Tea (*Camellia sinensis*) Production for Western Washington

Carol Miles and Srijana Shrestha, Department of Horticulture, WSU-Mount Vernon NWREC, 16650 State Route 536, Mount Vernon, WA 98273; milesc@wsu.edu, srijana.shrestha@wsu.edu

Introduction

Camellia sinensis is an evergreen plant whose leaves and leaf buds are used to produce a tea beverage. Tea is the second most widely consumed beverage in the world and the U.S. is the third largest importer of tea in the world after Russia and Pakistan (Tea Association of the USA, Inc., 2022). The estimated total wholesale value of the U.S. tea industry as of 2021 was $13.47 billion (Statista, 2022). Yet, there is essentially no research to support tea production and marketing in the U.S.

Tea plants generally flourish in tropical and subtropical areas, between latitudes 41^0 N and 16^0 S, that receive more than 130 cm (50 in.) of rainfall a year. In the U.S., tea plants can be grown in the USDA Hardiness zones 7–10 where the temperature ranges from 70 to 84 °F (21 to 29 °C) in the summer and 0 to 40 °F (-17.8 to 4.4 °C) in the winter. Optimum plant growth occurs at 75-85% relative humidity (never less than 40%) and with rainfall of 59-98 inches/year (150-250 cm/year). Thus, tea plants can be grown in many regions of the U.S. including the maritime Pacific Northwest. The first commercial planting of tea in Washington State was in 1997 in Mount Vernon, located in the Skagit Valley (Richard Sakuma, personal communication; Walcott, 2012). Today there are several small-scale tea plantings in the region.

Tea Cultivars

There are two primary tea cultivars. *C. sinensis* var. *sinensis* is native to China (China-type), has small erect leaves, and tends to be more cold hardy. *C. sinensis* var. *assamica* is native to the Assam region of India (Assam-type), has large horizontal leaves, and is better suited to warmer regions where it tends to be faster growing and higher yielding. Most of the tea produced in Asia is *C. sinensis* var. *sinensis* and is used to make green tea that is marketed within Asia, some at extremely high value. Most of the tea exported to the U.S. and Europe is black tea made from *C. sinensis* var. *assamica*.

There are hybrid cultivars of C. *sinensis* var. *assamica* x C. *sinensis* var. *sinensis* that are well suited for production in Mediterranean climates, and thus may be appropriate for western Washington. Tea cultivar trials are just beginning in western Washington at WSU Mount Vernon NWREC (https://vegetables.wsu.edu/tea/). Propagation studies at WSU NWREC have used the tea cultivar Minto Pacific (formerly cv. 1-2), collected from 21-year-old plants in Burlington, WA, donated by John Vendeland from his home tea planting. This cultivar was originally from Ilahee Hills Tea Farm in Salem, OR, which was discontinued at the end of 2020 and the tea block is now part of Minto Island Growers in Salem, OR.

The USDA National Plant Germplasm System (NPGS) has a collection of tea cultivars in Hilo, Hawaii. The tea germplasm curator identified four cultivars as potentially suitable for western

Washington: Beni Kaori, Yabukita, Yutaka Midori and Bohea. Tea seedlings are not recommended for propagation, and rooted material is difficult to import to the mainland U.S. thus, tea is generally propagated by cuttings. Anyone requesting tea cuttings should first develop successful cutting propagation methods for their site.

Tea Plant Propagation

Please refer to 'Tea plant propagation protocol' on the WSU Mount Vernon NWREC https://vegetables.wsu.edu/tea/ for detailed information on tea plant propagation from cuttings. This protocol was developed at Mount Vernon and has a 77-100% success rate.

Site Selection for Growing Tea

Tea plants prefer deep, light, well-drained, acidic soil with pH ranging from 4.5 to 5.5. Soil pH above 5.5 stunts tea plant growth and produces untimely flowering. This pH range is similar to blueberries, and blueberry field preparation recommendations can be followed in each region. Assam-type tea plants benefit more from shade compared to China-type tea plants, which can be attributed to their different leaf angles. Excessive wind adversely affects tea plants. Windbreaks help to prevent high evapotranspiration, water stress and cold damage.

Field Establishment

Plants propagated by cuttings should have a well-developed root system and a primary shoot about 8 inches tall before planting into the field. At WSU Mount Vernon NWREC cuttings achieve this growth in about 12 to 18 months. If you are planting a single tea plant, leave 6 feet between the tea plant and other plants or structures. If you are forming a tea hedge, space plants about 2 feet (60 cm) apart in a row. Tea plants can grow to the size of a small tree, but when cultivated for tea, plants are pruned to waist height to facilitate leaf picking.

Tea can be planted using either the hole or trench method. For the hole method, dig a hole about 18 inches deep and 18 inches wide (45 x 45 cm). Place about 1 oz (28 g) of superphosphate in the bottom of the hole and cover with at least 2 inches of compost mixed with field soil. Set the plant in the hole so that the soil surface is aligned with the soil line of the potted tea plant. Fill the hole with a mixture of compost and field soil. Tap the sides down firmly. For the trench method, use a tractor to create trenches 30 cm wide and 45 cm deep. Mix compost into the soil that was moved by trenching. Place about 1 oz of superphosphate fertilizer into the bottom of the trench where the plant will be placed, and cover with 2 inches of soil-compost mixture. Place the plant over this fertilizer-soil-compost and fill in the trench with the remainder of the soil-compost, tapping down so plants are firmly in place.

Irrigation is essential for tea plant production, especially in areas where there is little summer rainfall. Drip irrigation systems are the most efficient for water conservation and they deliver water directly to the base of the plant, where it is most effective. Refer to drip irrigation systems for blueberries or other berry fruit crops in your area for installation and operation recommendations.

Tea Plant Pruning

Tea plants naturally grow as a tree with a main leader stem. Pruning of young tea bushes is essential to develop a frame/shape with a high density of plucking points. After planting tea, cut

the main leader stem, leaving about ten mature leaves, to induce the development of axillary buds into secondary branches. When the bottom two secondary branches have developed a total of 10 leaves, cut the leader stem just above the two secondary branches and pinch off the tips of the secondary branches; this is referred to as tipping. The second tipping is done when the tea bush exceeds 2 feet height. Tip all branches that have at least four mature leaves so that the bush is no greater than 2 feet tall. Tip the bush three or four more times, each time allowing the bush to gain a little height, with the final height for this stage of training of about 28 inches. This process of cutting back branches is called skiffing. Pinch and cut back branches throughout the summer, allowing the bush to gain a few inches in height each time. Do not tip or skiff tea bushes in the Autumn or winter, otherwise plants may be severely impacted by cold damage. The final height for tea bushes should be approximately 4 feet, and it likely will take at least 3–4 years to reach this height. Formative pruning is usually performed after approximately 6 years of planting. The tea bushes are trimmed to the height of 18 inches to rejuvenate the bushes.

Pest Management

While there are over 1,030 arthropod species associated with tea (Chen and Chen, 1989), only about 3% are common worldwide (Hazarika et al., 2009). Banerjee (1981) reported latitude has no effect on the number of pest species on tea, but age and size of the acreage have the greatest influence. Tea research in Hawaii thus far provides the most comprehensive information regarding insect pests and diseases that occur on tea (Hamasaki et al., 2008). Information on arthropod pests infesting U.S. tea is limited, and there is very little information for the Pacific Northwest. At this time, only one insect pest, cottony camellia scale, has been reported of significance in this region.

Cottony camellia scale. Cottony camellia scale (*Pulvinaria floccifera*) is a soft scale that infests multiple hosts, including camellia, holly, hydrangea and rhododendron, all of which are widely grown in Washington. The scale overwinters as adults, which are sessile and flat. Females produce ovisacs (cottony white egg masses) during early summer, and eggs hatch from late June to early July. Newly hatched scales are motile crawlers and are vulnerable to chemical treatment. The crawlers settle near veins to feed, utilizing piercing and sucking mouthparts. Like all soft scales, cottony camellia scale produces large amounts of honeydew, which promotes the growth of black sooty mold. In ornamental camellias in the Pacific Northwest there is a single generation of scale per year.

Preliminary studies by Childers and Gerdeman (unpublished, 2016) found cottony camellia scale and several species of thrips and beetles infesting tea growing at a farm in Mount Vernon, WA, but no formal survey of pests was carried out. While there is some knowledge of the scale pests of ornamental *Camellia* species in the Pacific Northwest (Rosetta, 2017), specific details regarding seasonality and extent of damage in tea is unknown.

Insecticidal soaps and horticultural oils are effective for the control at the ovisac stage. Systemic conventional pesticides such as imidacloprid, dinotefuran, and azadirachtin can be used to control Cottony camellia scale (Rosetta, 2017).

Tea Leaf Production

Once the tea plants have become established, after about 4 years, the leaves can be hand-picked for tea. The size of tea leaves varies by cultivar and can range from 1.5–6 inches (4–15 cm) long and 1–2 inches (2–5 cm) wide. The number of times that a tea plant is harvested depends on the cultivar and growing environment (Tipton et al., 1990). In general, tea leaves can be picked every 1-2 weeks during the summer growing season. Pick the tip of each shoot, with 2-3 immature leaves and the bud.

Each harvest is termed a 'flush' for tea. Each flush produces a characteristic flavor (Mitchell, 1907). Spring (May) flush teas are light and aromatic, and produce high quality tea. Summer (June through August) flush teas have slightly more tannin, and produce medium-grade tea. Fall/autumn (September and October) flush teas tend to have the lowest quality. Young leaves are bright green, and the green color will deepen as the leaves mature on the plant. The maturity or age of the leaf will produce differing tea qualities, as leaf chemical composition changes with age.

All tea made from *Camellia sinensis* starts by harvesting fresh, young leaves. It is the time of year and processing method that creates a particular type of tea, not the tea plant cultivar. Leaves harvested from a tea plant can be processed following different methods to produce the different types of tea that are available. The level of oxidation and fermentation during processing results in the different tea types. For example, green tea is only dried, oolong tea is partially fermented and dried, and black tea is fermented and dried (Tipton et al., 1990). However, different tea cultivars do have nuance differences in flavors that are more suitable for different types of tea.

Green tea. A non-fermented type of tea made by wilting, steaming, rolling/shaping, and drying the leaves. Very popular in East Asia, especially in Japan and China. The main active constituent of green tea is EGCG (Epigallocatechin Gallate), which is a plant-based compound commonly called catechin. One cup of green tea contains approximately 15-50 mg of caffeine.

Black tea. Extensively oxidized before being processed and is a fully fermented form of tea. Wilted leaves are rolled for 15–60 min per roll and the number of rolls varies from 2 to 5 depending on degree of wilt, rolling speed, and temperature. After rolling, the leaves are fermented, dried, then sorted and graded. Black tea constitutes 80% of the total manufactured tea and hence is the most consumed tea; it contains about 17 mg of caffeine/100 mL.

Oolong tea. Harvested leaves are wilted followed by semi-fermentation, resulting in partial oxidation. The oxidation period for oolong tea is less than that for black tea. After the desired level of oxidation is reached, the leaves are pan-fried at high temperatures to prevent further oxidation. The taste and aroma of oolong tea is somewhere between green tea and black tea; it is mostly popular in Southeastern Asia and Taiwan.

White tea. A type of non-fermented tea obtained by drying the leaf buds, it is the least processed tea. Plants are shielded to prevent sun exposure, which leads to reduction in the formation of green pigment (chlorophyll) in the leaf buds and leads to the final white appearance of young leaves. The harvested leaves are wilted for 4–5 hours then dried to obtain the final product.

There are three main kinds of black tea produced in India from *C. sinensis* var. *assamica*.

Darjeeling tea is grown in the cool, wet region in the foothills of the Himalayan Mountains, is delicately flavored, and has one of the highest values on the world market. Plantations are located up to 2,200 m.

Assam tea comes from the heavily forested northeastern region of India, and has a rich, full-bodied flavor. The first tea estate was established in Assam in 1837 for export to England.

Nilgiri tea is from the southern region of India, grown at 1,000–2,500 m, and has a subtle, gentle flavor that is most commonly blended with other, more strongly flavored teas.

Tea Leaf Processing

Tea processing includes the following steps:

- **Wilting or withering:** Harvested fresh leaves are spread out in thin layers on trays and hot air is blown from the bottom to evaporate the moisture, leading to drying of leaves.
- **Rolling:** The tea leaves are rolled by hand or using a rolling machine to cause the tea leaf to wrap around itself; essential oils and liquids are released from the leaves, which further enhances the taste of the tea.
- **Oxidation:** The tea leaves are exposed to the air in order to dry and darken, contributing to the flavor, aroma, and strength of different teas.
- **Fermentation:** The tea leaves are subjected to 24–27°C temperature and the leaf color changes from green to coppery red along with development of a pleasant characteristic aroma.

Tea leaf processing varies by region and type of tea that is being produced, and each tea maker has their own particular methods. The following processing steps are general and provide a place for a tea grower to start. As the tea grower gains experience and determines desirable flavors and characteristics they would like to achieve, the processing steps are adjusted accordingly.

Basic guide to tea leaf processing. To process all tea flushes, first wilt the leaves by tossing them lightly to expose all leaves to the air, then rest the leaves for 1 hour. Next, roll the leaves for about 1 minute, and again rest the leaves for 1 hour. For spring and early summer harvested tea, repeat this process 2–3 times. For summer and autumn harvested tea, repeat the process 6–7 times and extend the resting period to 1 ½ hours. Next, spread the leaves in a layer 2 inches thick and store in a cool, humid room for approximately 2 hours. This step must be closely monitored because if the leaves are left too long, they will become sour and unfit for consumption (Mitchell, 1907). Finally, dry leaves to remove moisture, so that leaves do not crumble when handled but will store well in an airtight container.

Small-batch method for oolong-grade tea. A modern, simple small-batch method to make oolong-grade tea (partially fermented, or 8–25% oxidation) was developed by Zee et al. (2003) using a micro-wave. This method is suitable for home processing and does not require any special equipment or supplies. First, place the leaves in a bamboo steaming basket and place in a microwave on high setting for 30–45 seconds. Toss the leaves gently by hand in the basket. Repeat micro-wave drying and tossing 3–5 times. Roll the leaves by hand for 1 minute, then dry them again in the microwave for 30–45 seconds on high; repeat this step 3–4 times. Throughout the process, handle the leaves gently so as to keep them whole.

Tea Leaf Health Constituents
Fresh tea leaves contain caffeine (about 4%), *O*-methylated catechins [epigallocatechin-3-*O*-(3-*O*-methyl) gallate (EGCG"Me), and epicatechin-3-*O*-(3-*O*-methyl) gallate (ECG3"Me)]. The main active constituent of green tea is EGCG"Me, commonly referred to as EGCG or Epigallocatechin Gallate, or more simply catechin. These catechin compounds have bioregulatory activities, including anti-allergy and anti-obesity effects (http://www.naro.affrc.go.jp/english/vegetea/benifuuki/). Levels of catechin vary due to cultivar, plant part, and harvest time. Tea leaf processing also impacts catechin, and compounds are present in green tea but are eliminated by the process of making black tea.

Economic Value of Tea
Fresh tea leaves in general contain 78% moisture (Tipton et al., 1990). In general, multiply the fresh weight of tea leaves by 0.22 (22% dry weight) to calculate the amount of finished tea that will be produced. Thus, 100 lbs of fresh tea leaves will produce about 22 lbs of finished tea. The average total yield of finished tea in well -stablished tea fields in productive tea regions is about 3500 lbs per acre (2800 kg per acre). Tea growers will need to measure their harvested leaf fresh weight and dry weight to determine yield for their production practices and region.

The price that can be obtained for U.S.-produced tea is unknown. Growers will need to decide the type of tea they wish to produce and the quality they wish to achieve. Pricing will depend on market factors such as availability of similar products in the market and consumer willingness to pay for a local product. For example, tea grown in Cornwall, England (see https://tregothnan.co.uk/) has a high market value ($10 per serving), demonstrating the potential for locally grown tea when there is a consumer base.

Tea can be made into several different types of consumable products such as ready-made tea (bottles ready to drink) including kombucha, candy, supplements, body creams and lotions. It is also noteworthy that the seeds of *C. sinensis* can be pressed, and the resulting tea oil (not to be confused with tea tree oil *Melaleuca alternifolia*) has a sweetish flavor that is used for seasoning and cooking oil.

Currently there are no economic budgets for tea production in the maritime Pacific Northwest. To determine if tea is profitable to grow in your area, follow these general steps. Record inputs (labor hours, materials) associated with plant procurement, establishment, pruning, pest management, harvest and processing. Estimate the break-even price for tea based on the three grades of tea where the highest quality tea is handcrafted for fresh market (target is 20% of production), the mid-range tea is sold in bulk (target is 50% of production), and the bottom grade tea is used for processed products (target is 30% of production). As a tea grower gains experience and knowledge regarding tea processing and quality of the end product, these percentages can shift; however, to begin a business it is advisable to be conservative regarding the quality of the product and the price that can be attained.

Online resources
The tea research project at WSU Mount Vernon NWREC will be posting on the program website, https://vegetables.wsu.edu/tea/ as new information becomes available.

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