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Myanmar Tea Cultivation and Processing Guide

Isaac Cowan-Gore and Than Than Sein

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Contents

1 Introduction

In Myanmar, most tea farmers apply traditional cultivation and processing methods, which often lead to low yields and, in some cases, low quality tea leaves. The tea produced in Myanmar is mostly for the beverage, but an edible form of tea, which is called fermented tea or pickled tea, is also produced. The quality of dried and fermented teas (and therefore their value and price) is highly dependent on cultivation practices, plucking standards, processing methods and hygiene practices, among other factors.

This guide covers good agriculture practices in tea farming to help farmers in Myanmar achieve higher yields and higher quality fresh tea leaves. The guide also covers good manufacturing practices, more specifically, tea-processing methods for both green tea and fermented tea as well as basic hygiene and food safety practices that should be followed at all stages of tea production in order to ensure tea making of the highest quality. The section on processing methods covers mainly homemade green tea (as opposed to factory-produced green tea) as well as fermented tea production. On the other hand, the section on basic hygiene and food safety practices is applicable to the manufacture of all types of tea and both factory and home production.

Evidently, these guidelines do not include all good agricultural and manufacturing practices relevant to tea production and, as such, should not be considered exhaustive in any way or discourage best practices that are omitted or incompletely described. Rather, this guide provides an overview of the main issues in tea cultivation and processing in Myanmar so that it could be used as a resource for sensitization or training measures, especially where export certification (e.g. organic, HAACP, ISO, FDA, USDA, etc.) is sought.

It is hoped that applicable recommendations included in this guide (or at least the major points) are shared with farmers, processors and distributors of tea in Myanmar with a strong recommendation to comply with them.

This guide has been produced by the International Labour Office with the financial assistance of the European Union as part of the project “Strengthening the Impact of Trade on Employment in Myanmar”. The guide is mainly based on information contained in previously published guides produced by the Myanmar Tea Association, the Myanmar Department of Agriculture, Deutsche Gesellschaft für Internationale Zusammenarbeit (GiZ), and the United Nations Development Programme.

Tea Cultivation in Myanmar

2 Botany of Tea & Growing Conditions

Tea species: Tea is a heterogeneous evergreen plant, which falls under the Theacea familly in the Camellia genus and is named Camellia sinensis.

- **Major tea varieties**: It consists of two main varieties: var. sinensis and var. assamica known generally as China and Assam varieties, respectively. The China varieties have small erect leaves and are classed as erectophiles (leaf angle < 50°), while the Assam varieties (considered small trees thought originally to have grown in the forest) have horizontal and broad leaves and are classified as planophile (leaf angle > 70°).
- **Myanmar tea varieties:** In Myanmar, both Assam and China varieties are grown but Assam makes up the majority of the total land dedicated to tea (China varieties are mostly grown in regions along the border with China). There are also various hybrid varieties which are grown such as the variety native to Myanmar called var. Irrawadiensis. Although some buyers do not pay attention to the tea variety, international buyers often ask for a certain variety and consistency of product (no mixed product with different varieties). Therefore, it can be useful to know what varieties are grown on a tea plantation.

Tea bush growth patterns: Tea can grow into a tree attaining a height of 20-30m and have a life span of more than 1,500 years. On average, one tea bush under optimum conditions and good agricultural practices can produce approximately 3.5 kilograms of fresh tea leaves per year.

Environmental conditions: Tea requires rainfall of 1200mm to 2200mm that is well distributed throughout the year, relative humidity of around 80% (never less than 40%) and temperatures ranging from 13ºC to 30ºC. Tea does not tolerate long droughts or frost and extreme heat. The best quality tea is produced at high altitudes of 1500 to 2250 meters above sea level.

Soil quality: Tea requires acidic soil, with a pH between 4 and 5.5. Fields with pH above 5.5 should not be planted with tea (alkaline soil stunts plant growth and produces untimely flowering and fruiting). Tea grows especially well in deep (minimum 1 meter depth) well-drained red volcanic soil.

3 Establishing a Tea Plantation

3.1 Land Selection & Clearing

Land selection: Before planting, farmers should make sure that the soil of the intended plantation is suitable to grow tea i.e. that it is deep enough, that it drains well, and that it is within the adequate pH range. This can be verified through soil analysis but also to a lesser extent by observation of neighbouring fields having healthy tea or the presence of plants that enjoy similar conditions to tea.

Land clearing: To establish a tea plantation, other plants and stones should be removed from the land prior to planting. The root system of felled trees should also be removed to the extent possible in order to avoid spread of root diseases and allow the root systems of tea bushes to develop unobstructed. Where root removal is not possible or too costly, care should be taken to first kill the trees by ring barking / girdling and then cut them down, in

order to avoid root rot diseases. Farmers may also use Trichoderma myco-parasite treatments to control root rot diseases.

Disposal of prior vegetation: In any case, removed vegetation should not be burned on the land destined for tea given that the ashes are alkaline and tea requires acidic soil.

Wind belts: Wind breaks reduce the speed of wind thereby decreasing loss of moisture from soil by evaporation and from the plants by evapotranspiration. Tall trees on the edges of plantations may therefore be left untouched as long as they do not produce shade beyond recommended amounts (see section 3 on Shade Trees) for the tea plants.

3.2 Water Management

Objectives: During land preparation, various water management measures should be taken to encourage water retention and minimize surface runoff, especially when the plantation is on a steep slope.

Water Drains: The main water management measure consists of digging water drains, which will help control water flow.

- **Boundary/Contour drains**: Digging contour drains 1.5-2 feet wide and 1.5-2 feet deep once every 4 to 6 walking rows (the steeper the slope, the closer drains should be) prevents water from entering into the field from above, retains soil and drains surplus water into the leader drain. Establishing boundary drains on the edges of the field will prevent entry of water from the upper reaches.
- **Leader Drain**: The natural drain of rain should be built as a leader or vertical drain 2 feet wide and 1.5 feet deep, with steps every 3 feet (lock and spill over drain).

Picture 1: Water drains with water revetments (Source: DoA, Collection of Presentations)

- **Drain design:** Adequate drain design will affect the durability and effectiveness of drains.
  - **Drain revetments:** Stone revetments along the drains (see picture above) and suitable grass ground cover in and/or along the drains will help hold the ground firm and maintain drains.

- **Drain water velocity control:** Water flow velocity within drains can be reduced by using lock and spill over drains and by digging a drain across the slope diagonally rather than down vertically from the top.

Picture 2: Lock and spill drain design (Source: DoA, Collection of Presentations)

Water catchments: Water catchments dug in the ground will also help reduce surface run-off and conserve water. While small pits will evidently be useful, digging staggered trenches is ideal, especially on steep slopes. Staggered trenches should be dug to be 6-10 feet long (perpendicular to the slope), 1 foot wide and 1.5 feet in depth; and located 6 feet from one another between rows of tea bushes in staggered / Zig Zag position.

Picture 3: Staggered Trenches (Adapted from: DoA, Collection of Presentations)

Contour wall: Finally, the establishment of contour walls made out of stones or vegetative barriers made up of tall grasses such as vetiver grass at different levels of the plantation will help in retaining soil and draining excess water. Vegetative barriers can also be slashed

periodically and used as mulch or incorporated to the soil to increase organic matter. The vertical interval between contour walls varies with the degree of slope (on steep slopes, consider establishing a contour wall every ten contour rows).

3.3 Plant Population

Contour row systems: Growing tea using a contour row system is ideal for hilly lands. Growing tea using a contour row system means growing tea plants at the same level of height on the slope horizontally (contour lines are completely level lines across a slope). This method of planting will help control soil erosion and improve water retention.

Contour double hedge planting: This method involves planting two rows of tea plants two feet away from each other (vertically) in staggered / zig zag position, and spacing the tea plants in those rows 2 feet away from one another. Each double row should be 4-6 feet away vertically from the next double row. Contour double hedge planting is the preferred planting configuration for tea because it results in a dense, high plant population (average of 7400 tea plants per acre), which will also help conserve soil better and minimize weed growth. It will also allow for a high early yield.

Figure 1: Double contour line plantation (Source: MoAI, Tea Cultivation)

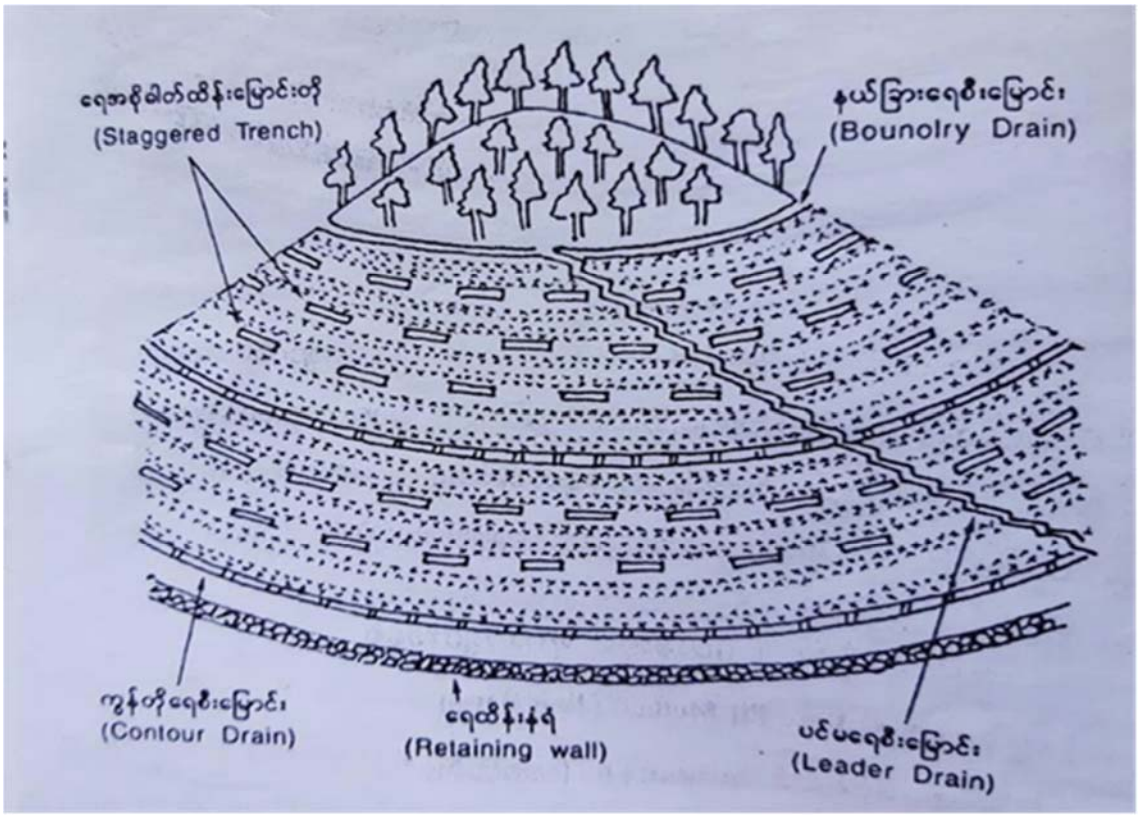
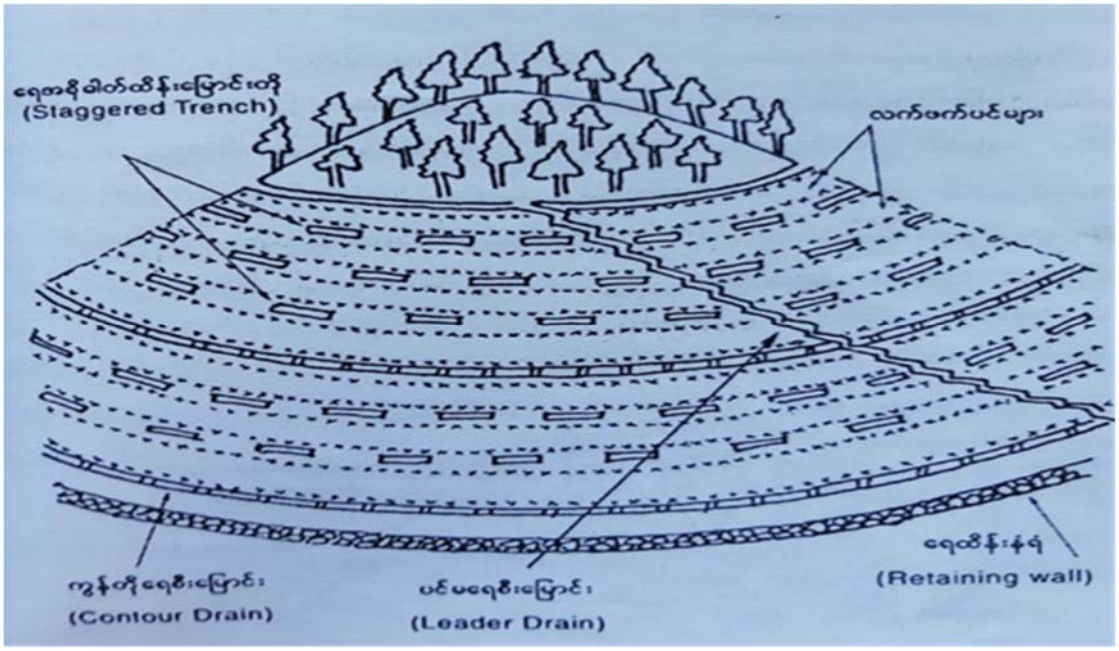


Figure 2: Single contour line plantation (Source: MoAI, Tea Cultivation)



Infilling: Infilling refers to planting of additional tea bushes (or other crops) where there are gaps in a tea plantation.

- **Low density drives low yields:** In Myanmar, the average yield per acre of tea plantations is half that of Sri Lanka, which is caused in large part by a lower density of plants per acre. Where there are large gaps in a plantation, these should be filled with new tea bushes (as to increase plant population per acre) or other crops (see section 3.4 below on Intercropping).
- **Timing:** In order to allow proper sun exposure for newly planted tea bushes, infilling should ideally be done the same year as pruning. Otherwise, the side branches of adjoining mature tea bushes may be trimmed to facilitate proper sun exposure.

3.4 Intercropping

Intercropping: Growing tea alongside other crops (i.e. intercropping) can have numerous benefits, including lower pest and disease incidence as well as increased tea yields per plant. In areas where diseases and pests proliferate, it may therefore be preferable to intercrop tea with ginger, soy bean or another crop rather than having a densely populated plantation of exclusively tea. In any case, the effects of intercropping should be carefully considered. For instance, nitrogen fixing crops such as pulses may be especially advantageous depending on soil conditions.

Green manure: Green manure is made up of green decomposed materials. It can be produced by growing green manure crops. It can also be produced by collecting green leaf (along with twigs) from plants grown in wastelands, field bunds and forests.

- **Advantages of green manure:** Green manure improves soil structure, increases the water holding capacity of the soil and decreases soil erosion. It also constitutes a valuable source of nitrogen.

- **Green manure plants**: Green manure comes from plants usually belonging to the leguminous family, which are grown on the field and incorporated into the soil once they have achieved sufficient growth. The most important green manure crops are sunnhemp, dhaincha, pillipesara, clusterbeans and Sesbania rostrata.
- **When to plant green manure plants:** Green manure can be grown in parallel with tea. It can also be grown before land preparation for tea growing to improve soil fertility.

4 Shade Trees

4.1 Overview

Definition and objectives: Planting shade trees alongside tea will improve yields given that tea grows best with a certain amount of shade (coffee requires 80% shade while tea requires between 20% and 50% of shade). Shade protects the tea bushes from sun scorch, especially following pruning of tea bushes, when the tea bush frames are most exposed. Beyond providing shade, shade trees have other benefits including:

- **Micro-climate regulation:** Such trees will also be useful because they can help regulate the micro-climate, by lowering leaf and air temperature and therefore also maintaining moisture in the soil. They also act as windbreaks and reduce incidence of dry weather pests, by notably providing a better habitat for pest eating birds.
- **Improving the soil:** Shade trees help retain soil and thus reduce soil erosion. They also help retain water and loosen the soil in the plantation as their roots develop. And finally, they can help improve soil health by constituting a source of organic matter from leaf fall; biologically fixating nitrogen in the soil (e.g. when shade trees are of leguminous species); and by favouring microbial and earthworm activities as a result of increased shade.
- **Providing an additional source of income:** The wood collected from shade tree branches or when the shade tree is removed can be sold or used as firewood.

Risks of planting shade trees: Shade that is too thick can nevertheless cause various ill effects including greater incidence of diseases such as blister blight and competition with tea for resources including sunlight, water and nutrients.

Picture 4: Shade Trees (Source: DoA, Collection of Presentations)

4.2 Planting Shade Trees

When to plant shade trees: Both permanent and temporary shade trees/plants should be grown before tea planting. In an already established tea plantation, shade trees should be grown after pruning in order to allow proper sunlight exposure and therefore adequate growth of the shade trees.

Choosing shade trees: Different criteria should factor into the choice of the shade trees to plant including factors pertaining to:

- **Nature of shade tree**: The shade tree planted should be tolerant to wind and frost and have low pest and disease incidence. Regarding permanent shade trees, these should be evergreen trees that are deep rooted, that do not defoliate during summer months and that have fringed leaves and provide filtered shade.
- **Ease of management:** The shade tree should be easy to manage e.g. they should be easy to propagate, grow quickly, withstand frequent lopping (cutting of their branches) and regenerate quickly.
- **Commercial value:** Shade trees chosen should ideally have commercial timber value or some other value as to provide tea farmers an additional source of income.

Temporary shade plants: Temporary shade plants are temporary as their name indicates. Once permanent shade trees have reached a certain height, temporary shade plants/trees can be removed.

- **Example of temporary shade plant:** Pigeon pea is a crop that can be grown as a temporary shade plant that will also increase the amount of nitrogen in the soil and provide an extra source of income to tea farmers.
- **Planting configuration:** Temporary shade plants should be grown along one line after every two contour lines of tea bushes. Plant to plant distance within the same line should be 8 to 10 feet.
- **Removal:** At the age of 3 or 4 years, temporary shade trees can be removed.

Permanent shade trees: Permanent shade trees are trees that are used to provide shade to tea over longer periods of time (upwards of 20 years).

- **Examples of permanent shade trees:** Grevillea Robusta (i.e. silver oak) can be grown as a permanent shade tree, and it will provide an extra source of income to farmers who can cut it down once it becomes old and sell the timber (Grevillea has an average life span of 30 years). Other possible permanent shade trees include Cassia fistula, Cassia renigera, and Delonix regia.
- **Planting configuration:** Permanent shade trees should be grown four contour lines of tea bushes apart, (one line apart of temporary shade trees to avoid overlap of temporary shade lines and permanent shade lines). The distance between permanent shade trees within the same line should be 20 feet.

Shade tree management operations: To achieve the ideal amount of shade, permanent shade trees need to be thinned out (some shade trees removed), lopped or pollarded whilst taking into account factors such as the growth of the shade trees, the altitude of the garden and the aspect of the field (e.g. Southern facing slopes are exposed to more sunlight and therefore require more shade).

- **Lopping:** Shade trees should be annually lopped (i.e. have their branches cut) before the onset of the rainy season to permit better penetration of sunlight, which will also minimize the incidence of blister blight. Only erect branches should be

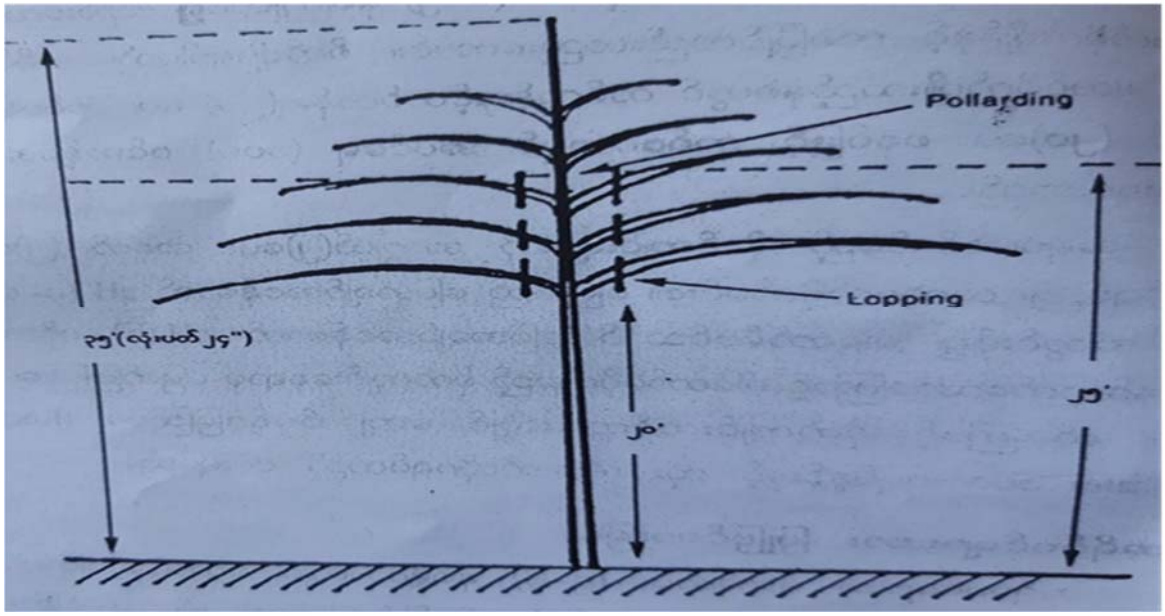
lopped, laterals should be retained. Branches should be allowed to spread as far as possible. Lopping will also reduce the moisture uptake of the shade trees from the soil during the dry season.

- **Thinning out the shade**: After 3 to 4 years, every alternate tree along the East-West shade tree rows can be removed. If required, further thinning may be done at later stages (12-15 years from planting), by removing alternate trees in North-South Rows.
- **Pollarding:** Shade trees should also be pollarded at given heights. Pollarding consists of cutting the main stem to develop lateral branches. Pollarding should be performed when the trees attain a girth of around 50cm at elbow level. They should also be pollarded at 8m height at high altitudes and 9m at lower altitudes. One branch should be left in each direction, with 3 to 4 tiers of branches on the tree.

Removing / thinning out shade trees precautions: As during land clearing, when thinning out / removing shade trees, their root systems should also be removed. In case this is not possible, these should be ring barked approximately 2 years prior to removal. Once their leaves turn yellow and fall to the ground, the shade trees can then be cut down, ideally making the cut below the soil level and then covering the stump with earth.

Replacement of shade trees: When shade trees are to be replaced, the new shade trees should be planted well before the old ones are removed in order to ensure the field is not left without shade.

Figure 3: Lopping and pollarding shade trees (Source: MoAI, Tea Cultivation)



5 Planting

5.1 Transplanting

Tea transplanting: Growing new tea plants can be done by directly sowing seeds into the soil or by transplanting tea cultivars grown in a nursery in the field. In this sub-section on Transplanting, we only address transplanting operations. The rest of the Planting section (5.2 and 5.3) is also applicable to direct seedlings.

When to transplant seedlings or cuttings: Newly planted tea bushes need water to grow properly. Therefore, they should be planted at the beginning of the rainy season, between the last week of May and first week of June if there is already enough moisture in the soil (for more information on planting, see Propagation, section 10).

Plant readiness for transplanting: Before transplanting propagated materials to the field, they should have developed healthy roots and shoots (leaves), which will facilitate their intake of nutrients, anchorage in the soil and allow adequate photosynthetic rates. Sleeved plants are ready for transplanting once they have been exposed to normal sunlight and temperature variability, and when the roots have reached the bottom of the sleeves and top growth is approximately 8 inches.

Operations before transplanting: Weeds around the planting hole should be removed prior to planting to avoid competition with new tea plants. Before transplanting, also make sure there is enough moisture in the soil in the sleeves with propagated materials.

Transplanting operation:

- **Planting hole:** The planting hole should be dug 2 feet deep and 1 foot wide and garnished with compost (which contains all necessary plant nutrients).
- **Moisture in tea sleeves:** At the time of transplanting, the soil in the sleeves should be moist. If they are dry, they should be watered prior to planting.
- **Careful handling of tea sleeves**: The plants must be handled carefully to avoid cracking the cylinder of soil and disturb the roots. Similarly, if tea cultivars (seedlings or cuttings) need to be transported by vehicle, they should be stacked carefully and tightly on any vehicle taking them to the field.
- **Removing the polythene sleeves**: Right before transplanting, the sleeves containing the tea cultivar must be removed carefully, making sure not to damage the cylinder of soil and the roots.
- **Placing the cultivars in the planting hole:** Place seedlings/cuttings in upright position at the center of the planting hole.
- **Refilling the hole with soil:** After, refill the hole with the same soil that was previously removed from the hole while respecting the order in which it was prior to removal. Once the hole is replenished, press the soil around the seedling but be careful not to raise the soil along the stem as this can encourage canker disease. The soil should be at the same level as the rest of the plantation. If the soil around the seedling is below the level of the rest of the plantation, this can cause water logging (excess water impedes normal root function). If it is above, roots will struggle to get the water they need.

5.2 Post-planting care

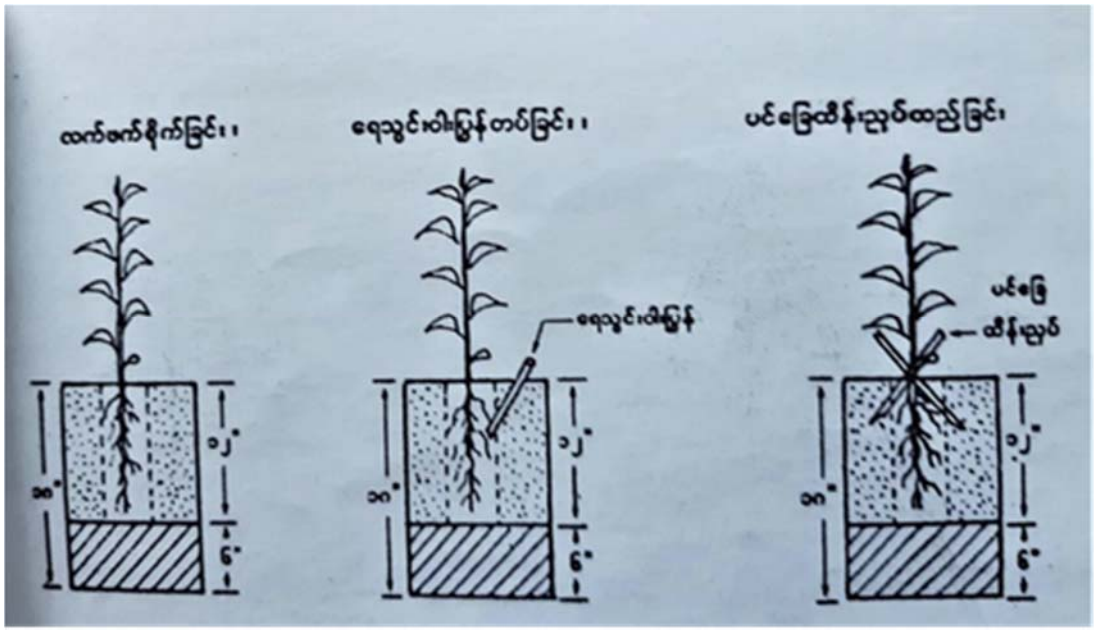
Importance of post-planting measures: Following transplanting, seedlings are in their most fragile state as they need to take root in their new environment. Certain measures

should be taken to improve their access to resources and protect them from adverse environmental conditions.

Improving plant access to water: The availability of water, in the right amount, is one of the keys of healthy root development and overall plant development. The most efficient measure is to facilitate sub-soil irrigation. This will improve root access to water and promote the development of deep root systems, lead to less weed growth than other types of irrigation, and lead to minimum casualties arising from surface moisture favoured diseases and pests:

- **Bamboo pipe aided sub-soil irrigation:** After transplanting, a bamboo pipe (8 inches long and 2 inches in girth) should be inserted in the soil 3 inches away from the plant at a 45 degrees angle. It should then be pushed in to 6 inches in depth, leaving it exposed approximately 2 inches out of the soil. This operation should be conducted close in time to planting. It should not be performed during the dry season given that the bamboo pipe might break because of harder soil during insertion.
- **Coupled with man-made irrigation**: In case rain patterns are irregular/infrequent and man-made irrigation is needed, sub-soil irrigation measures will also help economize water.

Figure 4: Post-planting care measures (Source: MoAI, Tea Cultivation)



Protection from wind and uprooting: In windy places, in order to prevent plants from being uprooted or falling down, two bamboo poles should be inserted in the soil at a 45 degrees angle to form a cross at the opposite side of where strong winds comes from.

Trampling protection: Given their size, transplanted seedlings are especially vulnerable to trampling. Animals may walk over them just as humans might just not see them and do the same. Therefore, transplanted seedlings should be protected from trampling by putting pegs around them (made of metal or any other suitable material that will stick into place).

Picture 5: Protection from wind and trampling (Source: DoA, Collection of Presentations)

Mulching: Mulching, which consists of covering the soil surface with organic matter, will help reduce soil erosion, conserve soil moisture, suppress weed growth, increase organic matter in the soil and regulate soil temperature. Mulch should therefore be applied immediately after planting, making sure to keep mulch material away from the collar region / stem of the plant (for example by putting a peg above the plant on the slope). Straw, grass cuttings or green leaves can be used as mulch. Pruned branches and leaves of tea bushes in non-mulched fields may play a similar role.

Nutrient needs: In its first few years after planting, the plants need nutrients to maintain their health and extra fertilizer to encourage the development of strong root and branch systems, which will support vigorous cropping at maturity. Application of fertilizer will facilitate adequate growth. This should be done when fields are free from weeds and when there is adequate soil moisture. Adequate care should also be taken when applying nutrients in order to avoid damaging plantings (see section 7 on Soil Health).

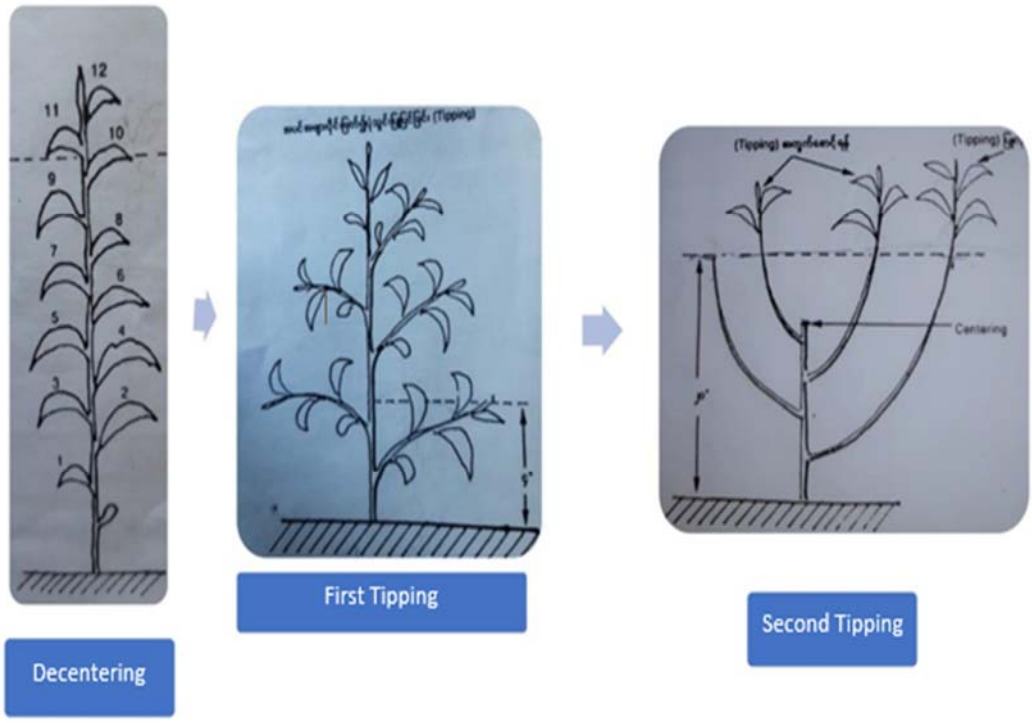
5.3 Tea Training

Definition and objectives: Tea training consists of cutting the young tea bush at specific intervals in order for it to develop a tree frame/shape which is low, broad, heavily branched and capable of producing a high density of plucking points (large number of shoots). Proper training of young tea bushes is essential to encourage higher yields and to enable plucking to start earlier, which will allow greater and quicker financial returns on investment. There are different training methods to develop tea bushes into an ideal frame. Here, we present the "decentering and pruning" method, which involves a number of steps to be followed.

Decentering: Tea plants naturally grow along a main leader stem. In order to facilitate the development of the plants into a wider frame, after planting, when the leader stem of tea bushes has developed at least ten leaves, decentering should be performed. Decentering means cutting the leader stem above leaf number 10 to arrest apical dominance (i.e. main growth along a single leader stem) and induce the development of axillary buds into secondary (lateral) branches.

Tipping: After decentering has been performed, the remaining axillary buds along the stem will develop into branches with multiple leaves on them.

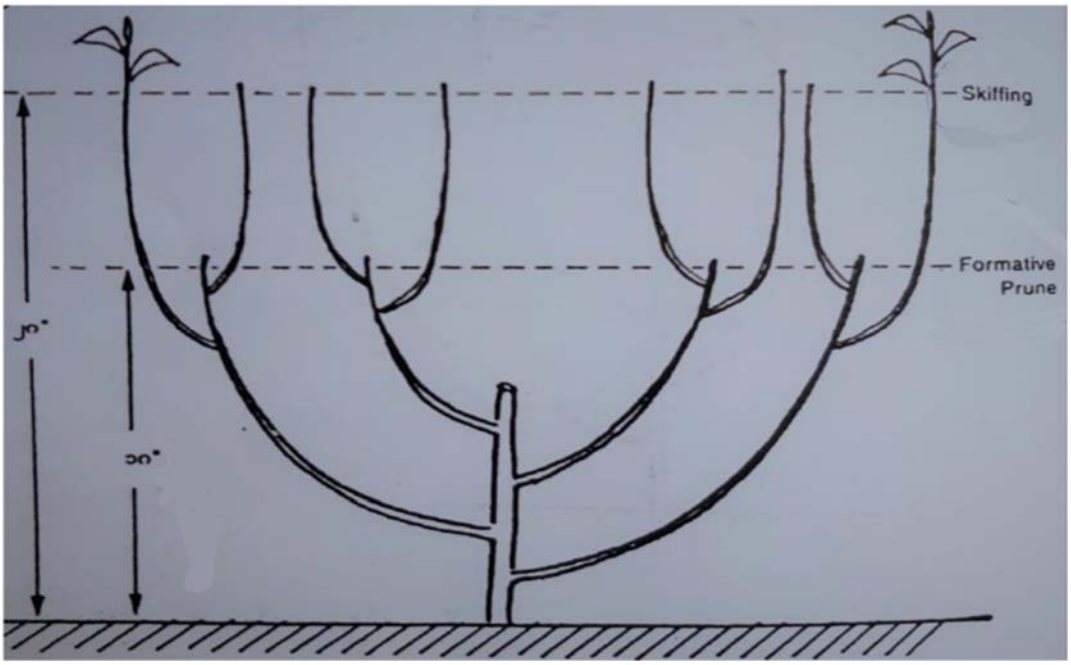
- **First tipping:** The first tipping occurs when the bottom two secondary branches have developed a total of ten leaves. At that time, the leader stem should be cut again above those two branches at the height of approximately 4 inches.
- **Second tipping:** The second tipping occurs when the height of the tea bush rises above 20 inches. At that time, all the branches which rise above 20 inches should be cut at the height of 20 inches if they have more than four leaves. If the branches have not yet developed four leaves, this operation should wait until they do. This operation will stimulate the growth of lateral branches on the portion of the stem below 20 inches. The leaves on the removed branches can be used for tea making. After that, the plucking table is made. Young shoots coming out above 20 inches from the branches that had previously been cut can be plucked.



Skiffing: While plucking will slow the growth of the tea bushes, the plucking table will inevitably grow above 20 inches. When the plucking table exceeds 28 inches in height, branches above 28 inches should be cut for better quality and yield.

Formative pruning: Formative pruning is usually performed approximately 6 years following planting, once the tea bushes have reached approximately 44 inches in height. The tea bushes are cut at the height of 18 inches from the bottom of tea bush.

Figure 5: Skiffing and Formative Pruning (Source: MoAI, Tea Cultivation)



Additional considerations in tea training: As with pruning operations, tea training operations should be done when there is sufficient moisture in the soil and when tea plants have sufficient starch reserves to recover. Additionally, when removing branches, the cut should be made at a 45 degrees angle with a tool suitable for the task (gardening tools are preferred to knives; see also section 11 on Occupational Safety and Health).

Picture 6: Decentering with appropriate tools (Source: DoA, Collection of Presentations)

6 Tea Pruning

6.1 Overview

Natural tea bush growth: Even if young shoots are harvested at proper intervals, tea bushes exhibit normal vegetative growth. They grow above the ideal plucking table height, naturally form Banji Buds (sterile buds), enter reproductive growth phases (flowering/seeding), and have branches that become intertwined or that dry out. Moreover, if left untouched, tea bushes naturally exhibit less juvenile shoot growth over time and therefore naturally become less productive.

Pruning definition and objectives: The major solution to these problems is pruning. Pruning consists of cutting the branches of the tea bush at pre-determined heights and at specific intervals.

- **Developing and Maintaining tea frames**: Pruning will help develop and maintain tea frames, which will help maintain convenient height and accessibility of plucking tables (tea bushes grow approximately six inches per year) as well as maximize plucking points and therefore yield.
- **Controlling vegetative growth:** Pruning will also help control vegetative growth in a way that will prevent the advent of the reproductive growth phase (flowering-seeding), minimize Banji bud formation, control the crop during rush periods and stimulate rejuvenation and productivity of tea bushes.

Pruning and ground cover: Higher pruning/tipping heights and longer pruning cycles will make for increased ground cover and hence reduced soil exposure. This will reduce the growth of weeds and favour conservation of moisture in the soil by reducing evaporation of water.

Yield management: If done correctly, pruning results in higher yields overall. However, the crop gains are not evenly distributed over time. Indeed, tea bushes that have been pruned naturally produce less for one or two years and then recover to normal levels and above. In order to avoid untimely loss of income, farmers should consider:

- **Choosing the right type of pruning:** The pruning method adopted should take into account the impact it will have on yields over time. The lower the pruning cut is, the more severe and lengthy the temporary crop loss will be.
- **Varying pruning cycles and pruning types in the plantation:** Additionally, farmers may consider pruning different parts of their plantation at different times (e.g. half of it one year and the other half two years later) or using different methods on different tea bushes.

6.2 Pruning done correctly

Making sure the tea bushes can recover: Pruning is naturally a stressful operation for plants. Therefore, in order to make sure that tea bushes are able to recover quickly from pruning, three major recommendations should be followed.

- **Remedying nutritional deficiencies months before pruning:** If severe nutritional deficiency is detected before pruning, it would be preferable to make a fertilizer application before pruning rather than after. An interval of less than six months before pruning may be too short for full benefit of a fertilizer application to be shown. The time interval before pruning should be several months, and if the vigour

of the bush is very poor, pruning could be delayed until there is evidence of improved growth.

- **Resting tea bushes for six weeks prior to pruning:** In order to recover quickly from pruning, tea bushes must have enough starch reserves. Tea bushes should therefore be rested (not plucked) for six weeks before pruning operations begin and/or lungs be left on the tea bush (see lung pruning method below) in order to allow those reserves to be replenished. It should be noted that tea bushes tend to store starch better at higher altitudes.
- **Ensuring adequate soil moisture at the time of pruning:** Moisture in the soil is also essential to facilitate good recovery of tea bushes. Pruning should not be done when soil has low moisture content.

Conduct pruning operations safely and effectively: In order to minimize the risk of injury to oneself and to the tea bushes:

- **Prune tea bushes with an open canopy:** Prior to making the pruning cut, remove as much as possible all dead, small, dry, loose and diseased branches from the tea bushes.
- **Cleanly remove/cut branches with appropriate tools:** Cuts should be clean and performed at a 45-degree slant (so that rain water will slip off the cut end and minimize the risk of fungi proliferation, splits and bark injuries) with gardening scissors (preferred to sharp knives, sicles or saws).

Picture 7: Tea bush bark injury (Adapted from DoA, Collection of Presentations)

Post-pruning care: Post-pruning measures should be taken soon after pruning and well before new bud growth to minimize potential damage resulting from pruning.

- **Cut ends treatments:** Fungicide, painting paste or tar may be applied to cut ends to prevent entry of fungal pathogens.
- **Tea frame treatments:** Agriculture lime solutions (52kg of lime for 520 litres of water for one acre of pruned tea bushes) may also be applied to the tea bush frame in order to help early and even bud growth, kill moss and lichen on the frame, and

minimize sun scorch to frames. Moss and Lichen on the stem of tea bushes can also be removed by hand or using a wet cloth or gunny bag.

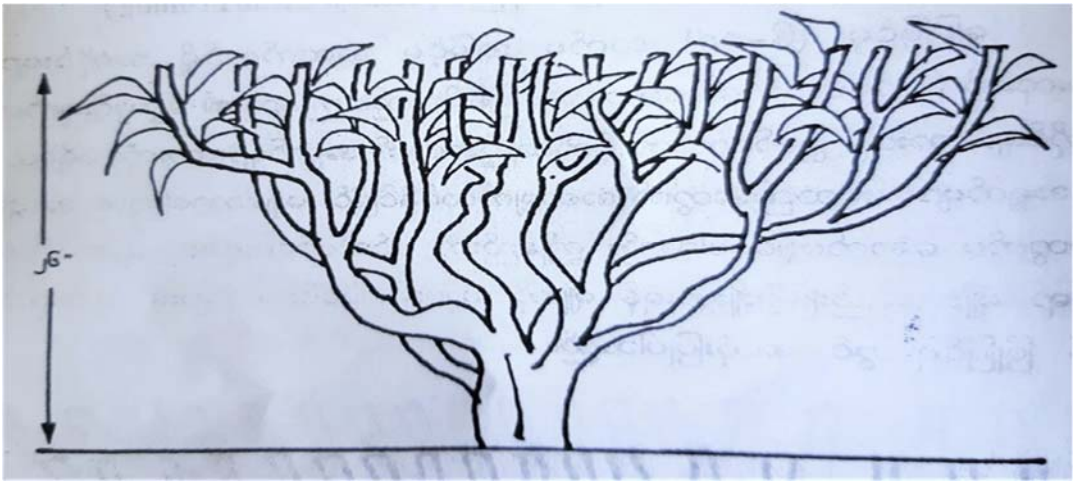
Picture 8: Moss on the tea bush frame (Source: DoA, Collection of Presentations)

6.3 Types of pruning

How often to prune tea bushes: Different types of pruning should be undertaken at different stages of tea plant growth/maturity and depending on weather and plant conditions. The full pruning cycle should take between 3 and 5 years before being reinitiated. The cycle may be shorter or longer depending on the plucking regime as well as other factors such as altitude. In regions which are located above 4000 feet, pruning can be done once every five years. In regions which are located below 4000 feet, pruning can be carried out once every three to four years.

Medium Pruning: Medium pruning consists of cutting all the branches of the tea bush above 16 inches high. This operation is performed on bush frames that are healthy. In the first year following medium pruning, the yield will go down 60 to 70%. In the second or third year, the yield will return to normal levels. Medium pruning is usually performed between December and January.

Figure 6: Medium Pruning

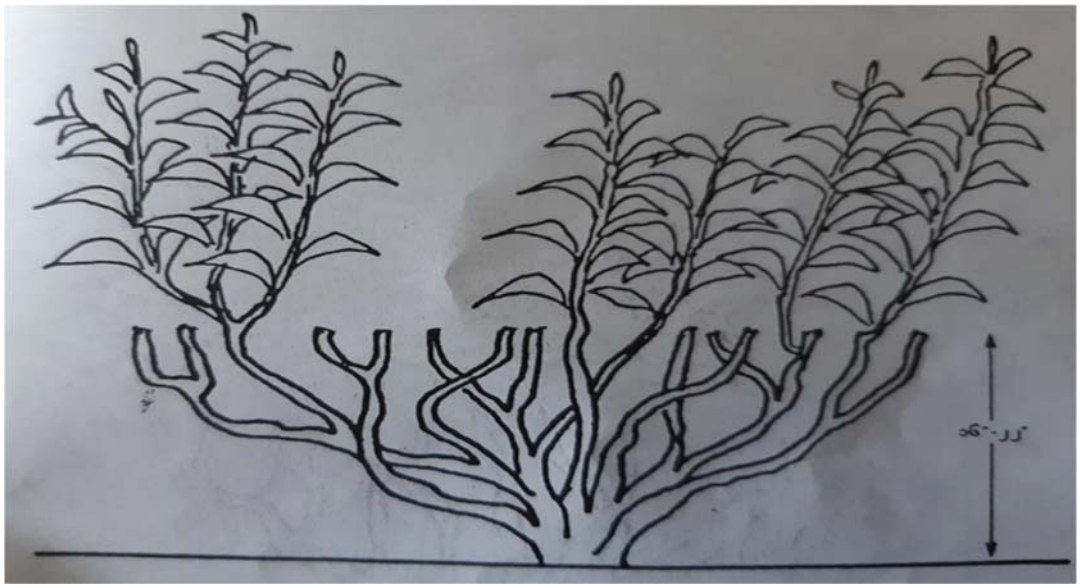


Light pruning: 3-4 years following medium pruning, the next pruning is performed at 2 inches above the last cut that was made during medium pruning. This operation should be done after Shwephi season in May. The objectives of light pruning are to promote juvenile factors of plants, an even yield and to shape the plucking table.

Skiffing: Skiffing is the cutting performed at 4 inches above the last cut made during light pruning. At that time, branches become intertwined and shaped like chicken legs. The objectives are to lower the plucking table and to promote the coming out of qualified tea shoots early. It can also be performed to postpone other pruning operations. Skiffing usually takes place between June and August.

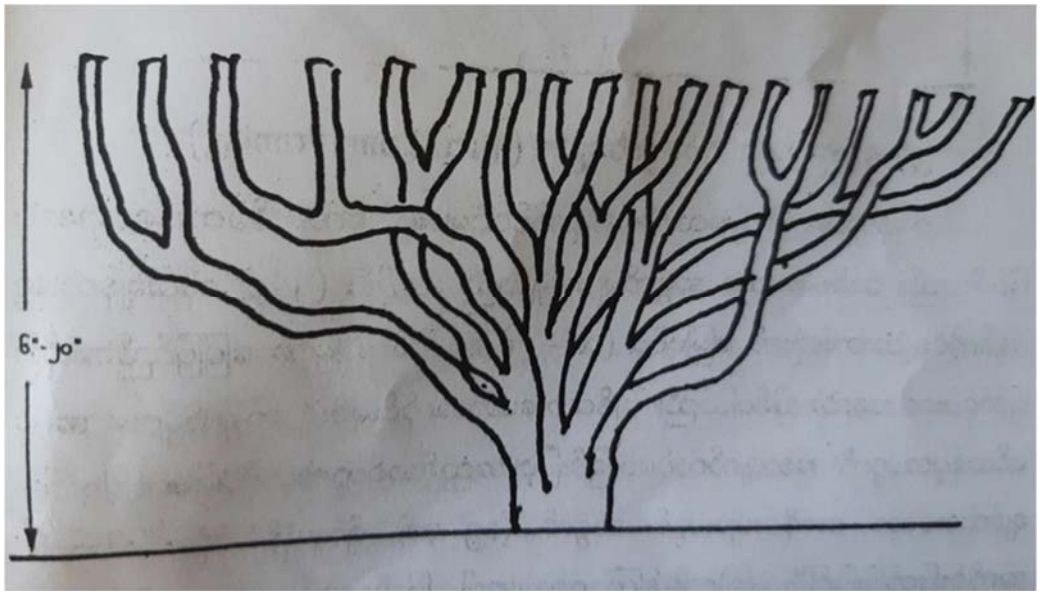
Lung Pruning: In order to facilitate recovery of tea bushes and allow plucking of tea bushes despite pruning, a special type of pruning called Lung pruning can be performed. This pruning method involves adopting the same methods as mentioned above while purposely not cutting certain branches above the pruning cut i.e. “lung branches”. Lung branches offer protection from sunburn and they allow photosynthesis, which gives more energy to the plant to recover and produce new shoots. It is recommended that 1-2 branches with 35 to 40 leaves should be left as lung branches during strenuous pruning operations. When new branches develop above the pruning cut and these have 2 or 3 leaves, the remaining lung branches should be cut. This method is used in modernized tea growing countries. It is typically performed between May and September.

Figure 7: Rim Lung Pruning



Heavy Pruning: Heavy pruning is applied to tea bushes that are more than 20 years old, whose yield is gradually decreasing. Firstly, all the branches above half the height of the tea bush should be cut to reduce the plant weight. After this operation, all of the branches of the tea bush above 6 to 10 inches have to be cut leaving no leaves left on the remaining branches. Here, all above ground parts of the tea bushes are cut down and this operation is carried out only when the root system is considered strong enough to withstand the shock and initiate new growth. This method is nevertheless rarely used nowadays as it results in high levels of mortality. Therefore, although this method can significantly improve productivity of old tea bushes, the risks involved should be carefully considered beforehand, making sure that the plants are healthy enough and that they have enough starch reserves. Evidently, the yield will also go down significantly in the years following pruning.

Figure 8: Heavy Pruning



Tipping-in after pruning: Tipping-in consists of the first plucking after pruning. The objectives of tipping-in after pruning are to produce a level plucking surface that facilitates efficient and easy plucking operations, help develop an adequate depth of maintenance foliage and help achieve good spread of the tea plants.

- **Timing and height:** Tipping-in should start before shoots go banjhi, at a height of 10-12 inches. The best tipping-in height is 4 inches above the pruning level (usually 3 months after pruning - depending on the weather and the tea plant/clone). Tipping-in should not be delayed so that buds just below the tipping level do not become mature as they will then take longer to redevelop into new shoots after removal.
- **Method:** During tipping-in, shoots that have developed to three leaves and a bud above the tipping-in level should be plucked off at the tipping-in level. Tipping-in aids may be used (Caution - Never perform this operation with a knife).
- **Tipping height considerations:** High tipping and hence high plucking tables allows greater spread of tea bushes. This helps in establishing early ground cover but also facilitates higher pruning in the subsequent cycle.

7 Soil Health

7.1 Overview

Importance of soil health: Soil provides anchorage for the roots of tea plants, it contains nutrients that plants need to grow properly, and it acts as a reservoir for water. Good soil health is therefore crucial for proper growth of tea plants and hence to produce quality tea.

Soil enhancing measures: In order to prevent soil degradation and tend towards ideal soil health, it is necessary to adopt measures that:

- **Reduce soil erosion:** Topsoil consists of the top layer of soil, in which plants concentrate their roots and acquire most of the vital nutrients needed for their development. Reducing soil erosion and loss of valuable topsoil can be achieved by implementing appropriate water management measures (see section 3.2 on Water Management) and increasing ground cover.
- **Improve the physical properties of soil:** Measures should be taken to ensure the best anchorage structure for the roots of tea bushes as well as achieve the best water retention potential (neither too porous nor to compact soil structure).
- **Improve soil pH:** Soil pH is considered a master variable in soils as it affects plant nutrient availability by controlling the chemical forms of the different nutrients and influencing the chemical reactions they undergo. When soil pH is not within ideal ranges for tea bushes, measures should therefore be taken to amend it.
- **Improve the nutrient composition of soil:** It is important to make sure the soil in which tea bushes are planted contains the right nutrients in adequate proportions by adding organic matter to the soil as well as fertilizer. Insufficient fertilizer application can lead to lower yield and lower quality. Excess application will also lead to lower yield and lower quality and additionally waste time and money.

7.2 Organic matter

Definition and objectives. Organic matter, which consists of the decomposed remains of plants, is important for maintaining soil health and soil structure, reducing soil loss and increasing nutrient and water use efficiency.

Sources of organic matter. Organic matter is naturally present in soil. However, the amount of organic matter in the soil might be insufficient and moreover, it naturally decreases over time following planting. Organic matter levels should therefore be maintained at, or increased to, a satisfactory equilibrium level for a given particular soil type. Measures to increase organic matter in the soil include:

- **Leaving plant litter in the plantation:** Retain tea bush prunings as well as leaf fall and prunings from shade trees within the tea plantation.
- **Adding organic inputs to the soil:** Add organic matter (e.g. manure, plant litter) and organic fertilizers such as compost to the soil, taking account of the benefits of different sources in respect of nutrients, micro-organisms and water retention.
- **Using soil rehabilitation crops before planting tea:** Consider soil rehabilitation by planting a prior crop (leguminous species) in areas designated for tea and growing it for 2 years before planting tea.
- **Minimizing soil exposure:** Minimise the period of time when there is no ground cover to avoid loss of top soil and organic matter due to surface run-off.

7.3 Compost

7.3.1 Overview

Definition and objectives: Compost is a natural organic fertilizer produced as a result of the oxidization of organic materials, which is facilitated by aerobic microbial activity. Compost should be used on all tea farms given its wide array of benefits, especially on organic tea farms (as petroleum-based fertilizers are prohibited when applying organic standards). Compost has many benefits including:

- **Improving soil structure**: Compost improves the physical properties of soil. It can help improve the soil structure of muddy soil and make compact soil more aerated,

which will make it easier to plough when soil is hardened by dry weather. It can also improve the water holding capacity of soil.

- **Slowly releasing all necessary plant nutrients:** Compost contains all the necessary nutrients to improve tea plant growth. Furthermore, the nutrients it contains are released slowly into the soil, which reduces the need to frequently add inputs in the soil.
- **Favouring beneficial soil organisms:** It is beneficial to organisms such as soil microbes and worms living in the soil, which naturally improve the soil, notably by improving soil structure and reducing the prevalence of soil-borne diseases.
- **Cheap:** Compost uses agriculture waste and turns it into plant nutrients. It is therefore a cheap method of producing fertilizer.
- **Preserving the environment and the health of farmers:** Using compost reduces the need to apply agrochemicals and it therefore helps protect the environment and the health of farmers.

When/where to apply compost: Compost is used at different stages of tea cultivation. It can be added to the soil after land clearing and mixed in with the soil as a soil amendment or simply added on top of it. It can then be applied during tea cultivation, by simply laying it on the soil around tea bushes where it will serve as mulch and slowly release nutrients into the soil.

7.3.2 Compost Materials and Process

Compost Materials: In order for the composting process to occur, only appropriate materials should be added to the compost pile, in the right proportions. In deciding what materials to add to a compost pile, the following recommendations should be followed:

- **Use appropriate compost materials:** Agricultural waste such as weeds, fallen leaves, corn stalks, straw, rice husks, over ripe fruit and farm yard manure (i.e. chicken and cow manure) can therefore be used for composting. If raw materials for compost are sourced from outside of the farm, care should be taken to ensure they do not contain contaminants such as heavy metals or pesticides/herbicides which can significantly reduce compost quality.
- **Only use (unprocessed) plant-based materials:** Kitchen waste can also be used for compost but beware: bones, meat and oil are attractive to rats and other insects; and fats and oil can delay the composting process.
- **Right proportion of high and low carbon content materials:** In order to achieve an ideal Carbon (C) to Nitrogen (N) ratio in the compost pile, the proportion of brown coloured agricultural waste (high C:N ratio), green coloured agricultural waste (low C:N ratio), and farm yard manure (lowest C:N ratio) needs to be carefully observed. The optimum C:N ratio in compost should be between 19:1 to 30:1.

Composting process determinants: Compost is produced from the activity of aerobic microbes (that need oxygen), which degrade organic materials. However, mixing the right materials together will not automatically produce compost. Additional factors will influence the effectiveness of the composting process including:

- **Particle Size of Substrate:** For efficient composting, materials need to be broken into smaller pieces in order to provide a larger surface for micro-organisms to react with the materials. If the materials are big, more time is required to compost them. For woody materials, the maximum size should not exceed 3 inches.

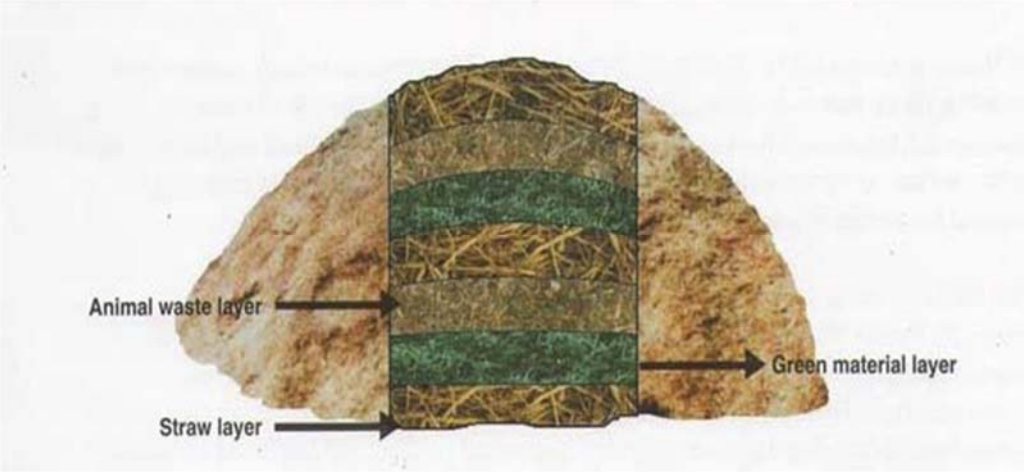
- **Air Aeration:** The pile needs to be aerated during composting as aerobic microbes that degrade the materials need oxygen to survive. Regular overturning is required to ensure that the compost heap has adequate oxygen.
- **Moisture Content:** Moisture is necessary in the right amount in order to support the metabolic process of the microbes. The optimum moisture content required during composting is between 60-65%. Moisture content below 40% inhibits microbial activity, while moisture levels above 65% restrict air movement. When moisture levels are too low, water should be added to the compost pile. Additionally, the compost pile should be done under the shade and sheltered from the rain.
- **Size of compost heap:** An optimum compost pile size is needed in order to maintain heat and moisture in the pile. The compost pile should be 10 feet long and 5 feet wide. It should not be any smaller than 5 feet long and 3 feet wide because if the heap is small, heat will easily be dissipated into the air and moisture easily evaporate due to the small internal area.

7.3.3 Making compost

Day 1 - Making the compost pile

- **Three layer stacks:** Brown coloured agriculture waste (High C: N ratio materials) should be spread up to a height of 6 inches and green colour materials (Low C:N ratio materials) stacked on top of it 6 inches. Then, the farm yard manure layer is added on top of the two layers, again 6 inches thick. After spreading the farm yard manure, pour water on the compost pile. And then repeat the stacking of the three different layers in the same order until the compost pile reaches 3 feet high.
- **Moisture & frost protection:** Lastly, cover the pile with banana leaves during summer (when it is hot) in order to retain moisture in the compost pile, and a plastic sheet during winter in order to protect the pile from the cold. The compost pile is then left untouched for three days.

Picture 9: Compost pile layers



Day 4 - Mixing the pile, testing moisture content and adjusting accordingly

- **Mixing:** On the fourth day, open the compost pile and mix it thoroughly (using appropriate tools such as a rake). After mixing, reshape the compost in its original

shape. The moisture content, which has been spread evenly within the compost pile, is then measured to determine what should be done next.

- **Moisture content measurement:** This is done by taking a handful of compost and making a ball with it. If water flows out of the ball when it is squeezed, the moisture content is too high (highly absorbent compost materials should therefore be added or the pile spread out and left to dry for a few hours). If making a ball is difficult, the moisture content is too low (water should thus be added). The optimum moisture content is one where you can make a ball with no water coming out if you squeeze it.

Picture 10: Ideal compost ball

After 2 weeks - Regular mixing: After two weeks, the compost pile should be mixed again between once every five days and once every two weeks. The temperature of the compost pile will gradually increase to between 60 and 65 degrees.

After approximately 1 month - Final result: After one month, the temperature decreases gradually. After 8 weeks, the compost pile should have changed to a brown and black colour and the materials in the pile should have decomposed to the point where it looks like soil.

7.3.4 Common problems and solutions

Table 1: Compost pile problems and solutions

Problem	Possible Causes	Solutions
None or very slow rise in temperature	Pile is too small	Add more materials
	Pile is too dry	Add water
	Imbalance between carbon and nitrogenous materials	Add more green agricultural waste material or farm yard manure (i.e. low carbon content materials)
	Not enough air	Break up the pile and turn it
Compost has bad odour	Too Wet	Turn the pile to aerate it. Add in some dry materials, possibly materials of high absorbent content such as coconut coir dust or break up the pile and let it dry for a few hours before heaping it again.
	Too acidic	Add wood ash or dolomite to neutralize the acidity
A lot of flies are present	Presence of meat or food protein	Avoid using such materials
	Presence of materials with high sugar content and high nitrogen	Cover the compost with a thin layer of soil
Composting materials gets dusty white	Material is too dry or not mixed for a long time	Mix and set up the pile again or Wet the pile with water and add nitrogen rich materials

7.4 Specific nutrient deficiencies

Definition and objectives: Organic fertilizers such as compost have all plant nutrients. However, tea under severe stress from missing one nutrient may require applying a curative fertilizer. Beware, many of these fertilizers are not compatible with organic standards.

Applying the right amount of inputs to the soil: Inputs to the soil need to be applied in the right amount. For instance, both too little and too much of a given nutrient in the soil will be bad for the plant. Using compost is the ideal solution in this sense, because if made properly, it contains all the necessary nutrients for the plant in a balanced way and will help improve the physical properties of the soil naturally. However, when specific nutrients are applied to the soil, various measures can be taken to inform the right amount.

- **Soil analysis:** Soil analysis is the best way to know how to improve soil health. It can help assess when soil pH needs to be amended and the presence of nutrients in the soil. This will help to inform optimal fertilizer application leading to maximum return on investment.
- **Calculated residual nutrients**: If soil analysis is not feasible, application rates can also be adapted in response to roughly calculated residual nutrients in order to maintain a nutrient equilibrium. The calculation should take into account the amount of nutrients already in the soil at the time of planting and how much of a given nutrient has already been added to the soil minus outputs i.e. how much is taken out in the harvested product as well as stored in the soil, tea bush biomass and in ground vegetation.

Specific nutrient deficiencies and treatments: The following table presents the major potential nutrient deficiencies tea bushes may face, their symptoms and the treatments that can be adopted to remedy the nutritional deficiency in question:

Table 2: Nutrient deficiencies and treatments

Nutrient	Deficiency symptoms	Solution/Treatment
Nitrogen (N)	- Slowed growth of tea bush. - Leaves changed to yellow colour. - Lower leaves falling.	If nitrogen is the deficient nutrient, fertilizer application should wait until the grower can be sure that rain will follow within a few days. Excess application: Dark green, fleshy and succulent shoots throughout the plucking table.
Phosphorous (P)	- Old leaves become deep green and smooth. - Sometimes, changed to purple colour. - Tips of leaves become Yellow	Consider the use of ground rock phosphate (except in high pH 'hut sites') and specifically when carrying out land preparation for replanting. Incorporation of rock phosphate will reduce subsequent reliance on soluble/liquid Phosphorous fertiliser which may enter into water courses.
Potassium (K)	- Liners of leaves dry. - More branching- Rosette - Stems become smaller and white colour. - Leaves form rollers	Excess calcium, sodium, or nitrogen in your nutrient solution prevents plants from absorbing potassium. Those conditions can be the result of using water that is high in minerals.
Calcium (Ca)	- New top leaves appear mottled, misshapen, or stunted.	When the pH of your nutrient solution falls below 6.0, calcium becomes less water-soluble and plants are not able to absorb it efficiently. Adjust the pH so that it is not too acidic. If the pH is in the right range, use a bone-meal supplement, which is rich in calcium, to increase the supply of the mineral. Liming will be needed. Egg shell with vinegar mixed with 100 times of water can be applied for calcium.

Magnesium (Mg)	- The older leaves (lowest on the stem) turn yellow or bright green - starting at their edges, and may even become white while veins remain dark green. The leaves begin to curl upward and eventually drop off.	The pH levels of the nutrient solution must be between 6.0 and 6.5 for plants to absorb magnesium, and plants need appropriate levels of calcium to take up and use magnesium, too. When you need to add supplemental magnesium, Epsom salts (magnesium sulfate) are a widely available source. Bear in mind that leaves afflicted by a magnesium deficiency probably will not recover, but the yellowing and loss of lower leaves should stop when the problem is corrected.
Zinc (Zn)	- Leaves become smaller ("Little leaf") - Shortening of the internodes ("Rosette") - Due to the difference on growth, leaves curl in the shape of sicles. - Increased banjhi formation	Spray Zinc sulphate. Zinc is vital for plants' production of chlorophyll and healthy leaf and stem development. As with other minerals, alkaline and acidic conditions (high and low pH) block plants from absorbing zinc. Bone-meal supplements both raise the pH and increase plants' calcium content, which helps them better absorb zinc.

pH management: Small areas of high pH soil should be planted with high-pH tolerant clones in a large planting hole (25cm x 40cm) with sulphur added at the rate of 60g per hole. Hut sites may be indicated by young tea plants showing stunted growth, crinkled leaves and balling of the roots. If soils become too acidic (below pH 4), apply lime at the time of pruning, using good quality dolomitic lime if available. Recommended rates should be obtained from local research/advisory services.

Climatic conditions: Normal fertilizer applications should avoid prolonged cold or wet seasons, and if they are made during dry weather they should be delayed until it appears that rain will fall within a few days.

Balanced application: The first consideration should always be given to planning a fertilizer programme that allows efficient and even distribution of the fertilizer. Timing of the last application in a cycle would depend on the anticipated cropping pattern in the last few months.

Applying liquid fertilizer correctly: Certain precautions should be taken in applying non-organic fertilizer including:

- Do not apply liquid fertilizer during periods of drought.
- Temporarily remove mulch so that the liquid fertilizer can penetrate the soil directly, and place the mulch back afterwards.
- Spread the liquid fertilizer around each plant in a broad circle never less than 10cm wide. Fertilizer must not to touch the plant's stem, and the ring should therefore be extended from 5cm from the plant stem to just beyond the spread of the shoots. Dribble the fertilizer into the soil to a depth of 5cm.
- Avoid applying fertilisers within 3-4 metres of watercourses. Algae blooms in ponds within the farm should be investigated. Blooms indicate nutrient leakage to surface water.

8 Plant Protection

8.1 Pest Management

8.1.1 Overview

Pests and pest control: All crops including tea are subject to damage by pests such as insects, mites, nematodes and rodents, which can attack the roots, the stems or the leaves of tea bushes. In order to maximize the economic value of crops and protect harvested products from food safety risks, various pest control measures may be warranted.

When to control pests: The presence of pests is normal on any tea plantation and seeking their total eradication is therefore usually not a realistic or economically sound objective. Instead, it is only when the economic damage caused by pests outweighs the costs of pest control measures (in terms of time, effort, money, etc.) that pest control measures will need to be adopted.

How to control pests: Pest population dynamics depend on environmental factors, biological factors and human factors (i.e. pest management practices and cultivation practices). Coincidentally, different methods of control can be used to manage pest populations such as:

Table 3: Pest control methods

Type of control	Example
Cultural control	Plucking, pruning, shade management, weed control, use of pest resistant clones intercropping and other measures favouring insect biodiversity
Mechanical Control	Manual collection/removal of pests or infested plants and destruction
Biological Control	Use of predators, parasites and pathogens to eliminate pests
Chemical Control	Use of insecticides, pheromones, juvenile hormones and chemo-sterilants

8.1.2 Integrated Pest Management

Ideal pest control system: While different control methods will be more suitable in some cases than in others, combining different methods i.e. Integrated Pest Management (IPM), which minimizes recourse to chemical control methods, is the key to sustainable pest control.

Objectives of IPM: Careful consideration of all available pest control measures and their subsequent integrated use will serve to improve biological balance and minimize the use of pesticides. IPM will keep control measures within economically acceptable levels, and will also minimize risks to health and the environment.

Key requirements for an IPM system: Implementing an IPM system implies combining different pest control methods but also doing so in a well thought out manner that will result in the best choice of control method and greatest economic benefit. Key requirements for

an IPM system include:

- **Routine cultural controls:** Regular cultural control methods should be adopted such as the destruction of breeding sites when discovered, and maintaining good ground cover to control weed growth.
- **Understanding risk:** Farmers should learn as most as they can regarding the main pests they face, including what is their life cycle and what are their natural enemies in order to be able to better respond to them when needed. Records should be kept on their presence and their effects to inform what measures can be taken to limit the damage they cause and when.
- **Establishment of action thresholds:** Based on the economic damage that main pests can cause, which is informed by past experience (especially if records are kept), thresholds should be determined as to when control measures are warranted. As previously mentioned, the objective is to adopt control measures when the benefits outweigh the costs.
- **Pesticide use as a last resort:** Pesticides should only be used as a last resort. If pesticide use is necessary, selectivity is important to reduce eco-balance disruption and ensure operator safety. In any case, prophylactic (preventative) use of pesticides should never occur.

8.1.3 Common pests & control measures

White grubs: White grubs are root feeding larvae of scarab beetles (chafers or cockchafers). The adult beetles deposit their eggs in the soil from March to June. The larvae start to emerge from eggs from about June until about August. The grubs can move from plant to plant.

- **Effects:** White grubs can cause damage both in tea nurseries and tea plantations. White grubs eat mainly the underground portion of tea bushes, namely the roots. As a result, the upper portion of tea bushes, leaves and branches become dry.
- **Control measures:** Given that white grubs proliferate in undecomposed farm yard manure, when manure is brought to the field, make sure it is sufficiently decomposed beforehand. Additionally, chemical controls such as neem extract or pyrethrum-based insecticide, or biological controls such as beneficial nematodes or Beauveria Bassiana (fungi) can be used.

Picture 11: White grub

Thrips & Mites: Thrips and mites are major pests in all tea growing countries, which feed on tea plant sap. Thrips are small in size but often large in number when they appear. They proliferate under warm and humid conditions and mostly spread with the wind as they are weak fliers.

- **Effects:** As a result of the sap being taken out by thrips or mites, the surface of leaves become uneven, curled and matte. Additionally, the leaf margins become yellow.
- **Control measures:** Different control methods are available to combat thrips and mites.

- **Spraying water**: Attach a spray nozzle to a hose, and blast the infested plants with a high-pressure cold-water spray to dislodge and drown the pests. If spider mites are the problem, focus on the undersides of the foliage. To completely eliminate thrips, you may have to spray for three consecutive days.
- **Pruning:** Prune thrip-infested leaves from tea bushes, and seal them in plastic bags for disposal. Use stem cutters to snip individual leaves. Cut larger branches back to leaf nodes or branch junctions with pruning shears.
- **Insecticidal soap:** Kill spider mites on tea bushes with insecticidal soap. Make a 2 percent soap solution by mixing 5 1/3 tablespoons -- or the manufacturer's recommended amount -- of insecticidal soap concentrate per 1 gallon of water. Using a hand-held trigger or knapsack sprayer, apply the solution until it drips from the infested plants, taking care to hit the undersides of the leaves. For most effective thrips control, spray every three days for two weeks.
- **Spinosad insecticide**: Eliminate outdoor thrips with ready-to-use, microbe-based spinosad spray, covering the infested plants until the insecticide runs from their leaves. Spinosad kills on contact or through ingestion but works best when the thrips ingest it. Spray in the early morning or after dark so that you don't harm honeybees, and repeat as needed until no more larvae are hatching from eggs deposited in the leaf tissue.

Picture 12: Possible Effects of Thrips (Source: DoA, Collection of Presentations)

Crickets: Crickets are insects that like to feed on young plants.

- **Effects:** Crickets attack especially the transplanted plants from the nursery. Crickets cut the stems close to the ground and eat the leaves.
- **Control measures:** Different control methods are available to combat crickets.

- **Cricket water traps:** Mix some molasses with water in a large container or jar. Place the container close to the cricket-infested area. The crickets will be attracted to the scent of the molasses and drown once they hop into the container.
- **Sealing nursery entry points:** Prevent more crickets from entering the nursery by sealing up any gas or cracks along the wall.
- **Food-grade diatomaceous earth**: Food-grade diatomaceous earth is a non-toxic powder that will eradicate crickets by piercing and drying out their exoskeleton. Grab a bag of food-grade diatomaceous earth and spread food grade diatomaceous earth along areas where crickets are likely to hide, such as wall crevices.
- **Poisonous cricket bait:** Create poisonous cricket bait by mixing two cups of cornmeal with two teaspoons of boric acid. Mix it well and then place the bait close to areas where crickets are likely to gather at night.

Root knot nematodes: Root knot nematodes are parasitic worms that attack the roots of tea bushes.

- **Effects**: They can appear both in the nursery and on the plantation. These nematodes attack the roots of tea plants, which causes them to develop knots or galls and become defunct and devoid of lateral roots. The above ground portions of the plant will exhibit stunted growth and chlorosis (inability to produce chlorophyll).
- **Prevention and control measures**: Adding organic matter to the soil encourages the growth of numerous beneficial organisms including fungi, bacteria and beneficial nematodes that may provide some level of biological control for root-knot nematodes. Additionally, adding neem cake can be effective, especially for mature tea.

Rodents: Rodents include rats and mice.

- **Effects**: Rodents dig holes near the tea bushes which disturb the proper development of the tea bushes' roots or they might even feed on the roots.
- **Control measures**: Rodents proliferate in fields full of grasses. Therefore, one major cultural control measure is to keep plantations free from grasses as much as possible. Other traditional control measures are manual trap setting and using poison baits. Lastly, Gliricidia sepium (Tropical trees) can be grown at the border of tea plantations to prevent entry of rodents given that its leaves are poisonous to rodents.

8.2 Weed Management

Weeds definition: Weeds consist of any plant which competes with the planted crop for resources or that adversely affects the cultivation of a crop in any way.

When to control weeds: The growth of weeds on any plantation is a normal occurrence which is to be expected. As such, their total eradication is neither feasible nor economically sound. Instead, the objective of weed control should be to avoid weeds from significantly adversely affecting the tea plants. As such, control measures should be taken when weeds:

- **Compete for resources:** Weeds compete with tea bushes for nutrients, moisture and sunlight.

- **Favour pest and disease incidence:** The presence of weeds may provide a favourable habitat for pests and increase the incidence of diseases such as blister blight.
- **Complicate cultivation:** Weeds may sometimes make it harder to cultivate tea as it might for instance impede circulation in the plantation.

Weed control methods: There are different methods to control the proliferation of weeds.

Table 4: Weed Control Methods

Cultural control	Mulching, raising cover crops, closer planting of crops, infilling, longer pruning cycles and higher tipping heights
Mechanical	Manual weeding by hand or with tools and implements
Chemical	Using herbicides
Biological	Controlling weeds using living organisms (e.g. that eat the weeds)

Mechanical and cultural control methods: Cost-effective cultural control methods should be adopted, including the use of mulches as well as developing high plucking tables with many plucking points (which will provide more shade and therefore limit weed growth). Regular manual weeding is also recommended.

Homemade Organic Herbicide: White vinegar sold in grocery stores is about 5% acetic acid, which is usually strong enough to kill most weeds. An industrial strength version with up to 20% acetic acid is also available in many gardening supplies stores. Great care should be taken when using the stronger version as it can be harmful to skin, eyes, or lungs and protective measures (e.g. wearing gloves, long sleeves, a surgical mask). The vinegar can be applied by spraying full strength onto the leaves of the weeds, being careful to minimize any overspray on tea bushes and nearby soil. Repeated applications may be necessary, and the addition of a little liquid dish detergent and one cup of salt may improve the effectiveness of this homemade herbicide.

8.3 Disease Management

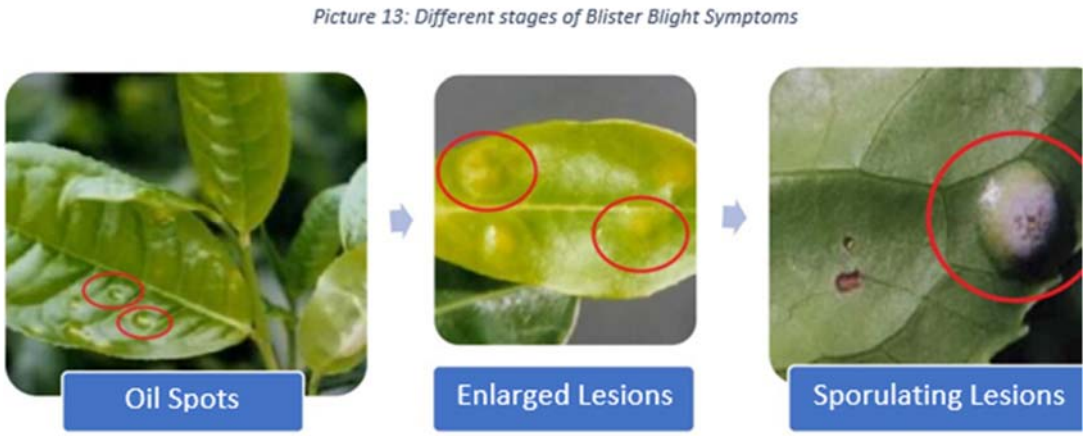
Diseases and disease management: Diseases can cause great damage to infected tea plants by disrupting their normal function or even causing their death. Control measures must therefore be taken to avoid their occurrence and control the damage they can make and their spread.

Different types of diseases and effects: Different types of diseases have different major effects. Root diseases will often have effects on the whole tea plant, affecting yield, quality and sometimes even leading to the death of the tea plants. Stem diseases will mostly lead to less productive plants and therefore yield stagnation. Leaf diseases will make leaves unusable and therefore lead to crop loss.

Blister blight: Blister blight is a disease caused by a pathogen called Exobasidium vexans that proliferates under high humidity conditions, cooler temperatures and low sunlight exposure. It can therefore be a major problem at higher altitudes and especially in the later months of the rainy season when sunlight levels and temperatures are diminished.

- **Effects:** The symptoms appear on young tea leaves where small, pinhole-size spots can be seen, developing gradually into blister like white and velvety bulbs, which in turn gradually turn brown and eventually causes infected stems to become bent and distorted and possibly break off and die.
- **Control Measures:** Detection of Tea Blister Blight is done via a visual inspection of the crop plants for the characteristic blisters. The pathogen that is responsible for blister blight is very sensitive to direct sunlight, which in excess of 4 hours will readily destroy it. Therefore, cultural control methods limiting shade given to tea plants should be taken such as planting rows at greater distances apart or diminishing the shade from surrounding trees (see section 4 on Shade Trees. Otherwise, removing and destroying the infected stems will diminish the potential spread of the pathogen

Picture 13: Different stages of Blister Blight Symptoms (Adapted from DoA, Collection of Presentations)



Root Diseases: Root diseases are generally caused by fungi, which proliferate in wet and damp soil. Its major cause is therefore improper drainage of the soil. Care should be therefore taken to look out for occurrences of water logging (accumulation of water around tea bushes).

- **Effects:** Fungi infect the roots, which then start to rot. As a consequence, the upper portion of tea bushes will start to wilt and dry. When the symptoms become obvious, that will mean the fungal pathogen has attacked 50% of the plant already.
- **Control measures:** Detecting root disease is very difficult. Once infection has been detected, infected tea plants (including their roots) should be removed from the plantation and burnt (transported in hermetic bag away from the tea plantation and burnt elsewhere). Besides uprooting and disposal, another control measure is the application of neem cake and Trichoderma viride or P. fluorescens. The selection of healthy nursery material as well as ensuring proper water drainage will help prevent the advent of root rot diseases.

Picture 14: Potential Root Diseases (Adapted from DoA, Collection of Presentations)

8.4 Chemical Control

Risks of chemical control: The use of synthetic pesticides and herbicides should be minimized as they can pollute the soil and water sources, and cause ill-effects for humans. It should also be noted that pesticides may kill natural enemies of pests and allow an epidemic to develop.

Precautions in pesticide use: Pesticides should therefore only be used where unavoidable and in the context of a well-managed Integrated Pest Management programme. The use of pesticides and herbicides is often severely restricted for certified land. Certification should therefore be consulted before resorting to a given pesticide. If used, certain additional recommendations should be followed including:

- **Ensuring safety of pesticides**: Ensure that ecologically and medically safe compounds are used, applied in accordance with industry and advisory service best practice, as well as applicable standards.
- **Varying products used:** To achieve sustainable weed/pest control and reduce the risk of developing herbicide/pesticide resistance, a planned programme of changing active ingredients may be introduced.
- **Minimizing spraying volume:** Ultra low volume or similar technology should be used to minimise discharge chemical levels. Spot spraying with proper targeting of the weeds should be practiced.
- **Using proper equipment and following proper use procedures:** Pesticides must not be used in the absence of proper training, proper use procedures and appropriate application equipment and protective clothing. Spray equipment must be designed and maintained to target the application effectively and use the minimum amount of chemicals to achieve the desired outcome. It is important to minimise spray-drift, especially where watercourses could be contaminated or near to accommodation.
- **Keeping records**: Accurate records must be kept of pesticide use.
- **Pesticide storage**: Pesticides must be stored safely and securely; and use procedures, including action to be taken in the case of spillage accidents, must be clearly defined and enforced.

Usually not needed for mature tea: Disease and insect problems should not be significant in mature tea, which will almost always outgrow short-term infestations, such as red spider mite, without the need for pesticide application.

Organic pesticides: Where it is necessary to resort to pesticides, organic pesticides should be prioritized. Different organic pesticides may be used, including:

- **Spinosad:** Spinosad is a soil-based bacterium that kills garden pests including bagworms, borers, beetles, spider mites, tent caterpillars, and loopers, and comes in liquid and dust formats under a variety of brand names (just look for Spinosad as an active ingredient). Once Spinosad dries, it will kill insects that ingest it. The risk of harming bees or other beneficial insects can be reduced if sprayed in the evening when they are less active.
- **Rotenone:** Rotenone is an organic pest killer that is also moderately toxic to most mammals and occurs naturally in seeds and stems of some plants. Rotenone will kill leaf-feeding caterpillars, beetles, aphids, and thrips. Patience should nevertheless be observed as it is a slow-acting chemical that requires a few days to work. Rotenone should be used with extra caution in proximity to ponds or lakes as rotenone is extremely toxic to fish.
- **Pyrethrin:** Pyrethrin is extracted from the chrysanthemum plant. It is non-toxic to most mammals, making it an especially safe choice. This insecticide is a powerful, fast-acting deterrent, even at low doses. Upon exposure, most flying insects will immediately drop, but may not always be killed. Some manufacturers mix pyrethrin with more fatal solutions to ensure insect death.
- **Bacillus Thuringiensis (BT):** BT is a naturally-occurring bacteria that makes pests sick when ingested. Spray on leafy vegetables that caterpillars eat and BT will kill them from the inside out. Because it is only harmful upon eating, this is an extremely safe organic pesticide for preserving beneficial insects.
- **Neem oil:** Neem is extracted from a common Asian tree and inhibits the growth cycle of insects. Its active ingredient, azadirachtin, will cause infected insects to eat less and grow more slowly. This is a good option for those who do not yet have major pest infestations and want to get a head start on reducing the quantity of potential pests.

9 Plucking

Definition and objectives: Tea plucking is the removal of the top most bud and tender shoots of tea, which are used for processing into drinkable or edible tea.

Choosing the right plucking style: Plucking practices affect bush health, yield and quality of tea. Moreover, plucking is typically one of the most labour intensive and hence expensive cultural operations. The ideal tea plucking style will therefore differ depend on availability of labour and the price offered for different standards of plucking.

Plucking styles: Plucking only two leaves and one bud will produce the highest quality tea and hence fetch the highest price per viss. Plucking three leaves and one bud will also result in high quality tea. On the other hand, plucking more leaves will allow a higher plucking average and result in a low increase in the height of the plucking table (therefore making it easier to pluck). This will nevertheless adversely affect bush health, delay new shoot development and facilitate crow's feet branch formation, which altogether will decrease yield over time. The mother leaf (under the plucking point) should therefore be left untouched in order to shorten the time until the next plucking can take place. Fish leaf plucking (plucking more than 5 leaves) is strongly discouraged.

Plucking period and frequency: In most of the tea cultivated areas in Myanmar, tea plucking is performed between March and October (over 8 months). In March, April and May, plucking is performed 3 times per month (a total of 9 times). Tea picked before the rainy season begins in May is known as Shwe Phi Moe Lut, and is famed for its stronger taste and higher quality. In June, July, August, September and October, plucking regime decreases to twice per month (a total of 10 times). The total times a tea bush is plucked per year therefore should be approximately 19 times.

Plucking success factors: In order to facilitate plucking and ensure plucking of high-quality shoots, certain recommendations should be followed:

- **Plucking age of tea bushes:** Young tea bushes should not be treated as a source of fresh tea leaves until tea training is finished (see section 5.3 on Tea Training). When they are young, the priority is to shape the tea bushes into ideal frames.
- **Ideal plucking table:** In any case, the plucking table of a tea bush should be even and at an adequate height (see section 6 on Tea Pruning), which will make identification of pluckable shoots and their removal easy.
- **Climatic conditions of plucking:** Plucking should ideally be performed when the leaves are dry as to avoid the proliferation of fungal pathogens in the freshly picked tea leaves.
- **Regular plucking interval:** The plucking interval, which is the time between two successive plucking operations, should be regular. If the plucking interval is longer than the regular plucking time, young shoots will become rough and Banji buds will form, which will decrease the yield and quality of tea. Long plucking intervals will also produce unwanted increases in the height of the plucking table.

Educating workers doing the plucking: Owners of plantations should educate workers to pluck correctly and according to the standards of buyers. If workers are rewarded only based on the amount of fresh tea leaves they pluck, they will tend to also pluck large and rough shoots rather than pluck only high- quality shoots.

10 Propagation

10.1 Introduction

Propagation methods: Different methods exist to produce new tea plants. Tea plants can be raised from seed, cuttings and tissue culture (micro propagation). In this guide, we describe best practices relative to seed propagation (i.e. using tea bush seeds) and vegetative propagation (i.e. using tea bush cuttings). Seed propagation can be performed by sowing the seeds directly in the plantation or by first growing them within seed bags in a nursery, which will be transplanted to the plantation at a later stage. Here, we do not describe best practices for direct seeding.

Ideal propagation method: Seed propagation and vegetative propagation both have advantages and disadvantages that need to be weighed carefully before choosing which propagation method will be adopted.

- **Vegetative propagation:** Vegetative propagation has the advantage of guaranteeing that the genetic characteristics of the new tea plant are the same as those of the mother bush, and it therefore allows farmers to select what genetic characteristics they want from a new tea bush (e.g. high yield or drought resistance). Additionally, vegetative propagation is operationally easy, rapid and cheap compared to seed propagation.

- **Seed propagation**: Seed propagation, on the other hand, will allow stronger root development as tea bushes growing from seeds will develop a taproot system compared to cuttings, which will only develop a fibrous root system (which is less strong). Tea bushes propagated by seed therefore take root more easily in their new environment and are less likely to fall over or be uprooted.

10.2 Nursery

Definition & objectives: Propagation is a delicate operation during which propagated materials i.e. seedlings or cuttings are most vulnerable to environmental variability, pests and other pressures. Nurseries serve as the protective environment that will house tea cultivars before they are transplanted in the plantation.

Why establish a nursery: Establishing a nursery is both costly and time-consuming. It is therefore generally more efficient to acquire tea cultivars from commercial nurseries or other sources. On the other hand, if quality tea cultivars (cuttings or seedlings) are not readily available or if they are located very far away, a tea nursery may be established.

Nursery site selection criteria: In order to ensure the ideal environmental conditions for propagated materials, nurseries should ideally be built in places conforming with certain criteria including:

- **Shelter:** Adequate shelter or an adequate space to build shelter should be available to protect propagated materials from prevailing wind, frost as well as wild and domestic animals.
- **Soil:** Deep free draining, friable soil with a pH range of 5.0-5.6 should be available in close proximity to the nursery as such soil is considered ideal for propagated materials.
- **Water:** The nursery should be established close to a permanent source of water suitable for irrigation of crops to facilitate regular watering of propagated materials.
- **Ease of access**: The nursery should be located as close as possible to the planting site or, at least, be easily accessible by road, which will minimize the risk of damage to propagated materials from transport at the time of transplanting as well as facilitate transportation of other needed materials to the nursery site (e.g. fertilizer or shed building materials). Finally, it should also be located in a place easily accessible to facilitate supervision of tea cultivars.
- **Terrain**: The surface of the nursery site should ideally be flat although it is acceptable if there is a gentle slope. Finally, low-lying areas which become very wet following rains or which get frost during dry months should not be selected as locations for the nursery site.

Nursery building: Following selection of the site, the nursery will have to be built, which maintains the temperature tea cultivars are exposed to, protects them from the wind and rain damage, and maintains a certain degree of moisture. Furthermore, the tea nursery should provide between 50% and 80% of shade to tea cultivars depending on weather/climatic conditions. In this process, farmers should also:

- **Adapt size of nursery to needs:** The amount of land to be used depends on the size of the tea plantation, its goals, and the availability of land in general.
- **Purchase nursery materials early**: Purchase the necessary nursery materials (fencing, construction materials, tools, pots, plastic potting bags, etc.) well in advance of the planned start-up date. Early purchase of materials will avoid delays in planting or transplanting.

- **Use local resources**: Whenever possible, local materials, local labour, and other resources and appropriate technologies available locally should be used. Costs may be reduced and local acceptance increased by the use of local materials and labour and the integration of local knowledge into the design and construction work. Materials not available locally can normally be acquired from government forestry offices or agricultural suppliers.

Picture 15: Tea nursery (Source: DoA, Collection of Presentations on Tea Production)

10.3 Vegetative Propagation

10.3.1 Introduction

Definition: Vegetative propagation (also known as "clonal propagation") consists of taking a cutting (i.e. a stem or leaf) from a "mother bush" and growing a tea bush "clone" from it. Vegetative propagation ensures that the genetic characteristics of the new tea bushes are identical to the genetic characteristics of the mother bush (i.e. that they are "clones" / true to type plants).

Advantages: Vegetative propagation is superior to seed propagation in ensuring new tea bushes are of the highest genetic quality given that it allows "cloning" of mother bushes with desirable characteristics. Additionally, it is a fast, easy and cheap method of propagation.

Disadvantages: Cuttings used for vegetative propagation develop fibrous root systems which are generally less strong than taproot systems, which develop during seed propagation.

Vegetative propagation in a nutshell: Vegetative propagation includes a number of successive steps, namely:

1. Selecting mother bushes
2. Preparing mother bushes
3. Collecting cuttings

4. Growing cuttings
5. Hardening cuttings

10.3.2 Selecting Mother Bushes

Definition and objectives: The first step in vegetative propagation is the selection of the mother bush from which cuttings will be collected. This is very important given that the tea bushes which develop from the tea cuttings will exhibit the same genetic characteristics as the mother bush from which it originates.

Selection criteria: Mother bushes should be selected based on a number of characteristics they exhibit including:

- **Plant production:** Good yield of pluckable tea leaves and good quality of pluckable tea leaves.
- **Branching profile:** Healthy and robust branches that are neither too spread out nor too upright.
- **Plant robustness:** Drought Resistance (erect tea bushes are more resistant to drought) Resistance to diseases and pests might also be taken into account if prevalence of diseases and pests is high.
- **Rooting profile:** Easy rooting types should be selected given that some types of cuttings struggle to take root.

Mother bush cultivar: Ideally, once selected as suitable to produce high quality cuttings, mother bushes should be cultivated only as mother bushes and not be plucked like other tea bushes in the plantation. Approximately 250 cuttings can be collected from a mother bush per year.

10.3.3 Preparing Mother Bushes

Pruning mother bushes: In order for mother bushes to produce suitable cuttings for vegetative propagation, mother bushes should be pruned approximately 6 months before collection of cuttings, in order to ensure the cuttings exhibit juvenile characteristics.

- **Frequency of pruning:** Prune mother bushes twice a year even if the cuttings are needed only once. Never allow new stems to remain on the mother bush for more than seven months as the material becomes hard and the resulting cuttings grow poorly.
- **Timing of pruning**: Mother bushes should be pruned in September and October. After that, young branches serving as cuttings are available in April and May.
- **Pruning method:** The pruning method producing the ideal cuttings is heavy pruning, which consists of cutting the branches above 6 to 10 inches, using a normal cut-across method. However, as previously mentioned (see section 6 on Tea Pruning), this method can be extremely harmful to the tea bush. Therefore, medium or light pruning might be preferred. In any case, clean out (remove weak and crossed branches) only once a year, during one of the prunes.

Mother tea bush inputs: Since mother tea bushes are usually used as regular sources of cuttings, removal of nutrients from mother tea bushes occurs at a much greater rate than plucked tea. Mother tea bushes that are weakened by a lack of nutrients produce less cuttings, which grow roots less easily and grow more slowly in the nursery. Fertilizer

should therefore be given to mother bushes to ensure they have access to an adequate amount of nutrients.

- **Double dose compared to plucked bushes:** Mother bushes should be given approximately twice as much fertilizer (of the same kind) per year as plucked bushes of the same age.
- **Frequency:** Fertilizer should be applied to mother bushes at least twice per year
- **Timing:** The fertilizer application can be made two or three months after each pruning. If it is anticipated that two or three months after pruning there will be no rain, then the fertilizer should be applied immediately after pruning.
- **Mulch:** Retain branches and shoot material left over after the cuttings have been prepared and use them as mulch laid down around the mother bushes.

10.3.4 Collecting Cuttings

Cuttings: A cutting is a part of a plant which is cut off its host ("mother") plant and that, under the right conditions, can grow into a new plant of its own.

Selecting quality cuttings: Cuttings should be selected based on a certain number of criteria to maximize the likelihood of growth into high quality new tea plants, including:

- **Healthy cuttings:** The cuttings collected should have a healthy mother leaf with an active axillary bud, and be free from pests and diseases.
- **Age:** Only vigorous young shoots between five to seven months old (i.e. having grown after pruning) should serve as cuttings.
- **Shiny Leaves:** The leaves on the cutting selected should be shiny (in order to ensure ideal photosynthesis rates of the cuttings.

Collecting and preparing the cuttings: Cuttings should be collected early in the morning or in the evening. Cut the young shoots that will serve as cuttings at a 45 degrees angle. The very soft tips and the very hard lower parts of the cuttings where bark is forming should be discarded. Only green semi hard wood portion should be retained. Each cutting should consist of a single leaf with 1 to 1.5 inches of stem below the leaf, with an active axillary bud towards the bottom of the stem.

Post-collection cuttings handling: Once collected, the cut branches or cuttings should be stored in wet sacking and taken to shelter under the shade. As soon as possible after the cuttings have been collected and the unwanted parts disposed of, the cuttings should be soaked in an anti-fungal solution for about 30 minutes and then planted.

10.3.5 Growing cuttings

Preparing sleeves: Polythene sleeves are recommended for growing cuttings. Sleeves should be packed with soil and the soil pressed gently so that it is neither too loose (in order to exclude air pockets and avoid loose planting) nor too compacted (in order to allow easy rooting).

Planting the cutting in the sleeve: Insert the cutting at the center of the sleeve. The leaf and the bud underneath it must never touch the soil (plant cuttings in the sleeves so that the bud is just above the soil level). In cases where the leaves of the cutting are natural deflexed (bending backwards instead of upwards), the stems should be inserted into the soil at an angle so that leaves are clear of the soil.

Fixing the cutting into place: The inserted cutting should then be fixed into place by pressing with 2 hands around the cutting. During planting, fingers should not touch the top or bottom cuts of the stems as the sweat from the fingers may affect their survival.

Watering: The cutting should be kept moist by frequent watering. Watering should be done gently as strong jets may displace cuttings.

Preserving moisture and temperature levels: Polythene sheeting (250-500 gauge) should be used to create a tent encompassing the cuttings and create a hermetic environment excluding excessive exchange of air and therefore preserving moisture and temperature levels.

Picture 16: Tea cuttings (Source: DoA, Collection of Presentations on Tea Production)

10.3.6 Hardening

Definition and objectives: Once cuttings have reached a certain level of growth, they have to be prepared for field planting by gradually exposing them to normal environmental conditions.

Hardening process: The hardening process should be conducted according to the following guidelines:

- **Gradually removing the polythene sheet:** 3 to 4 months following planting of cuttings in the sleeves, the polythene sheeting (hermetic tent) should be loosened at both ends while leaving it touching the ground as to allow air to enter. Approximately one week later, the polythene sheet should be rolled up at both ends as to allow air to circulate freely. The polythene sheet should then be gradually rolled up more and more each week until the whole bed is uncovered.
- **Gradually exposing the cuttings to exterior and increased sunlight:** After removing the plastic cover and at the age of 6 months old, cuttings should be moved under partial shade. Gradually, the cuttings should be exposed to more and more sunlight, until they are completely habituated to normal exterior sunlight conditions. Nevertheless, the bottom portion of the sleeves should be protected from sunlight in order to avoid potential damage to the roots.

- **Maintaining moisture levels:** In any case, the soil should not be allowed to dry up during the whole hardening process.

10.4 Seed Propagation

10.4.1 Introduction

Definition and objectives: Seed propagation consists of growing new tea bushes from tea seeds.

Advantages: Seed propagation allows stronger root development than vegetative propagation as tea bushes growing from seeds will develop a taproot system compared to cuttings which will only develop a fibrous root system. Seed propagation therefore gives rise to tea bushes that take root more easily in their new environment and that are less likely to fall over or be uprooted.

Disadvantages: Given that seeds are produced from pollination of tea flowers, their genetic characteristics are not identical to the bush which they come from which makes it more difficult to select seeds based on desirable plant characteristics (e.g. high yield or resistance to pests and diseases).

Seed propagation in a nutshell: seed propagation includes a number of successive steps, namely:

1. Collecting seeds
2. Selecting quality seeds
3. Cracking seeds
4. Transferring seedlings to bags
5. Hardening seedlings

10.4.2 Collecting seeds

Age of seed production: Tea bushes can start flowering approximately 3 to 5 years after planting. Nevertheless, older tea bushes will tend to flower and fruit more given that flowering and fruiting tends to increase with tea bush age. Additionally, in general, tea bushes of the Sinensis variety (Chinese variety) will tend to flower more than the Assamica variety.

Mother tea bush selection: Producing fruits and therefore seeds takes a lot of energy for tea bushes. Therefore, tea bushes from which seeds are taken should be clearly distinguished from tea bushes from which fresh tea leaves will be plucked. Additionally, seeds should also be collected from productive tea bushes (even if, as previously mentioned, resemblance with the mother tree will not be perfect contrarily to vegetative propagation).

At what time of the year do they produce fruits/seeds: Tea bushes can flower throughout the year, but the flowers present from June to July can transform into fruits. These fruits contain the seeds of the tea bushes, usually between one and three of them. Approximately 100 days following fertilization of flowers, tea fruits become mature. As such, in general, the ripening stage of tea fruits occurs from mid-October until the beginning of December.

When should fruits/seeds be collected: Fruits should only be harvested when their wall colour changes to dark green or brown, which will signal that they are ripe enough.

Quality seed selection criteria: While most tea bushes produce seeds, not all of these seeds are of the same quality i.e. they will not all germinate, produce strong seedlings and eventually robust tea bushes. Certain indicators can help to identify which seeds are of higher quality than others including:

- **One seed per fruit:** Generally, the seeds from fruits which have only one seed are of better quality than the seeds which come from fruits with multiple seeds in them.
- **Shiny dark seed coat colour:** Seeds with a shiny dark coat colour are usually of higher quality.
- **Half an inch seed size**: The diameter of seeds should be half an inch. Seeds of half an inch in diameter can be screened with sieves.
- **Heavier seeds**: Heavier seeds are usually of higher quality than lighter ones (seeds that are empty should be discarded).
- **Floating test:** Quality seeds should sink in water. To perform this test, put 1 kg of seeds in at least 5 litres of water. The good quality seeds should have dropped to the bottom after 24 hours.

Viability of tea seeds: The viability of tea seeds following collection is very short, usually up to a month or maximum up to six weeks, after which they will not germinate. Therefore, seeds should be germinated at the latest within 3 weeks after their collection from tea bushes. If seeds are not directly used following collection, they can be temporarily stored in paper cartons in a cool and dry place.

10.4.3 Cracking Seeds

Preparation of Cracking Bed: Cracking beds should be prepared in advance before seed cracking. Cracking beds should be 3 feet wide and at least half a foot high, with rough sand spread at a thickness of 2 inches on the top of the bed of soil. Length of the cracking bed should depend on land condition/availability as well as intended production quantity of seedlings.

Putting the seeds in the cracking beds: Seeds are placed on the cracking beds in rows one inch from each other. The distance between 2 rows is also one inch. The tea seed scar should be turned upside down and pushed down into the cracking bed leaving only one quarter of the seed exposed on the surface of the cracking bed. This will allow seed cracking to be observed.

Facilitating seed cracking: Seed cracking/germination requires moisture and higher temperatures.

- **Watering:** Prior to placing the seeds in the cracking beds, the cracking beds should be watered and the soil compacted. Following the placement of the seeds, the cracking beds should be watered regularly as to maintain moisture in the soil (at a level of between 20% and 30%).
- **Temperature and moisture conservation measure:** In order to increase the temperature and maintain moisture, the cracking beds may be covered with wet gunny bags or covered with a 400-gauge plastic sheet in airtight condition.

Seed cracking: At a temperature of 25 ˚C and with adequate moisture, the seeds should take approximately 4-6 weeks to crack. In any case, following placement in the cracking beds, seeds should be monitored regularly to verify whether they have cracked or if moisture levels are sufficient.

10.4.4 Transferring Seedling to Bags

Transferring seeds to seedling bags: Once the seeds have germinated, they should be transferred to previously prepared seedling bags. The seeds whose germination takes longer than 3 weeks should not be used. The seeds should be inserted at the center of the bag with the tap root in the soil, leaving one fourth of the seed exposed to the air.

Preparing the seedling bags: The seedling bags that are used to grow seedlings should be prepared in advance following certain criteria such as:

- **Materials and size:** Black plastic bags or clear plastic bags offer a cost effective medium to grow seedlings. By using clear bags, roots can be seen. The size of plastic bags should be 4 inches wide, 12 inches long and 150 gauge thick.
- **Seedling bag content:** The soil mixture in the seedling bags should be one quarter of sand sieved with 8 mesh sieves and, three quarters of compost sieved with 6 mesh sieves (1:3 ratio of sand to compost). This soil mixture is then filled in the seedling bag up to 9 inches and slightly pressed down. This will be the root growth media. Then, at the top of the bag, sand should be used to fill the 3 inches left. This will be the rooting media.
- **Packing the soil:** The compactness of the soil mixture in the bags should be neither too tight nor too loose in order to minimize the risk of breaking the bag and allow ideal rooting conditions for the seedlings.

Preserving moisture and temperature levels: Polythene sheeting (250-500 gauge) can be used to create a tent encompassing the seedlings and create a hermetic environment excluding exchange of air and therefore preserving moisture and temperature levels.

Watering: The seedlings should be kept moist by frequent watering. Watering should be done gently as strong jets may displace seedlings.

10.4.5 Hardening

Definition and objectives: Before transplanting the seedlings to the plantation, they should be hardened i.e. progressively exposed to harsher conditions, especially in terms of sunlight exposure.

When to harden tea seedlings: If the tea bushes are to be transplanted in the beginning of the rainy season, removing of shade can be done in January. If the weather is snowy and foggy, removing of shade can be done from February.

Removing shade: Suddenly removing shade can cause damage to the seedlings. That is why, gradually removing the shade is important.

11 Occupational Safety and Health

11.1 Introduction

Definition and objectives: Occupational Safety and Health (OSH) is more than accident prevention. It involves the promotion and maintenance of the highest degree of social, mental and physical wellbeing of farmers, workers, and household members.

Why adopt OSH measures: OSH measures will have many benefits including

- **Higher productivity:** Workers afraid of getting hurt generally produce less. Additionally, tool, process and workplace safety are all vital to protecting farmers and workers and avoiding work interruption.
- **Worker safety**: OSH measures can prevent injuries as well as ensure preparation in case of an emergency.
- **Increase profits:** Work-related accidents or diseases are very costly and can have many serious direct and indirect effects on the lives of farmers/workers and their families.
- **Increase competitiveness, maintain customer satisfaction and meet requirements of international buyers**: Buyers and end consumers often place a lot of importance on worker welfare. Making sure that tea is produced in a way that preserves worker safety and health will make it more competitive on the market, especially in export markets such as Europe.
- **Meet legal requirements**: Adopting OSH measures will ensure compliance with potential OSH related legislation (e.g. upcoming OSH law in Myanmar).

Tea and OSH: Tea cultivation can have negative effects on the health and safety of farmers/workers as well as their household members. For instance, farmers may be exposed to dangerous chemicals or injury because of improper use of farming tools. Adequate measures should therefore be taken to minimize the health and safety risks associated with tea farming.

Hazard Control System: A hazard control system is a system through which the risks associated with a given activity (e.g. tea farming) can be minimized. It involves three steps that have to be undertaken successively: 1. identifying hazards, 2. assessing the risk associated with those hazards and, 3. adopting measures to fix/control the hazards.

Figure 9: Hazard Control System (Adapted from Vision Zero Fund Training Manual)

11.2 Identifying Hazards

Definition and objectives: In order to ensure a safe and healthy working environment on their farm, farmers must first identify possible hazards. A hazard is a dangerous object, event, behaviour or condition in the farm which has the potential to cause injury, illness, or property damage.

Hazard classifications: There are many different types of hazards on tea farms. These hazards are classified into two types, safety hazards and health hazards. Health hazards can be chemical, physical, biological or ergonomic (see below). Safety hazards englobes machine hazards, fall hazards, material handling hazards and work practice hazards (see below).

Figure 10: Safety Hazards (Adapted from Vision Zero Fund Training Manual)

Tools/machine hazards: These consist of rotating or moving equipment (e.g. mechanical rollers), Hot parts (hot pans), absence of guards and poor maintenance.

Source: WorkSafe NZ

Fall hazards: These consist of working at heights or on steep slopes, Slips, trips, and falls.

Material handling hazards: These consist of operations where handling of hazardous materials occurs.

Workplace hazards: The consist of poor housekeeping, failing to develop or follow safe work practices and procedures.

Figure 11: Health Hazards (Adapted from Vision Zero Fund Training Manual)

Chemical hazards: These are substances that can be a risk to the person who comes in contact with it or is required to handle it, such as smoke (when diseased tea trees are burnt), solvents (e.g. cleaning agents used to clean farming tools) and mists (e.g. from pesticides).

Physical hazards: These are conditions which are hazardous when levels exceed established safe guidelines. Examples are extreme heat exposure, extensive sun exposure or bad indoor air quality.

Biological hazards: These consist of any living organism which can cause adverse health effects in humans i.e. viruses, blood borne pathogen (e.g. hepathitis), body fluids (urine, saliva), bacteria (salmonella; e-coli), fungi and molds, and parasites.

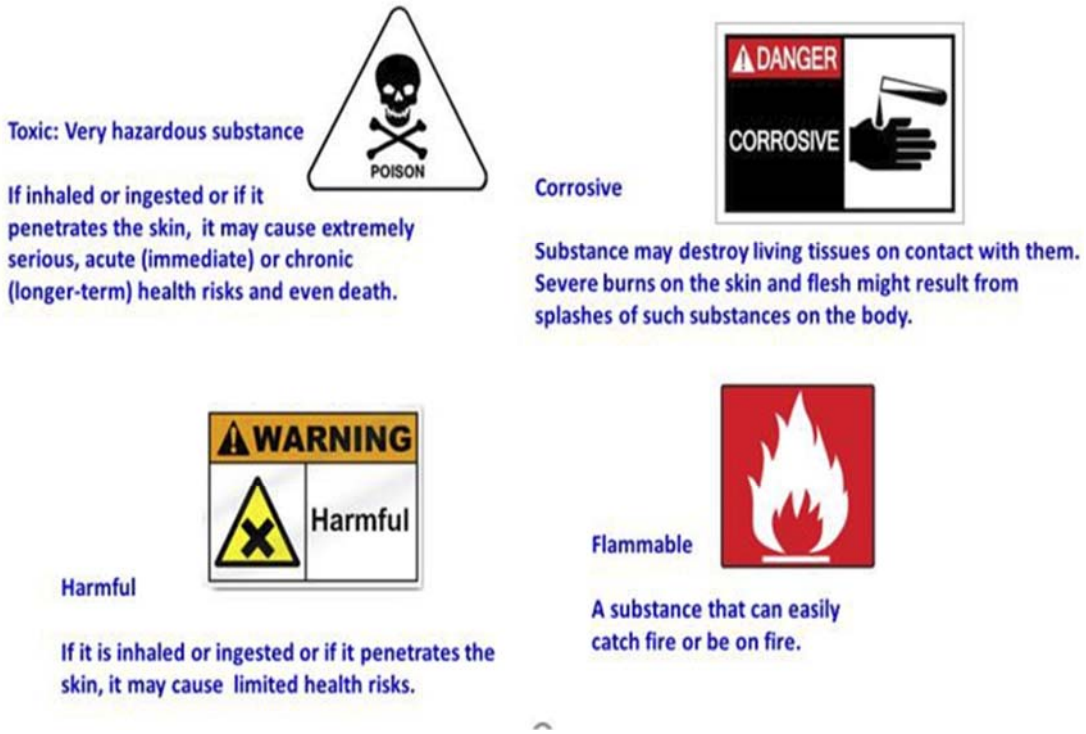
Ergonomic hazards: These consist of types of work, body positions and working conditions which can put a strain on the body and the musculoskeletal system. Examples include excessive force (lifting, pushing or pulling heavy fermented tea bags), repetitive movements (e.g. plucking), awkward postures (bending, reaching, twisting), and prolonged unnatural position.

How to identify hazards: There are different ways to identify possible hazards including:

- **Observations:** Sometimes simple observation is enough to identify a hazard and the risk it poses to human safety and health.
- **Information from past incidents / own experiences, peers, family:** Taking into account one's own past experiences as well as those of others can help inform what constitutes a hazard.

- **Product information sheet; information from input suppliers and other suppliers:** When farming equipment or agricultural inputs are purchased from third parties, farmers should ask them what kind of risks their products pose to health and safety and/or consult product information available on product labels or other sources.
- **Work safety analysis**: Finally, a work safety analysis can be conducted with the express objective of determining what are the hazards involved in a given occupation.

Figure 12: Product labels signalling hazard nature (Source: Vision Zero Fund Training Manual)



11.3 Assessing Risk and Hazard Control Measures

Assessing the risk: Risk is the chance or probability that a person will be harmed or experience an adverse health effect if exposed to a hazard. Assessing the risk means determining how likely it is that exposure to a hazard will lead to harm (e.g. 1% chance, 10% chance, 30% chance, etc.). It also means determining how severe the harm is likely to be (e.g. minor injury, serious injury, death).

Fixing hazards: Once the hazard has been identified and the risk it poses determined, farmers should try to control/fix hazards.

- **Prioritizing high risk hazards:** Tea production naturally exposes workers to many different hazards, some of which are more likely to lead to harm than others. Fixing hazards which present high risks of severe harm should therefore be prioritized
- **How to fix hazards**: Control measures that are reasonable and practical given the circumstances should be adopted.

Hierarchy of control measures: There are often different ways to minimize the risk associated with a given hazard. These are classified into five different categories, with decreasing degrees of effectiveness. The first, "elimination of the hazard", is the most effective, while "administrative controls" and "use of personal protective equipment" are the least effective in diminishing the risk associated with a given hazard.

- **Eliminate hazards:** Physically remove a hazard posed by equipment, animals, and the environment if at all possible. One can, for example, possibly discard a faulty tool or equipment. Another example would be to remove all possible breeding places for mosquitoes to significantly reduce risk of dengue.
- **Substitute something safer**: Replace the hazard by using a different machine, material or work practice that poses less risk to perform the same task. For example, you could substitute a safer chemical or organic input for a hazardous chemical.
- **Use engineering/design controls:** Isolate people from the hazard when it is not possible to eliminate hazards or substitute safer materials or machinery. Design controls that isolate the worker/family from the hazard such as fenced or separate storage areas for chemical inputs and farm inputs; establish shade spaces (man-made sheds, natural shades - trees) in the farm where workers can work or take a break when the sun is intense.
- **Administrative controls:** Change the way people work (e.g. training, behavior change) to help mitigate risks. For example, one can supervise new workers until they are competent to deal with hazardous situations. Ensure someone at the farm or community is trained in giving first aid.
- **Use of personal protective equipment:** Use and provide proper clothes and masks for handling dangerous chemicals or biohazards. Use good gloves when using sharp tools to avoid slippage.

11.4 Common Examples

Manual handling: Manual handling is a physical activity that commonly takes place on all farms. Manual handling can involve lifting, putting down, pushing, pulling, carrying or moving loads. Incorrect manual handling may result in back injury or other musculoskeletal problems for farmers. In order to minimize health risks of lifting:

- Keep lifts between hand level and shoulder level. Avoid lifts from the floor or over shoulder level.
- When lifting or lowering a heavy load, do this slowly in front of you, keeping the load close to your body.
- When lifting a heavy load, use the muscle power of your legs, not of your back, and keep your back straight. This is more easily done when carrying the load in front of and close to your body.
- Avoid twisting.
- Clear obstacles or slide the object towards you.

Picture 17: Lifting heavy objects (Source: Vision Zero Fund Training Manual)

Source: European Handbook for the Prevention of Accidents at Sea and Safety of Fishermen

Using hand tools: The use of hand operated tools is common on all types of farms. In order to avoid injury resulting from use of hand tools, proper tools should be used. Certain guidelines to follow include:

- **Lightweight but sufficiently strong**: Choose lightweight but sufficiently strong tools to reduce the workload on upper limb muscles.
- **Handles for larger tools**: Larger tools such as hoes and ploughs need handles of an appropriate length to ensure correct working posture.
- **Grip:** Attach sturdy, easy to grip handles to the tools for safe operation. When tools require force, handle size should allow the worker to grip all the way around the handle.

Figure 13: Proper handle size (Adapted from Vision Zero Fund Training Manual)

- **Slip-protection:** Handles should be covered with smooth, slip-resistant material (plastic or rubber). Gloves which allow a better grip and additionally might help protect from injury should be used.

Figure 14: Gloves and slip-resistant handles (Source: Vision Zero Fund, Training Manual)

- **Defect free tools:** Do not use a tool if the handle surface has splinters, burrs, cracks or splits. Do not use tools which are defective in any other way.
- **Guards on dangerous tools:** Sharp or dangerous tools might injure the fingers if the hand slips. Make sure that such tools are fitted with appropriate guards.

Figure 15: Guard on sharp tool (Adapted from Vision Zero Fund Training Manual)

12 Tea Processing and Good Hygiene Practices

Processing methods are extremely important in making high quality tea. However, perhaps more importantly, quality is also highly dependent on the quality of raw materials used and the application of strict hygiene standards at all stages of tea making.

Tea that is produced following strict hygiene and food safety standards can fetch prices 50% higher than tea which does not. Conversely, failure to follow hygiene and food safety standards can result in the production of lower quality tea or even tea unfit for human consumption, resulting in waste of product and loss of money. As illustrated by the widespread scandal related to the use of Auramine O, an industrial dye which was used to make fermented tea more yellow in colour, non-compliance with food safety standards can result in devastating effects at all stages of the value chain that can significantly reduce prices over extended periods of time and even result in the shutting down of tea making operations.

The following chapter presents a number of recommendations designed to improve food safety and hygiene related practices. In short, the objectives of these recommendations are to promote the production of tea that is:

- safe for human consumption
- free of potential (physical, chemical and biological) contaminants
- of the highest quality

The chapter is broken down into five sections. The first section presents recommendations relevant to all stages of tea production. The second, third and fourth sections present recommendations relevant to primary production, processing and associated operations, respectively. Primary production encompasses the growing and harvesting of fresh tea leaves. Processing encompasses any action subsequent to primary production aimed at altering the bio-physical properties of tea leaves such as heating, drying or fermentation. Associated operations encompass transport, storage and tea handling operations which do not substantially alter the nature of tea. The fifth and final section presents a short account of the basic requirements of GHPs, which may be thought of as a summary of the sections above it albeit evidently incomplete.

Note that this chapter is based in large part on food safety relevant guidance notes from Tea & Herbal Infusions Europe (THIE). Links to additional information on these guidance materials as well as other potentially relevant materials are included in Annex 1.

12.1 All Stages

It is a basic requirement that persons having contact with tea should observe a strict level of personal hygiene and that all tea handling sites and tea handling equipment should be clean when in use. Furthermore, given that food safety hazards may originate at different stages of tea production, it is important that all actors along the value chain (farmers, processors, distributors, buyers) share information on any potential risk they identify and take measures to document potential risks and where these originate. The following recommendations should apply to the greatest extent possible at all stages of tea making.

12.1.1 Handling Site & Equipment

Equipment usage: All equipment/utensils used for tea production should be used only for tea production in order to avoid cross-contamination from other crops or the presence of foreign matter[1].

Equipment cleanliness: All equipment/utensils used for tea production should be kept clean and, when not in use, kept in a clean place protected as much as possible from pests (e.g. insects and rodents), birds, farm and domestic animals, and children.

Handling and storage site cleanliness: Places where tea undergoes handling or is stored should be regularly cleaned and protected from pests (e.g. insects and rodents), birds, farm and domestic animals, and children.

Checking cleanliness: Before use, equipment and handling sites should be inspected to make sure they are clean.

12.1.2 Worker Hygiene

Prohibited behaviours: People engaged in tea handling activities should refrain from behaviour which could result in contamination of tea. For example, prohibited behaviours include smoking, spitting, chewing gum or betel nut, eating, sneezing or coughing over tea leaves when unpackaged as well as when packaged.

Hygiene equipment: Tea handlers should maintain a high degree of personal cleanliness and, where appropriate, wear suitable protective clothing, head covering, and footwear. Surgical style masks should be worn for an enhanced protection against human contamination of the product (e.g. from sneezing or coughing). Shower caps should be worn in order to avoid contamination of tea with hair (at a minimum, hair should be tied up). Footwear should be removed in tea handling areas (unless specifically designed for use in tea handling). Personal effects such as jewellery, watches, pins or other items should not be worn or brought into food handling areas if they pose a threat to the safety and suitability of food.

Wash your hands: Tea handlers should always wash their hands when personal cleanliness may affect food safety, for example, at the start of food handling activities, immediately after using the toilet, and after handling any contaminated material, where this could result in contamination of other food items. People handling tea leaves should have access to toilets with hand washing facilities.

Worker health: Tea handlers should not work in the tea handling area, if they are known to be suffering from diseases likely to be transmitted through food, including diarrhoea, and if there is a likelihood of direct or indirect contamination. Similarly, people with open wounds, sores should be transferred away from handling areas until completely recovered, if there is a likelihood of direct or indirect contamination.

[1] Further stage specific recommendations on equipment and handling are provided in sections 12.2, 12.3 and 12.4.

12.1.3 Hazard identification

Flagging hazards: If farmers, processors or distributors identify a possible food safety hazard, they must inform the buyers of the tea immediately. They should also inform their suppliers when the food safety hazard is thought to possibly originate at that level. When there is a risk to human health, the information should be passed on to the responsible authorities.

Record keeping: Beyond adoption of good manufacturing practices, it is also recommended that farmers keep records about the use of fertiliser and pesticides, as well as any other potentially toxic substance coming into contact with the crop or even any occurrence of pests or diseases that may affect the quality and food safety risk of fresh tea leaves. Processors and other actors involved in tea handling should also keep records of any potential hazardous products coming into contact with tea (e.g. fertilizer bags being used for transport) or being added to the tea (e.g. industrial grade additives).

Traceability: Buyers of tea are advised to (where necessary and possible) be able to identify the incoming goods (in order to follow its source of supply); install a documented purchasing control system; provide accompanying documents which carry all relevant information available for the customers on request.

12.2 Primary Production Stage

12.2.1 Cultivation

Tea cultivation area: Tea should not be cultivated in soils contaminated with sewage sludge, heavy metals, pesticides, radioelements and other industrial chemicals.

Inputs and phytosanitary products: When inputs and phytosanitary products are used, manufacturers' instructions for use of such products as well as appropriate legislation and certification standards should be followed. In general, fertilizers and pesticides should not be used in close proximity to the time of harvest to minimize food safety risks. Additional measures include:

- **Fertilizer**: Fertilizers should be applied in a way as to avoid coming into contact with tea leaves. Regarding organic fertilisers, they should be well composted before use. Sewage sludge should never be used for fertilization.
- **Pesticides**: Pesticides should only be used when absolutely necessary. In case of need, they have to be used with the minimum effective amount of authorised pesticides. The application may only be carried out by trained personnel with the use of adequate protective equipment.
- **Organic standards**: Most organic standards (including EU organic certification and USDA organic certification) prohibit the use of pesticides / petroleum-based fertilizers / sewage sludge-based fertilizers.

Contamination from neighbouring fields: Food safety hazards may also come from neighbouring plantations using pesticides and other potential contaminants, for instance as a result of surface run-off from heavy rainfall or windy conditions at the time of pesticide application in neighbouring fields. Prevention measures should be taken to minimize the risk of entry of contaminants in the tea plantation.

- **Establishing buffer zones**: A buffer zone should be established along the borders of the tea plantation and planted with detoxifying plants (e.g. vetiver grass) in order to arrest the entry of contaminants caused by surface run-off contamination or by air and detoxify the soil. The higher the risk of contamination is (e.g. if pesticide use is frequent), the wider the buffer zone should be.
- **Water Drains:** The establishment of drains along the borders of the tea plantation will help avoid the entry of rain-water that may be contaminated from bordering plantations.

Animals: Farm (and domestic) animals should not be allowed in the cultivation area. Where animals are present and there is no clear natural barrier preventing entry into the cultivation area, adopting preventative measures such as building a fence around it should be considered. Other measures such as establishing vegetative barriers may be just as suitable as long as they prevent entry of animals.

Irrigation: If water is used for irrigation purposes, it should be clean and substantially free from contaminants, such as faeces, heavy metals, agrochemicals (e.g. pesticides, fertilisers) and toxicologically hazardous substances.

12.2.2 Harvesting

Climatic conditions: Crop harvesting should not be carried out in wet or high humidity conditions (ground moisture, dew or rain). Wherever possible, harvesting should be carried out in dry, low humidity conditions. In this way, the risks of fungal contamination (e.g. mould growth and possible formation of mycotoxins) of the tea leaves can be minimized.

Harvesting equipment: Harvesting equipment must be clean and well maintained. For instance, all containers used for primary collection of tea leaves (e.g. "Palai" bamboo baskets and bags) must be clean and kept free from previously accumulated plant material.

Harvesting equipment storage: When not in use, harvesting equipment must be kept in a dry place free from pests and inaccessible to farm and domestic animals as well as birds.

12.3 Processing Stage

12.3.1 Processing Site & Equipment

Climatic conditions: The location used for processing tea leaves should enjoy dry conditions and be well ventilated as to reduce the risk of fungal contamination. Low temperature variability is also an asset.

Worker hygiene and behaviours: Smoking, chewing betel nut and other contamination prone behaviours should not be allowed, especially in processing areas, as this is where tea leaves are most exposed (not stored or packaged). Other measures to minimize the risk of human based contamination of tea should be taken (see section 12.1.2 on Worker Hygiene).

Protection from pests and animals: Additionally, tea leaves undergoing processing or having been processed must be protected from insects, rodents and birds as well as farm and domestic animals (e.g. by erecting physical barriers such as fences, nets or traps around the processing site). Processing areas should never be used for livestock.

Waste contamination: Contamination of the raw materials with waste should be prevented through appropriate measures, such as strict physical separation of harvested materials from

waste containers. Waste bins should be clearly marked as such, emptied daily and cleaned regularly.

Equipment/utensil cleanliness: Equipment/utensils used for processing (e.g. bamboo mats for wilting/drying; pots for boiling tea leaves; containers used for pickled tea making) should be kept clean and regularly maintained, particularly in order to avoid cross contamination with other crops or other potential contaminant sources. Before use, they should be inspected to make sure they are clean.

Equipment fit for purpose: Equipment/utensils used in processing tea leaves should not be used for any other purpose (e.g. pots for boiling tea leaves should not also used for everyday cooking). Equipment or containers having come into contact with known food safety hazards should never be used (e.g. old chemical fertiliser bags should never be used to ferment or transport tea).

Machinery maintenance: Drying furnaces as well as other suitable drying chambers have to be kept clean in order to prevent cross contamination with crops dried before. All equipment has to be maintained and inspected regularly to ensure food grade processing.

12.3.2 Tea Manufacturing Operations

Drying/wilting operation: Tea leaves should be placed in thin layers on elevated drying tables/nets as to allow free air circulation. Care should be taken to make sure the surface on which they are laid is clean. In any case, tea leaves should never be placed directly on the ground. Once they are laid out, they should then be stirred intermittently to ensure uniform drying and prevent composting or mould growth.

Sorting: During sorting operations, tea leaves are inspected and sorted to remove discoloured, mouldy and damaged material as well as soil, stones and other foreign matter. The surface on which sorting is performed should be kept clean, similarly to all other equipment.

Additives: Any products added to tea during processing should be safe for human consumption and their handling should follow strict hygiene standards.

Industrial Additives: As a precautionary measure, the use of industrial grade additives should be avoided altogether unless it is done in a controlled environment and led by qualified experts. Industrial grade additives may be unsafe for human consumption and their use may have devastating consequences on tea markets (e.g. 2009 Auramine O industrial dye scandal).

Fuel emissions contamination: With drying processes using oil, natural gas or wood firing, the fuel, the exhaust fumes and gas emissions must not come in direct contact with the tea leaves as this can significantly decrease quality of the final product. Drying furnaces must therefore be maintained in good working order to prevent contamination with gas emissions.

12.4 Associated Operations

12.4.1 Post-Harvest Handling

Sorting and Collection: If the fresh tea leaves are transferred to a different container before being brought to the processing location, during the transfer, visibly damaged and spoiled tea leaves should be discarded along with any foreign matter. Furthermore, the collection containers should be clean, kept free from previously accumulated plant material, and when not in use, kept in a dry place free from pests and inaccessible to farm and domestic animals as well as birds. Harvested tea leaves must not come into direct contact with the ground.

Temporary packing materials and density: Compaction/compression of fresh tea leaves and humidity promote composting. Care should be taken in using proper packing containers/materials and avoid packing produce too densely.

- **Packing materials:** Materials that allow exchange of humidity should be used where temporary storage of fresh tea leaves is necessary. Plastic containers therefore should not be used (except for woven plastic sacks which allow exchange of humidity, e.g. woven polypropylene).
- **Compaction of tea leaves:** Compaction of tea leaves should be avoided (also during primary collection) and fresh tea leaves should instead be packed in a loose/aerated manner before processing. Sacks should not be overfilled to ensure they can be closed properly and thus reduce risks of foreign matter contamination.

Post-harvest crop protection: The harvested crop should be protected from all types of pests, farm and domestic animals as well as birds. The harvested crop must not be allowed to stand for extended periods in direct sunlight and must be protected from water/rain.

Transportation to processing site: The time between harvest and transport of the crop to the processing site should be kept as short as reasonably practicable to maintain the quality of the tea leaves and avoid leaf damage. In any case, it is necessary to avoid a temperature rise of harvested material due to the risk of uncontrolled fermentation/composting and possible mould growth.

Unloading/unpacking quickly: Once the tea has been brought to the processing site, it should be unloaded and unpacked as soon as possible in order to avoid uncontrolled fermentation/composting or possible mould growth.

12.4.2 Packaging

Packaging timing: Tea should be packaged as soon as possible following processing operations for protection and to lessen the opportunity of pest infestation, as well as to prevent contamination with foreign matter.

Before packaging: Damaged material and foreign matter have to be eliminated before packing.

Packaging materials: Tea should be packed in clean dry sacks, bags or boxes (preferably new). If packaging includes labelling, the labelling must be clear and appropriate and must not contaminate the harvested material. The details on the label should also be sufficient to facilitate traceability.

Packaging material suitability: Packaging materials must be suitable for tea. Wherever possible, the packaging materials used should be agreed between supplier and buyer.

Storage of packaging materials: Packaging materials should be stored in a clean and dry place free from pests and inaccessible to farm and domestic animals and birds. They should also be stored in such a way as to avoid potential contamination with for example chemical substances (e. g. cleaning agents, smoke) and foreign matter, including hazards coming from humans (e.g. jewellery) as far as reasonably practicable.

Reusing packaging materials: Re-usable packaging materials such as jute sacks, woven plastic bags, etc. should be well cleaned and dried before re-use. The re-usable packaging material should only be used for tea. In any case, packaging material should be inspected prior to use, especially re-usable packaging material.

12.4.3 Storage

Storage climatic conditions: Packaged tea should be stored in a dry, well-ventilated building, with minimal variation in diurnal temperature. The packed crop has to be stored in a dry place away from the wall and off the ground so that sufficient space for protection measures against pests is available.

Storage protection from animals: Packaged tea should be stored in a place and in a way so that it will be protected from pests, farm and domestic animals as well as birds. Shutter and door openings have to be protected by wire screens to keep out pests (insects and rodents), birds and farm and domestic animals. Appropriate pest-control measures, such as traps, electrical insect-control devices, as well as measures for identifying an infestation (such as pheromone traps) should be used where appropriate.

Storage protection from human based hazards: Packaged tea should be stored in such a way that the risk of contamination with objects and substances from the human environment such as smoke is reduced so far as reasonably practicable.

Storage basics: It is recommended that packed dried crops should be stored in buildings with concrete floors or similar easy-to-clean floors; on pallets; away from the wall; well separated from all other crops whenever cross-contamination is possible; in non-smoking areas.

12.4.4 Transportation

Aerated containers: For bulk deliveries the use of vented containers and transport vehicles is highly recommended to minimise mould risks.

Contamination risks: In case of bulk transport of crop (e. g. unpacked crop in direct contact with the contact surface of the food transportation unit and the atmosphere), it is necessary to ensure that cross contamination with other crops (e. g. with other previously transported plant material), chemical substances or foreign matter is avoided. All chemicals such as pesticides should be kept in a separate, closable area.

Maintenance of transport vehicles: Transport vehicles should be clean and in good condition in order to protect the crop from contamination.

12.5 Basic Requirements of GHPs

Clean facilities, equipment and materials: All sites and facilities where tea is handled, tea handling equipment, and materials coming into contact with tea (e.g. crates, containers, vehicles) should be kept keep clean and, where necessary, disinfected in an appropriate manner after cleaning.

Hygienic handling conditions: Appropriate measures should be taken to ensure hygienic production, transport and storage conditions for plant products and their cleanliness.

Clean water: In order to prevent potential contamination, only potable water or clean water should be used whenever water is necessary.

Worker health: Workers handling tea should be in good health and receive basic training or instructions on occupational safety and health.

Worker hygiene: Workers coming into direct contact with fresh tea leaves and tea should maintain an appropriate degree of personal cleanliness (e.g. wash hands after eating or going to the bathroom, etc.) and behave and operate in an appropriate manner (e.g. not eat or chew betel nut during handling operations) in order to avoid contaminating the tea in any way.

Smoking: Smoking should not be allowed in any processing or storage areas. Smoking should only be permitted in designated areas which are clearly separated from any processing or storage areas and where contamination from smoke or ashes is unlikely.

Pests: Animals and pests should be prevented from causing contamination as much as possible, for instance, by adopting measures to impede their entry into handling or storage sites, or by adopting measures to eliminate their presence (e.g. traps for rodents).

Waste and hazardous material handling: Waste (including agricultural waste) and other hazardous substances should be stored and handled in an appropriate manner as to prevent contamination.

Record keeping: records should be kept on any potential food safety hazard coming into contact with tea (e.g. any use of plant protection products and biocides or any occurrence of pests or diseases that may affect the safety of products). Similarly, results of any relevant analyses carried out on samples taken from plants or other samples that have importance to human health should be kept and properly archived so that they can be shared with buyers or relevant authorities upon request.

Inputs and plant protection products: All soil inputs and plant protection products should be applied correctly in accordance with manufacturer recommendations, relevant legislation and applicable standards.

13 Tea Processing Methods

Each type of tea ready for human consumption (e.g. fermented tea, green tea or black tea) uses fresh tea leaves as raw materials. What makes each type of tea different is the processing methods that are used to produce them. The following sections give an overview of the methods used to produce green tea and fermented tea, which are among the most common types of tea produced in Myanmar. For green tea, the processes described are of homemade green tea production. For fermented tea, both the Northern Shan and Southern Shan methods of making fermented tea are described.

Before getting into processing methods, it should be noted that producing high quality tea is highly dependent on raw materials of high quality (i.e. high-quality fresh tea leaves). Using two/three leaves and one bud as raw materials to produce green tea will make the highest quality tea and fetch the highest price (it is also the most beneficial plucking style to plant health). Prior to processing, care should therefore be taken to make sure that leaves are of the desired quality standard and that they do not contain old and rough leaves, which are not suitable for tea making.

In deciding what kind of tea to produce, producers should take into account the amount of final product that can be produced from a given amount of fresh tea leaves, the availability of buyers and the prices offered by them for different types of tea (including different standards of tea), and the costs involved in producing the different types of tea.

In terms of the amount of tea that can be produced from fresh tea leaves, for green tea, during the dry season, 4 viss of fresh tea leaves will produce 1 viss of green tea while during the rainy season, this ratio becomes 5 to 1. For fermented tea, 1 viss of fresh tea leaves will produce approximately the same weight of fermented tea.

13.1 Homemade Green Tea

1. Withering Stage

Withering objectives: Withering is important in removing excess water from tea leaves, initiating the oxidation process, breaking down leaf proteins into free amino acids and increasing the availability of freed caffeine. These processes are important because they have a strong influence on the colour and taste of tea as well as its health promoting properties. During this stage, tea leaves progressively turn darker through enzymatic activity which transforms chlorophyll and tannins. The leaves also gradually become softer as moisture escapes from the leaves (due to the transpiration, approximately 30% of the weight of the crop is lost).

Withering timing: Withering should be performed as soon as possible following harvest in order to avoid fermentation of fresh tea leaves.

Withering method: After plucking, the tea leaves should be placed on bamboo mats in layers up to a maximum of 8 inches thick under the shade, preferably in a well aerated atmosphere-controlled room or chamber.

Withering duration: The tea producer decides when the oxidation process should be stopped, depending on the desired qualities in the final tea as well as the atmospheric conditions (heat and humidity) of the withering location. Under-oxidation/fermentation results in grassy flavours while over-oxidation results in overly thick winey flavours. In the case of green tea, it is recommended that this stage should span at least 60 minutes.

2. Panning Stage

Panning objectives: Panning renders the fibre of the leaf soft enough to withstand rolling or bruising without tearing.

Panning method: The pan is placed onto the stove with medium level heat. When the pan becomes hot, withered leaves are put in the pan and mixed thoroughly, making sure that no leaves are allowed to rest on the stove surface long enough to become burnt.

Panning duration: When tea leaves become soft and shiny green in colour, the pan is removed from the stove. Tea leaves should not change to yellow and brown colour, which signals lower quality. Total panning time is approximately 15 minutes.

Cooling down: Once the pan is removed from the stove, the tea leaves should be removed from the pan and spread on a bamboo mat to cool down for approximately 15 Minutes.

Occupational safety and health: During panning, workers should take adequate measures to protect themselves from the adverse effects of smoke (e.g. wearing protective breathing masks) and take care to avoid burning themselves with the hot pan.

3. Rolling Stage

Rolling objectives: The purpose of rolling is to produce a chemical reaction that will promote and quicken oxidation. It will also favour the production of Tannins, which have many health benefits and give tea a bitter taste. The rolling action also causes some of the sap, essential oils, and juices inside the leaves to ooze out, which further enhances the taste of the tea.

Rolling process: After having cooled down following the panning stage, tea leaves are rolled and formed into wrinkled strips, by hand or using mechanical equipment such as a rolling machine or wooden rollers, if available.

Hand rolling method: To roll tea leaves by hand, tea leaves should be spread by hand on a bamboo mat. Two hands should be placed in parallel position on the tea and pressed down on the leaves, and an up and down motion performed.

Rolling duration: Total rolling time by hand is approximately 15 to 20 minutes. In any case, visual cues should be used as signals to when rolling should be stopped e.g. when tea leaves have wrapped around themselves and that shaping is relatively uniform across the whole batch.

4. Drying Stage

Drying objectives: Drying is done to "finish" the tea for sale by reducing the tea's moisture content to safe levels of between 3-4%.

Drying timing: Drying should occur as soon as possible following rolling in order to prevent any opportunity for the leaves to ferment as this would result in tea which resembles more black tea than green tea.

Drying method: Rolled tea leaves are spread on a bamboo mat (or other suitable surfaces/materials) to be dried under the sun. After one hour of drying, tea leaves become yellowish green and brown in colour. Tea leaves are then collected, mixed thoroughly and water drops added by hand. The leaves are then spread again on the bamboo mats. After 5 to 10 minutes of spreading, tea leaves become smooth and rolled. All of the rolls are dried under sun on the bamboo mat. Tea is ready to be drunk after 3-4 hours of sun drying.

5. Grading/Sorting Stage

Grading/sorting process: Having completed the drying stage, the dried tea leaves are sorted using sieves or other suitable equipment (e.g. traditional weaved baskets), making sure these are clean and free of old tea leaves. Depending on buyer specifications, large and rough tea leaves should be removed. Additionally, any foreign matter which has not been removed prior to this stage should also be removed.

Tea leaf quality standards: 3 classes of green tea are usually distinguished based on the types of leaves it contains. The first class of green tea is the best and most expensive one, and it includes only raw materials with two/three leaves and a bud. The second class of green tea includes larger leaves (maximum four leaves and a bud) while the third class includes rough leaves. The third class fetches the lowest price because, in most cases, rough leaves are removed by buyers.

Additional quality standards: Additional quality standards will typically factor in pricing of green tea including its colour, texture and the lack of any foreign matter in the final product.

Producing to buyer specifications: Great care should therefore be taken in producing tea up to the standards specified by buyers. Otherwise, the product might simply be rejected by buyers, which will result in waste of resources and loss of money, and long-term commercial relationships could also be jeopardized.

13.2 Pickled/Fermented Tea

There are two main methods of processing fresh tea leaves into pickled tea. One method is the "Southern Shan State" method and the other is the "Northern Shan State" method. The following table sets out the different steps of each method:

<table>
<tr><th>Northern Shan</th><th>Southern Shan</th></tr>
<tr><td colspan="2">Withering: The fresh tea leaves are first withered in order to remove moisture from the leaves. Withering can be performed by spreading the leaves on bamboo mats in the shade or indoors, or placing them in steel tanks with fans blowing into the tanks. In any case, withering should be performed in a dry and aerated area.</td></tr>
<tr><td>Steaming: The tea leaves are first washed and then steamed using a boiler or boiling pots for between 3 to 5 minutes depending on the quality of the leaves. This softens the tea leaves and naturally alters the colour.</td><td>Boiling: The tea leaves are washed and boiled in hot water for between 3 to 5 minutes. Over-boiling of tea leaves can cause damage to the leaves, resulting in low quality pickled tea. After boiling, take out the water from boiled tea leaves. This softens the tea leaves and naturally alters the colour.</td></tr>
<tr><td colspan="2">Cooling: The tea leaves are spread on bamboo mats or other suitable surfaces and let to sit there for two to three minutes. Prior to cooling, tea leaves can be pressed to remove excess water.</td></tr>
<tr><td colspan="2">Rolling: Tea leaves are rolled by hand or using a mechanical roller. The tea leaves are normally rolled 20 to 25 times.</td></tr>
</table>

<table>
<tr><td>Fermentation underground: The rolled tea leaves are buried inside pits dug in the soil and left there during the entire fermentation process. Typically, the hole is dug 5 to 8 ft. wide and 10 to 12 ft. deep. Wooden logs of 1-foot girth (as to avoid decomposition) and/or stones are placed at the bottom of hole. Then, wooden plates or thick bamboo mats are place on top of the wooden logs or stones. The side walls of the hole are covered with thick plastic sheets, which are kept in place with bamboo poles on the interior.

After building the hole, rolled tea leaves are placed in 6 inches thick layer on top of one another. Once the hole is filled, a plastic sheet is used to cover the hole and then pressed with a heavy weight. Water should be prevented from entering in the hole by for instance building a hut over the tea hole. After 45 days, pickled tea can be eaten and stored year-round.</td><td>Fermentation in plastic bags: The rolled tea leaves are placed into large plastic bags. Bags should be stacked with tea leaves no more than four feet high as too much pressure on the tea leaves will drain the water from the tea leaves at the bottom of the bag and promote oxidization, which will result in lower quality fermented tea.

Black liquid (tannins) by the pickled tea stains the bags, making the bags look dirty. This does not affect the quality of the pickled tea leaves inside or the visual appeal to the wholesaler or manufacturer as they repackage the product.</td></tr>
<tr><td colspan="2">Fermentation duration: Tea leaves should be stored for at least 20 days to allow the natural anaerobic fermentation process to occur.</td></tr>
<tr><td colspan="2">Grading and Sorting: Following fermentation, tea is removed from underground or from plastic bags, checked for quality and, if needed, sorted. During sorting, sticks and unwanted materials such as hard leaves should be removed. Additionally, leaves which have suffered from excess oxidation and have become very dark in colour should be removed (this is often the case when fermentation occurs under temperature variability and stacking). Fermented tea that is yellowish green in colour is an indicator of quality.</td></tr>
<tr><td colspan="2">Further processing: Having gone through all the steps above, the pickled tea is ready to be sold. Pickled tea may also be further processed by adding other ingredients such as chili, ginger or garlic. Additionally, processing operations, such as packaging to sell to the final consumer may also be undertaken.</td></tr>
<tr><td colspan="2">Storage: Pickled tea can be stored for many years (once the fermentation process is complete), depending on demand in the market. Storing the pickled tea for longer reduces the bitterness of the taste; however, one of the major constraints when it comes to storage is adequate space.</td></tr>
</table>

Fermentation process best practices: The most crucial stage of fermented tea production is naturally the fermentation process itself. Various best practices relative to fermentation should be followed including:

- **Temperature stability:** Pickled tea undergoing fermentation must not be subject to wide variation in temperature. It should be kept in places where climatic conditions are stable (low temperature variability). When subject to temperature variability, the fermentation process is disrupted and becomes uneven, which results in some of the product being discarded. Low temperature variability, which is easily achievable

through underground fermentation, is why Northern Shan style fermented tea typically fetches a higher price.

- **Air and water tight:** Both oxygen and water should be prevented from entering in the containers where fermentation occurs as this would disturb the anaerobic fermentation process.
- **Stacking:** Avoid stacking bags containing fermenting tea leaves as the pressure caused by the weight of the bags on top will cause the moisture of the leaves to be pressed down to the bottom of the bag. This is bad because it favours oxidation of tea leaves contained in the bag and thus results in fermented tea of lower quality or even tea which is not fit for consumption and loss of product.

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Tea and Herbal Infusions Europe (2018), *Guidelines for good agricultural and hygiene practices for raw materials used for herbal and fruit infusions (GAHP) version 9*, accessible at http://www.thieonline.eu/fileadmin/inhalte/Publications/HFI/2018/2018-09_PU_GAHP_Version_9.pdf

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University of Horticultural Sciences Bagalkot, Presentation on Training and Pruning in Tea, accessible at: https://www.slideshare.net/shivanandhort/training-and-pruning-in-tea-by-shivanand-mr

Vision Zero Fund, *OSH for Ginger Farming Communities, Training Manual for Trainers*

Annex 1 - Additional resources/readings

Tea and Herbal Infusions Europe (THIE):

All THIE publications:

http://www.thie-online.eu/about-thie/publications/

Compendium of guidelines for tea:

http://www.thie-online.eu/fileadmin/inhalte/Publications/Tea/2018-08-20_Compendium_of_Guidelines_for_Tea_ISSUE_5.pdf

HACCP guidance notes for European tea packers, tea producers and processors in the country of origin:

http://www.thie-online.eu/fileadmin/inhalte/Publications/Tea/2_2012-09_HACCP_Guidance_Notes__Website_.pdf

Guidelines for good agricultural and hygiene practices for raw materials used for herbal and fruit infusions (GAHP):

http://www.thie-online.eu/fileadmin/inhalte/Publications/HFI/2018/2018-09_PU_GAHP_Version_9.pdf

International Organization for Standardization (ISO):

ISO website:

https://www.iso.org/standards.html

ISO tea standards:

https://www.iso.org/committee/47918/x/catalogue/p/1/u/0/w/0/d/0

Hazard Analysis Critical Control Point (HACCP):

HACCP principles and application guidelines:

https://www.fda.gov/food/hazard-analysis-critical-control-point-haccp/haccp-principles-application-guidelines

USDA Organic:

https://www.ams.usda.gov/about-ams/programs-offices/national-organic-program

European Union (EU)

EU organic farming resource directory:

https://ec.europa.eu/info/food-farming-fisheries/farming/organic-farming_en

EU Regulation on organic production and labelling of organic production (2018):

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.150.01.0001.01.ENG

EU legislation on imports of organic products from third countries (2008; 2020 amendment and correction displayed in second link):

https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32008R1235

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32020R0025

EU food safety – plants directory:

https://ec.europa.eu/food/plant_en

EU food hygiene legislation:

https://ec.europa.eu/food/safety/biosafety/food_hygiene/legislation_en