycle, the process of flowering and fruiting, and its reproductive biology. The chapter for the crop's propagation and management is when it directly starts talking about how it is that the crop can grow properly and what is needed for a tea harvest to succeed. In this chapter, topics will be directly related to planting of the crop, management of the crop, propagation of the crop, and finally its different pests and diseases. The fifth and final chapter of this monograph will directly relate to the emerging products and potential markets of the crop. In this chapter, topics will relate directly to the crop and how it creates sustainable economic markets. The main focus of this chapter is to discuss how multiple products can rise from *C.Sinensis*, products such as beverages, but also its medicinal usage. This monograph has the purpose to show readers that the C.Sinensis is of great importance not only because of its unique biological factors, but also because it is a crop with multiple accesses to economic markets all around the world. Tea is a beverage with many aspects behind it, that constantly remain without consideration. This monograph shows research that will enable readers to understand the relevance as a crop, as a beverage, and as a biological species.

Chapter 2: Ecology

2.1: Distribution:

2.1.1: Affinities:

Image 1: Shows the different leaves for different species of the Camellia genus.



Camellia sinensis is a species of plant, or shrub, that is responsible for the production of tea. The different types of this species help produce different types of tea, and the types of camellia sinensis are: *Camellia Sinensis Sinensis, Camellia Sinensis Assamica, and Camellia Sinensis Cambodiensis.*

The tea plant is part of the genus Camellia, which is a type of genus that has been classified into multiple different species. In a synthesis of research, Lu, Jiang, Ghiassi, Lee, & Nitin (2012), said that in 1958, the Camellia was divided into 82 different species, which were classified into 12 different sections. After this, other botanists decided to group the Camellia into four different types with 22 sections and 260 species. While other people classified Camellia into two subgenera, with 14 sections and 119 species. This created controversy and disagreement regarding the interspecies relationship of this specific genus. These classifications where made under a morphological approach, meaning that they were made considering the shapes of the leaves of the plant. Studies suggested that classifying plants by using a morphological approach was completely insufficient, which meant that botanists had to develop alternative taxonomic methods in order to correctly classify Camellia. Scientists used a leaf venation pattern to help identify the different species of Camellia plants, which means that the vein patterns in the leaves of Camellia species where of supreme importance in order to establish the variation of the species. After a research investigation, Wachira, Wayne, & Waugh (1997), expressed that 'Members of the genus Camellia interbreed relatively freely and several natural species hybrids exist'. Wachira *et al,* concluded that there is a constant introgression of the genes into the *Camellia Sinensis* species. This means that there was movement of genes into the genepool of another species, this being the *Camellia Sinensis.* Therefore, it is believed that currently the tea that is being cultivated using the *Camellia sinensis* is not the archetypal species that has always been cultivated.

Taxonomy:

- **Kingdom:** Plantae
- **Phylum:** Tracheophyta
- **Class:** Dicotyledonae
- **Order:** Theales
- **Family:** Theaceae
- **Genus:** *Camellia*
- **Species:** *C. Sinensis*

2.1.2: Fossil Record:

Although *camellia sinensis* is somewhat of a particularly new species, its genus *Camellia*, dates back even to the Oligocene period and has an extensive fossil record. After examining the results of their research, Huang, Jin, Quan, & Oskolski (2016), concluded that a member of the *Camellia* genus, called Camellia *Nanningensis*, was discovered in the "basis of well-preserved mummified wood from the upper Oligocene Yongning Formation of Nanning Basin in Guangxi Province, South China."(Huang *et al,* 2016). These botanists found that these wood was the most ancient related fossil to the *Camellia* genus. Showing that the *Camellia* genus present in the world as early as during the late Oligocene period, which dates back to almost 23 million years ago, a fact that suggests a more ancient presence of this genus than the one estimated by molecular dating. Although, other botanists' findings concluded that the earliest fossil records of *Camellia* are directed to the leaves of *C. Avensis* from Japan, or to the *C. abchasica* from Bulgaria.

2.1.3: Origin:

Probably due to its topographic and geographic characteristics, C. Sinensis is known to have originated from the Yunnan region of China. This is a region that is known for its vast amount of forests, which are of the likeliness of the Camellia sinensis shrub for it to grow and reproduce correctly (Goodwin 2018). After a vast amount of research, Duke (1983) indicated that Camellia Sinensis is native to the Southwestern region of Asia, more precisely the southern region of China (Figure 2), but is also very common in the Assam region (Figure 3) of northern India and Sri Lanka, where the climate conditions are perfect for the growth and distribution of this species. Of course, *Camellia Sinensis* is known for the plant responsible for the production of tea. It is precisely in this region of the world where the popular beverage originated back in 2737 BC, when supposedly the mythical emperor Shennong accidentally mixed some leaves of Camellia Sinensis with the water that he was drinking and created tea.

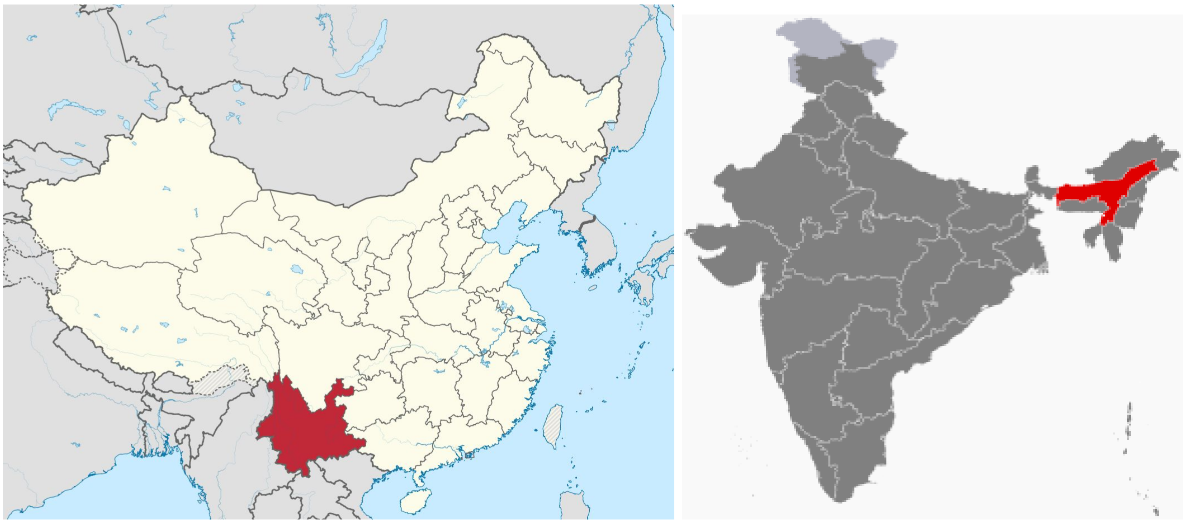


Image 2 & 3: Figure 2 (left) shows the Yunnan region of China and figure 3 (right) shows the Assam region of India, both are places that originated the C. Sinensis species

2.1.4: Present Distribution:

The authors from the 'Plants For a Future' (2005) journal expresses that C. Sinensis is a species that is most likely to grow in subtropical areas such as this region of Asia. The species has been also introduced into multiple regions around the world, where the climate conditions are completely suitable for the C. Sinensis to develop correctly. This places where it has been introduced include: Argentina, Bangladesh, Cambodia, Japan, Korea, Mauritius, Réunion, Seychelles, Tibet, etc. The common factor that unites all these places are the climate conditions that are suitable for the Camellia Sinensis to grow correctly, under the proper cultivation and appropriate harvesting. ('Plants For a Future'. 2005). After completing the recollection of data, Jegede (2019) expresses that currently China is the largest C.Sinensis producer in the world and is also the main tea exporter in the world right now. China currently produces 1,000,130 tonnes of tea per year. "In fact, approximately 80% of the green exported in the world, is from China only." (Jegede 2019).

Image 4: Shows the present distribution of the C. Sinensis producing countries around the world.

2.2: Environmental Factors in Distribution:

2.2.1: Elevation:

According to 'Plants For a Future', the elevation can vary on the different growth patterns of the C. Sinensis, meaning that it is an important factor but it is not something that has to be very specific in order for the plant to grow correctly. Camellia Sinensis is known for its native growth in the Yunnan region of China, which has an elevation that variates from 2100 to 2700 meters (Plants For a Future 2005). After a synthesis of research, the Kew Royal Botanic Gardens through their 'Plants of the World *Online'* platform express that in other subtropical regions where C.Sinensis has been introduced such as Sri Lanka, tea is grown in different altitudes in order to develop tea with different characteristics. These can variate from tea that is cultivated at an altitude of 1800 m, to some other tea that can be cultivated at an altitude of 600 m (Kew n.d.). The Tamil Nadu Agricultural University, which is sponsored by the Tea Board of India, also recognizes that "the performance of C.Sinensis is always going to be excellent at elevations ranging from 1000 - 2500 m." (Tea Board of India, 2014.)

2.2.2: Climate

After a synthesis of research, Duke (1983.) expresses that due to the subtropical climate ranging from warm temperature dry to wet, and vary between dry and moist forest life zones, tea can tolerate different climates in order for it to grow correctly. C. Sinensis plants can also tolerate “annual precipitation of 7 to 31 cm, annual temperature of 14 to 27°C...” (Duke 1983). Although being an evergreen plant (maintains a green color through the whole year), C.Sinensis cannot tolerate frosting climate and nor can it tolerate temperatures above 30°C. The Tamil Nadu Agricultural University, sponsored by the Tea Board of India, also states that the “Optimum temperature: 20 - 27 C.” (Tea Board of India, 2014.) This except some types of Chinese tea that can tolerate cooler temperatures. It is important for the plant to receive an annual rainfall of 120 cm or more and months with less than 5 cm of rainfall are completely intolerable, therefore, it must reside in humid climates.

2.2.3: Geology and Soils:

Tea can grow properly in multiple types of soils, but the best soil for C.Sinensis to grow correctly is a “light; friable loam with porous sub-soil which permits a free percolation of water” (Chand 2014.). This is mostly due to tea not tolerating stagnant water, or water that does not flow correctly. Soils are mostly acidic, with a pH that can variate from 4.6 but are mostly standing near a pH of 7.3, and without any calcium. Chand (n.d.) conveys that it is important to have iron in the sub-soil, and that in sloping land tea faces a problem of soil erosion that is often battled by planting the tea in the borders of the sloping area. The Tamil Nadu Agricultural University, sponsored by the Tea Board of India, also recognizes that tea needs a high amount of organic matter and supports the idea that tea needs a minimum of a 4.5 pH but must have a maximum of 5.5 pH in order to grow correctly. (Tea Board of India, 2014.)

2.3: Vegetation Component

Tea plantations are not usually intercropped with other species in order to help improve tea growth, mainly because *C.Sinensis* is a plant that usually grows without the need of intercropping. Nevertheless, multiple scientists have conducted experiments in order to determine which crops are more suitable for intercropping in tea plantations. According to Baruah *et al,* one of the most recognized experiments was conducted between 2000 - 2001 in order to find satisfactory vegetable crops for intercropping in young tea during developmental years for effective farm return. "The analysis of Tea Equivalent Yield (TEY) of different crop combinations indicated that the combination of Tomato (*rabi*) and Cucumber (*kharif*) produced the highest yield followed by French bean (*rabi*) and Cowpea (*kharif*) crop combination." (Baruah *et al.* 2005).

Tea has also been used in other experiments with other plantations as a subject of research to determine if it is suitable for intercropping. For example, tea was used in an experiment in Xishuangbanna, China, where it was used as a promising agroforestry system in order to test whether intercropping could improve the water use and weather tolerance of the rubber trees in South East Asia (Wu *et al*. 2016). The experiment used three different agroforestry systems (coffee, cocoa, and tea), but the most efficient was tea in water use terms, because "the interspecific competition for water was moderate and the agroforestry system retained much more soil water and improved the water use efficiency of the rubber tree." (Wu *et al.* 2016).

Chapter 3: Biology:

3.1: Chromosome Complement:

According to Furukawa *et al* (2018) the *C. Sinensis* is a perennial woody plant, which means that they have stems that do not die back every season but instead grow back with each passing season. After a synthesis of research, it was concluded that *C. Sinensis* has a "*chromosome number of 2n=30 and a 4-Gbp genome size"* In addition, a 1971 study lead by Ackerman concluded that the basic chromosome number for all *Camellia* plants is 15.

According to Furukawa *et al,* the chromosome morphology data of *C. Sinensis* was analyzed using CHIAS VI (Chromosome Image Analyzing System), and the results showed that the relative length of different types of *C. Sinensis* ranged from 2.34 to 4.46 (Furukawa *et al, 2018*) (Table 1, below). In addition, mostly the different types of *C. Sinensis* have similar karyotypes (Furukawa *et al*), which is the chromosome appearance and amount inside the cell.

Table 1: Shows the relative length of all 30 chromosomes of tea plant 'SAYAMAKAORI' (*Camellia sinensis* var. sinensis) (Furukawa *et al.* 2018)

Chromosome No.	Relative length[a)] (%)	Arm ratio[b)]		Chromosome type[d)]
		Mean	S.E.[c)]	
1	4.46	1.88	0.20	sm
2	4.19	1.62	0.18	m
3	4.13	1.62	0.20	m
4	3.97	1.57	0.22	m
5	3.94	2.34	0.41	sm
6	3.91	1.93	0.23	sm
7	3.86	2.26	0.34	sm
8	3.77	2.63	0.70	sm
9	3.67	2.17	0.36	sm
10	3.63	1.78	0.25	sm
11	3.55	2.57	0.41	sm
12	3.50	2.45	0.33	sm
13	3.41	1.89	0.40	sm
14	3.39	1.52	0.20	m
15	3.34	1.86	0.28	sm
16	3.27	1.95	0.33	sm
17	3.22	2.27	0.35	sm
18	3.17	2.26	0.42	sm
19	3.10	2.69	0.64	sm
20	3.07	1.81	0.25	sm
21	3.04	1.55	0.39	m
22	2.97	1.53	0.13	m
23	2.92	1.93	0.46	sm
24	2.85	2.19	0.44	sm
25	2.81	1.88	0.61	sm
26	2.72	1.54	0.23	m
27	2.69	1.59	0.12	m
28	2.59	1.49	0.25	m
29	2.51	1.13	0.02	m
30	2.34	1.11	0.04	m

a) Relative chromosome length is % of total chromosome
b) Long arm length / short arm length
c) Standard error
d) Levan *et al.* (1964)

3.2: Life Cycles and Phenology

Camellia sinensis experiences an alternation were the sporophyte - diploid - is characterized as the dominant stage in C. sinensis' life cycle and the gametophytes - haploid - are characterized as the minor stage. (Bell, 2009). After a synthesis of research, Bell goes on to affirm that through Meiosis, a sporophyte creates a gametophyte. Gametophytes use cross pollination in order to fuse and use wind or an insect as a pollinizer. Then the pollinizer will transport the pollen from one plant to another, which enables the creation of a fusion of gametophytes. When the gametophytes are fused together, a zygote, which is a diploid, is created and will use mitosis to grow in order to reach adulthood. (Bell, 2009)

Piyasundara *et al,* (2018) from the Tea Research Institute of Sri Lanka, concluded that there is an index in *C. Sinensis* that indicates that the periodicity, synchrony and intensity of reproductive phenophases (specific stage or phase in the annual life cycle of a plant) relate to the rainfall pattern pattern of the area.

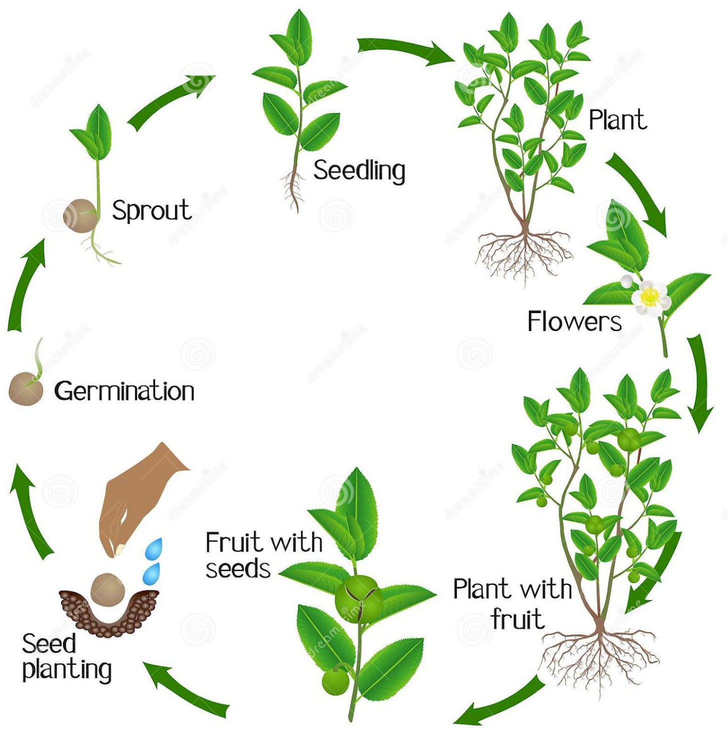


Image 5: Shows the life cycle of *C. Sinensis* - Retrieved from (Clipart of *Nadiia Havryliuk Kharzhevska,* 2019)

3.2.1: Seeding Protection

Succeeding his composition of research, Patel (2018) concluded that the "*tea seed is of spherical structure flattened slightly on the side of the hilum. Usually, it has one seed developed per locule. But sometimes two or more seeds may develop in the same locule. Seed developed from the same locule bear a flat or concave surface*." . In addition, Patel confirms that the seedling size depends directly on the size of the seed, which impulses the tea planters to maintain a standard seed size (Patel, 2018).

The seed development, more specifically the physiological process of the tea seeds can be divided into three main phases. The first phase of seed formation begins with pollination, which more specifically enables the emergence of the embryonic axis of the seed, the one directly related to the two embryos. The second phase of seed expansion initiates when both dry and fresh weight increase rapidly because of the building up of various reserve materials. The third phase of seed maturation begins when the accumulation of reserves slows down (Patel, 2018)

3.2.2: Flowering and Fruiting

According to the Tea Leaf Journal, *C. Sinensis* there is a difference between how the plant grows in the wild and how it grows in cultivation on tea plantations. The leaves "grow alternately, have serrated edges, taper to sharp points at their tips, and are otherwise smooth" (Tea Leaf Journal 2012-2015). In order to go more in depth about the leaves of *C. Sinensis*, Karen Stephenson concluded that leaves are oval in shape but alternate. Meaning that they can differ in their shape sometimes. "Most leaves tend to have a hairy underside and they usually grow to between 5 and 10 centimeters in length." (Stephenson 2011).

After a synthesis of research, Piyasundara *et al,* from the Tea Research Institute of Sri Lanka, concluded that the "Major flowering period was from September to December and the major fruiting period was from April to August." (Piyasundra *et al, 2018*).

3.3: Reproductive Biology

The growth of *C. Sinensis* is mainly donde though its own seeding. The tea growers are the ones in charge of making sure that tea seeds are correctly propagated. “The seeds germinate fairly quickly once sown in a warm, moist medium; however, they must be scarified before sowing to weaken their hull and ease sprouting.” (McMullen n.d). Germinating the seeds is a process that is done mainly done by the cultivators, because they must manipulate the conditions in order to grow the seeds correctly. Cultivators must keep the growing medium moderately moist, look for signs of germination, transplant the tea plant seedlings, and grow the tea plants under light shade during the seed cultivation process. (McMullen n.d).

Image 6: Shows the beginning of the germination process if tea seeds. Image taken by Ben Discoe

Chapter 4: Propagation & Management

4.1 Propagation

Tea plantations can either be propagated either through seeds or through cuttings. After examining the different processes of *C. Sinensis* propagation, Richards (2018) concludes that seed pods are produced the season following the tree blooming and take as long as two months to germinate. Once germinated, it takes another two to three years for the tea tree to be ready for harvest. The cuttings take a month or two to root, but the new tea tree will be ready for harvest in less time. (Richards, 2018)

The process of propagation through cuttings can be divided into different steps. The process begins by selecting healthy tea trees from which the cuttings will be removed, then using pruning shears to cut off the end of a branch of the tree. Cuts are made immediately 2 inches below the node of the leaf approximately, and buds will look like a tiny nub in between the leaf and the stem. After the cuttings are made, a propagation tray must be filled with a mixture of perlite and potting soil. The tray must moisten and then allowed to drain. It is important to keep the area around the cutting humid, as well as placing the tray in a clear plastic bag and opening the bag daily to let fresh air go in. Then comes a process of heating up the tray, where the soil must remain moist but not soggy for the following 8 weeks. At the end of this period is when the roots start to form, but the cuttings must remain in the tray until new growth is visible. Then comes a period of placing the new plant outdoors in the shade for short periods each day. The outdoor time begins to extend until the plant resists a continuous 24 hour period outside. It is very important to keep the C. Sinensis watered well until it is correctly established. (Richards, 2018)

4.2 Planting

In order for the tea plants to grow healthy and correctly, there are certain factors to consider before doing the actual planting. First of all, the population density of the plants has to be very precise. Depending on the planting materials used, planters can plant a maximum of 16,000 plants per hectare if his frames are compact in the planting. Otherwise, if the planter is using spreading frames, then a population of 14,000 to 15,000 should be enough. Planters must make sure as well that the plant is between 35 and 40 cm above the ground before pruning. (Chandra, 2015)

Another important factor to consider when planting tea is spacing, and the minimum space required between trees is of 60 cm. It is recommended that the maximum space between the bushes is of 1 meter. (Chandra, 2015)

Table 2: Guideline on spacing and bush population per hectare (Chandra, 2015). Retrieved from *Myassamtea.com*

Spacing	**Calculated Plants/ha**
100 cm X 60 cm	16666
105 cm X 60 cm	15873
105 cm X 65 cm	14652
105 cm X 70 cm	13605
105 cm X 75 cm	12698
110 cm X 60 cm	15161
105 cm X 75 cm X 70 cm	15238
105 cm X 75 cm X 75 cm	14814
105 cm X 70 cm X 60 cm	17316
105 cm X 70 cm X 65 cm	16806
110 cm X 70 cm X 70 cm	15873
110cm X 75 cm X 70 cm	14815

110 cm X 70 cm X 65 cm	16326
110 cm X 70 cm X 60 cm	16806

4.3 Management

Tea harvesting is a long process and complex process that centered around collecting the leaves of the plant and then processing them to make the different products. The initial steps of harvesting the tea plants are mostly done by tea collectors. This is where the actual process of tea harvesting begins, when collectors pick the leaves that are ready for processing. Collectors know that tea leaves are ready when they are about 4 years old, because this is when the tea can be harvested without damaging the plant for at least 100 years. Tea growers around the world prefer to do the collection of leaves by hand, not only because machine harvesting can damage the leaves too much before processing, but also because hand-harvesting preserve the highest level of quality for special types of tea such as flush teas. (Hunter, 2014)

After a synthesis of research, Hunter (2014) expresses that “another consideration is which leaves and buds are picked off the plant during harvest. Older leaves have a stronger flavor, so some plantations focus only on getting the top two leaves and buds from each plant for fine flavored teas.” Evidently, collectors must be very careful in knowing which leaves are suitable for processing and which are not. Collectors must also be very sensitive and careful when tearing off the leaves because otherwise they can damage them. This is the reason why multiple tea growers, mainly in Asia but in other parts of the world as well, prefer women to do the job of collecting the leaves. (Hunter, 2014).

Once the leaves are collected and plants are plucked, then comes a process of spreading the leaves in a thin layer on a tray and leaving them to try in the sun. This process can be made every 7-15 days depending on the development of the leaves. For black tea, different processes are used to harvest considering that the harvesting should be done during

July or August when the temperatures are at their highest points, of course this is depending on the geographical location as well (Grant, 2018).

Tea growers must prune the shrubs as well in order to maintain the youth of the tea plant. It is important to prune the plant at the correct time so that the leaves will grow back correctly. After a synthesis of research, Spengler (2018) clarifies that “once the tea plant forms the desired 5-foot (1.5 m.) flat-topped shrub it’s time to start tea plant pruning again. In order to prune tea leaves, collectors just cut the bush back to between 2 to 4 feet (0.6–1.2 m.). This will rejuvenate the tea plant.”

Image 7: Shows a tea collector in Asia. Image retrieved from (Martin Roll, 2019)

4.3.1 Pests and Diseases

Almost as every other crop, *C. Sinensis* is vulnerable to different types of pests and diseases that affect not only affect its growth, but also its development and quality. These pests and diseases can variate depending on what they do to the plant, and how it is that they work. Tea diseases can be classified in two different ways: between diseases that affect the leaves or those that affect the roots directly.

After a synthesis of research, Lehmann (2000), confirms that one of the most common diseases that affect the tea leaves is called blister blight, which is caused by the exobasidium vexans pathogen. This disease, only caused by this pathogen, is well known for affecting almost every tea growing region in Asia. "Symptoms are known for being First, pale yellow translucent spots, then circular blisters on leaf underside. Then white velvety and later circular brown spot." (Lehman, 2000).

Another disease that is known for affecting tea is called red rust. This disease is caused by the Cephaleuros parasiticus pathogen and currently affects almost every tea growing region in the world. Symptoms of this disease include orange-brown velvety areas appearing on the leaves of the plant. (Lehman, 2000). Other recognized diseases that affect leaves of *C. Sinensis* is tea's pink disease. This disease, according to Lehman (2000), is "caused by the Corticium salmonicolor pathogen and its symptoms include a pink crust on twig and branches. The portion above the branches dies off and cause dieback." This disease is mainly present under humid conditions in tropical areas.

Another disease that currently affects many *C. Sinensis* cultivation is known as the thorny stem blight of tea. This disease is caused by the *Tunstallia Aculeata*, which is an ascomycete fungus that is a plant pathogen infecting tea. This disease is present at almost every tea growing area in India and symptoms include branches dying off, as well as fruiting bodies (perithecia) projecting from the bark of dead branches giving the plant a thorny appearance. (Lehman, 2000). Other diseases known for affecting the leaves of the plant *C.Sinensis* are: the black blight of tea, the grey blight of tea, the wood rot of tea, and the stem canker of tea. All of which are present in Asia as well as other tea growing regions around the world.

Table 3: Serious root diseases of tea. (Lehman, 2000). Table retrieved from *Reasearchgate.net*

Common name	Causal agent	Symptoms on tea
Red root rot	Ganoderma pseudo ferreum (Wakef.) van Over.	Wilt of the plant and dieback. Roots with white surface mycelium which later turns red, to which soil adheres. Rot pale brown and hard.
Brick-red root rot	Poria hypo lateritia Berk. (Basidiomycotina, Aphyllophorales, Polyporaceae).	Root surface white speckled with mycelial strands. These turn into a smooth sheet hardening into plates or ropes of red colour.
Black root rot	Rosellinia arcuata Petch; R. bunodes.	Rot of root and stem base, black wood discolouration. White mycelium on roots, later grey to black.
Charcoal stump rot, charcoal root, ustulina charcoal rot	Ustulina deusta (Hoffm.)	No surface mycelium. Under bark of roots white fan-like patches. Wood at base of stem with irregular double lines.
Diplodia root rot	Lasiodiplodia theobromae (Pat.)	Dieback. Root and stem-base rot. Blackened vascular system and black discolouration of wood. Large number of host plants
Armillaria root rot or root splitting disease	Armillariella mellea (Vahl:Fr.)	Sudden browning of leaves and root splitting.
White root rot	Rigidoporus lignosus (Klotzsch)	Dieback, white mycelium (rhizomorphs) on root. Roots rotten and white.
Brown root disease	Phellinus noxius (Corner)	Adherence of a crust of earth and gravel round the entire root. White or brown mycelium under the bark.
Rhizoctonia seedling blight	Rhizoctonia bataticola (Taub.)	Seedlings wilt and dieback. Soil inhabiting fungi

Chapter 5.0: Emerging Products and Markets

5.1 Emerging products and potential markets

5.1.2 Camellia Sinensis Products

Evidently, tea is the most famous product that comes from C.Sinensis, but the crop is present in many other products and in multiple types of markets. As a plant, the bush is not only present in cultivation areas, considering it is used constantly in gardens due to its fine appearance and scent. Apart from gardening and landscaping, *C.Sinensis* can also be found in many other products that boost the benefits of the plant in a more commercial way. The tea plant is used in multiple beauty products, including skin products that take advantage of the capacity that the plant has to benefit the human body. Considering that *C.Sinensis* is rich in antioxidants, several types of make-up and beauty products are manufactured with *C.Sinensis* because it is an even more potent anti-oxidant than artificially manufactured antioxidants. Skin products also contain *C.Sinensis* because it has a calming effect on the skin and its anti-inflammatory properties make it beneficial for treating skin conditions like rosacea and psoriasis. Also, products to treat acne include *C.Sinensis* because green tea can help to reduce acne. Natural extracts of green tea are used in some types of sunblocks as well. (Florishe, 2018)

Image 8: Tea-Infused skin care products. Image retrieved from *People.com*

5.1.3 Medicinal Uses

Drinking tea has multiple benefits, not just enjoying the refreshing taste of the beverage. Tea helps your body stay fresh by giving it more than enough fluids into the body every day. Tea has multiple antioxidants, which help the body maintain a young composure and protecting it from the damage caused by pollution. In terms of caffeine, tea contains less than half the caffeine that coffee has and this means that people can consume it repeatedly without it having negative effects on the nervous system. Studies have found that there is around twenty percent reduction of heart attack risk and a thirty five percent reduction of a stroke risk among the people that are habitual tea drinkers. Other studies have found that tea is very effective when it comes to strengthening people's bones. There is a specific type of tea called moringa tea that is known for having more calcium than milk, as well as iron, vitamin A and K. Finally, other research has found that tea can help the body's immune system by boosting up immune cells so that they can reach their targets quicker. It is important to consider that C.Sinensis contains the polyphenol epigallocatechin-3-gallate (EGCG). EGCG polyphenols are widely known for their anti-carcinogenic and antioxidant abilities. (Carroll, 2016)

5.2 Imports and Exports

Although the tea industry has grown substantially over the years, and is now an industry that deals with billions of dollars every year, there has been a downfall on the value of tea exports during the past years. Last year (2018), the total of tea exports by country totaled an estimate of around 7 billion dollars. This number represents a loss of 10.9% of the value of tea exports since 2014 when tea shipments were valued at $7.8 billion. (Workman, 2019).

After a synthesis of research, Workman (2019) concluded that "*Asian countries generated the highest dollar worth of exported tea during 2018 with shipments valued at $4.1 billion or close to three-fifths (58.8%) of the global total. In second place were African exporters at 21.9% while 15.1% of worldwide tea shipments originated from Europe.*" The smaller percentages of tea exporters came from the Americas, and the last percentages were the ones from the continent of Oceania with Australia and New Zealand. The countries listed on table 4 shipped 84.5% of global tea exports in 2018 by value.

Table 4: 15 countries that exported the highest dollar value worth of tea during 2018 (Workman, 2019)

Country	***Total Tea Exports***
China	US$1.8 billion (25.7% of total tea exports)
Kenya	$1.1 billion (16.2%)
India:	$763.2 million (11%)
Sri Lanka	$721.6 million (10.4%)
Germany	$252 million (3.6%)
Poland	$202.3 million (2.9%)
Japan	$142.2 million (2%)
United Kingdom	$140.7 million (2%)
United States	$124 million (1.8%)
Vietnam	$116.8 million (1.7%)
Taiwan	$111.9 million (1.6%)
Indonesia	$108.4 million (1.6%)
Russia	$97.9 million (1.4%)
Argentina	$94 million (1.4%)
Netherlands	$93.5 million (1.3%)

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