Bote Central, Inc.

#21 Graceful corner Menchie Sts., BF Almanza,
Las Piñas City, NCR 1740 Philippines
Phone: +632.8360216, +632.8012682 Fax: +632.8050713
E-mail: basil@arengga.com URL: http://www.arengga.com

PRODUCTION GUIDE FOR ARABICA COFFEE

Bote Central- Serenity Coffee Corporation

Preface

This manual was designed to serve as a guide for Arabica coffee cultivation in the Cordillera highlands of the Philippines. It comprises of both theoretical and practical aspects of coffee production, harvest and post-harvest management of Arabica coffee. Keeping in mind the actual needs of Coffee growers in the Cordillera, this production guide presented here has been brought out to transfer improved coffee cultivation techniques to them. It is also intended to help them improve their current coffee management practices, thereby producing better quality beans to be competitive in the domestic market.

This publication was made possible through Bote Central- Serenity Coffee Corporation, in cooperation with the German Development Service in Manila. I particularly would like to thank Vie and Basil Reyes at Bote Central for their generous support, suggestions, ideas and interest in preparing this manual. In addition, I wish to express my sincerest gratitude to Lupe Coromina who invited me to stay on her farm estate in Tuplay for taking photos of Arabica varieties organically grown under a canopy of forest tree species.

And last but not least, I want to thank the coffee growers for sharing information and insights on all aspects of coffee cultivation in Tublay, Benguet Province.

Manila, 1. September 2009

Roland A. Ferstl

DED Consultant

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Introduction

Coffee is a brewed beverage prepared from roasted seeds, commonly called coffee beans, of the coffee plant. Dried beans are roasted, ground, and brewed to make one of the most popular beverages worldwide.

Coffee cherries or berries, which contain the coffee bean, are produced by several species of the genus *Coffea*. The two most commonly grown species are *Coffea canephora* (also known as Robusta coffee) and *Coffea arabica* -which accounts for 75% of the world's production; less popular species which are grown on a smaller scale are *Coffea Liberica* and *Coffea dewevrei* (Excelsa). All four types of coffee are grown in the Philippines.

C. Arabica is a tropical plant which requires very specific environmental conditions for commercial cultivation. Temperature, elevation, rainfall, sunlight, soils and the pattern of rainy and dry periods are all important and do influence growth and development of the coffee plant. Arabica is a higher value coffee grown in cooler, elevated areas at 1000m (3300 feet) or more above sea level. Normally, higher altitudes produce better beans, not only because they have the effect of increasing the acidity of the bean and thereby improving flavor, but also because the cold nights mean that trees develop more slowly, which allows the beans to develop a fuller flavor.

The importance of coffee in the Philippines cannot be overstated. While the domestic demand currently stands at 65,000 metric tons, domestic production is forecast at only 30,000 metric tons in 2009. The shortfall of 35,000 metric tons has to be imported. The production of Arabica accounts for only 5-10% of the county's total coffee, but it is well worth looking out for it. Arabica as a high-value crop is known to fetch higher prices and to provide an important source of income and employment for many upland farmers and their families in the Cordillera provinces and Mindanao. The extension materials on Arabic coffee cultivation are in very limited supply; especially in the more remote areas where opportunities for coffee are often greatest. Thus, these coffee production guidelines aim at providing farmers with basic knowledge on coffee management practices for improving the yield and quality of coffee beans. Topics such as factors influencing coffee production, cultural requirements, harvest and post-harvest management are covered. The information may be used by farmers, extension officers, and those interested in coffee.

Understanding the growth and fruiting habit of the coffee tree

Coffee like all plants, responds to the changing environment (temperature, rainfall, drought, day length) in which it grows, as influenced by the seasons. As the seasons change, the coffee tree changes from vegetative - root and shoot growth, to reproductive growth - where it flowers, sets and matures fruit to harvest then begins re-growth for the next cycle. Trees come into bearing 3-4 years after planting and are in full bearing at 6-8 years.

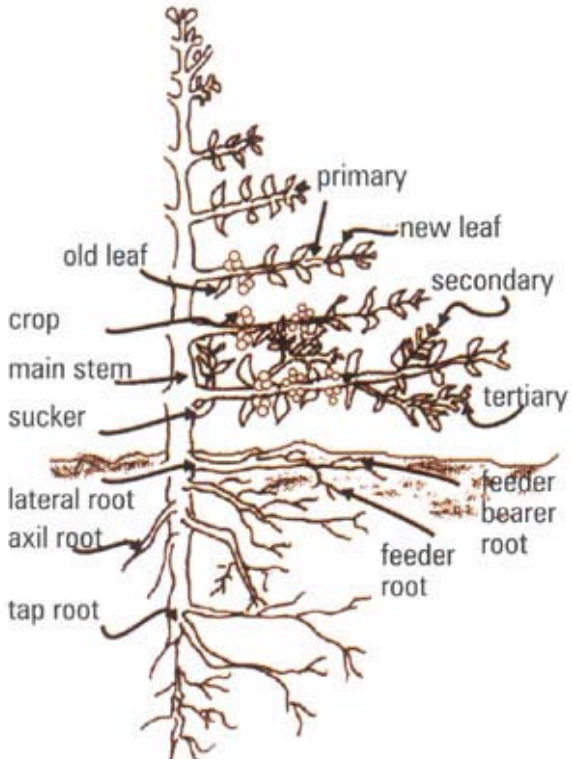


Figure 1. Parts of the coffee plant

The coffee tree has two distinct types of branches: vertical (orthotropic) and lateral (plagiotropic). The first shoot emerging from a seed becomes a vertical. As the vertical grows, lateral branches grow from buds produced at leaf axils (the node or base of each leaf) on the vertical. Normally, two laterals (rarely, three) are produced at each node on the vertical. The basic difference between vertical and lateral branches is growth habit. Verticals always grow upward, producing laterals once at the nodes and thereafter only new verticals at those nodes, if the conditions are favorable. The trunk is an old vertical. Laterals grow horizontally and produce leaves, flowers, and new laterals.

Flowering and fruiting occur at the nodes of the laterals and rarely on the verticals. Under normal conditions, flowers are produced only once at each node. Fruits (cherries) on the verticals are few and inconsequential, while good fruits are produced at every node on the bearing wood of the laterals if sunlight is adequate; heavy shade results in a node with few or no flowers.

The new growth on laterals is called growing wood. Fruit clusters appear at the nodes of this new growth during its second year, when it becomes known as bearing wood. While fruit is maturing on the bearing wood, new growing wood for the next crop is being produced at the end of the lateral. The size of the next crop will depend upon how much growing wood is produced during any given year, or, more exactly, on the number of new nodes on laterals.

Because the growing wood is being produced while the fruit is maturing, the tree is taxed for nutrition simultaneously by the growing wood and the developing fruit. As a result, when the tree is overloaded with fruit, very little growing wood is produced. Because the next year's crop is produced on this year's growing wood, overbearing during one year results in a small crop the next year.

On the other hand, if the crop is small this year and the tree is able to produce more growing wood, the result will be a larger crop next year. This tendency of bearing a heavy crop one year and a light crop the following year is commonly called biennial bearing.

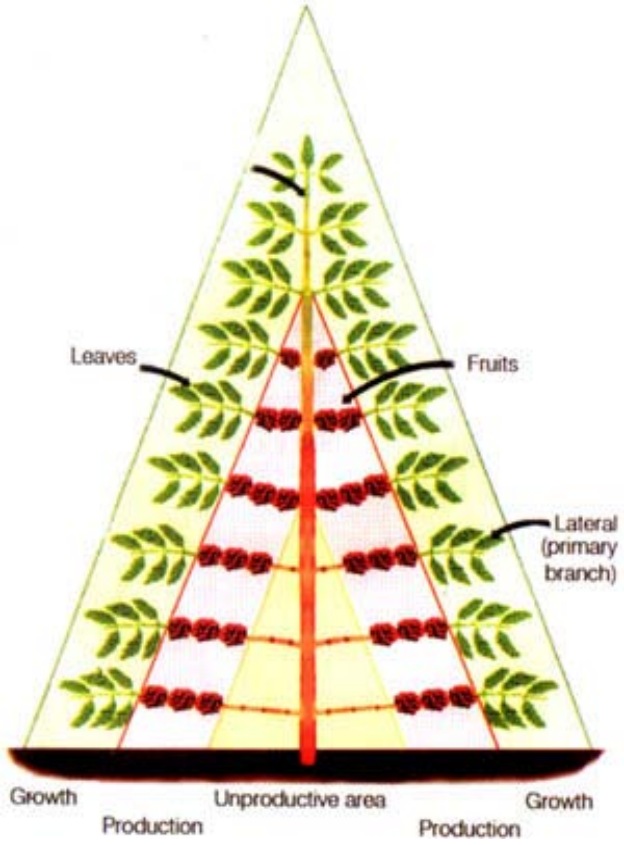


Figure 2. Growth habit of a coffee tree

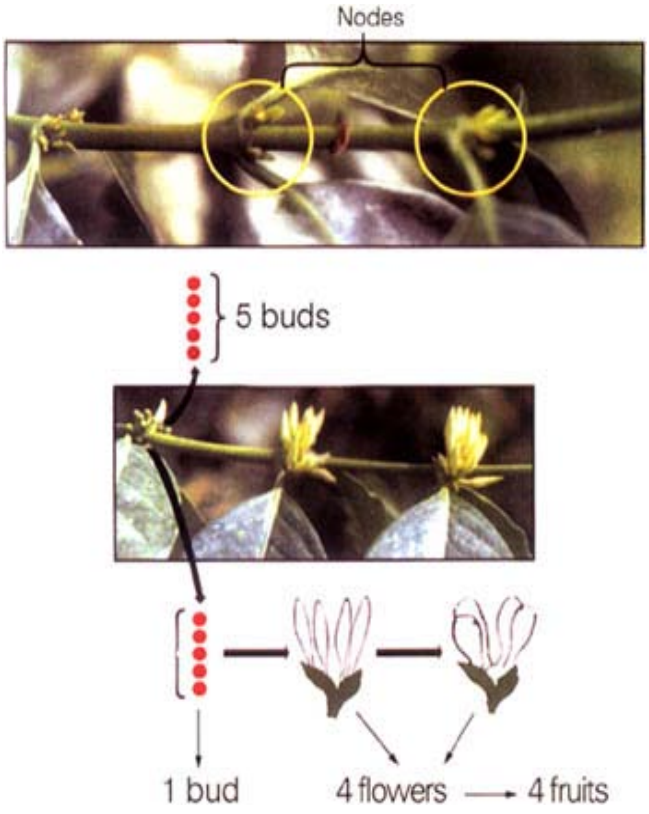


Figure 3. Potential of yields

Coffea Arabica is self-pollinating. After pollination, a fruit develops into a cherry containing two seeds (the coffee beans).Three to four years after plantin, white flowers appear in small bunches at the nodes. At each leaf node there are 5 buds each with 4 flowers, which may form 20 fruits(see Fig.3). Fruits mature 7-9 months after flowering.

Factors influencing coffee yield and quality

Successful coffee production depends on a favorable growing environment, careful planning and crop management, and a commitment to quality. The following factors influence coffee yield and quality:

Genetic factors (varieties to plant)

Coffee quality begins with the plant's DNA or genetic make-up and the genes that generate the chemical compounds that behave as aroma agents to be expressed during the roasting process. Likewise, the yield potential of a coffee tree is determined by genetic factors. If a seed came from a mother tree of high yield potential, then it would most probably take on the same characteristics. Thus, proper seed selection is essential in Arabica Coffee Production. When it comes to selecting the cultivar to be planted, cup quality is mostly the first priority. For example, Catimor and other Robusta hybrids, even with good disease/pest resistance, often impart undesirable flavors to the cup.

The variety of choice should ideally have the following characteristics:

- dwarfish or compact growth;
- high yield;
- leaf rust resistance;
- outstanding cup quality.

The best known varieties are 'Typica' and 'Bourbon' but from these many strains have been developed, including Caturra (Brazil, Colombia), Mundo Novo (Brazil), Kent (India), the dwarf San Ramon and the Jamaican Blue Mountain. Some more popular Arabica/Robusta hybrids are Hibrido de Timor, and Catimor – a cross between Caturra and Hibrido de Timor (resistant to coffee rust). Typica, Bourbon, San Ramon and Catimor are mainly grown in the Philippines.

Figure 4. Arabica varieties: San Ramon (left) and Typica (right)

Environmental factors (site requirements)

Figure 5. Coffee arabica grown under Benguet Pine (1700 m above sea level)

The environment has a strong influence on coffee quality. Altitude, daily temperature fluctuations, the amount of rain and the physical and chemical characteristics of the soil are very important. The altitude from sea level is a very important factor affecting coffee quality. Generally, it is recognized from research that the coffee quality increases with altitude.

Arabica should be grown in cooler, elevated areas at 1000 m or more above sea level (up to 1800m). High elevation improves the quality of the bean. The coffees grown at higher elevations i.e. 1200m and above are known to possess a distinct flavor and acidity in cup due to slower development of beans. The coffees are of high quality with dense beans. The ideal average temperatures range lies between 15-24°C. Temperatures greater than 30°C cause plant stress; temperatures below 10°C inhibit growth. The ideal amount of rainfall lies between 1500-2000mm per year. Both the total amount and the distribution pattern are important. Arabica requires adequate water during the growing and cropping period; however it also requires a dry stress period followed by sufficient rain or irrigation to promote uniform flowering and a good fruit set. Water requirements can be reduced by use of suitable, well-established shade trees and mulch. Well-drained soils with a minimum depth of 1.0 m are best suited. The ideal soil is a fertile, volcanic red earth or deep, sandy loam. Avoid heavy clay or poor-draining soils. The optimum pH value of the soil lies between 5-6.

Cultural Requirements

Seed Propagation

Coffee may be grown from seed or from cloned plants in the form of cuttings, grafts or tissue cultured plants. Arabica coffee is generally seed propagated. Arabica flowers are self-fertile, and varieties come true to type from seed. Seedlings are raised in seed germination beds under shade and then transplanted into polythene planting bags at the 2-3 leaf stage. The plants are ready for field planting in about 8-12 months.

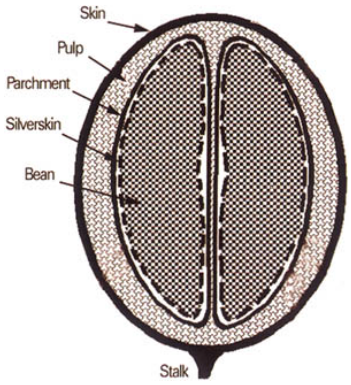


Figure 6. Parts of the cherry

Note: Coffee seed that is used for planting is actually parchment with the parchment hull and silverskin still in place. It is not green bean from which parchment hull and silverskin has been removed. Arabica coffee should be grown from fresh seed of the recommended varieties.

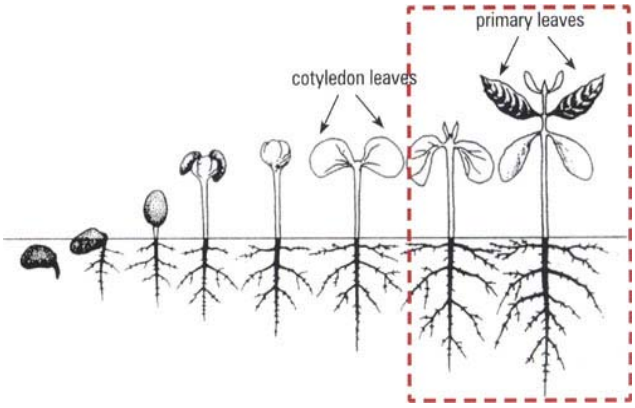


Figure 7. The Germination process

Germination is induced by placing the seeds in a sufficiently moist environment to absorb water. Depending on temperature and moisture, the cotyledon leaves develop after four to six weeks. Seedlings from germination beds are transplanted to polythene bags when they are at the cotyledon (butterfly) stage before the taproot is well developed. (see Fig. 7 for germinating process).

Select seeds

Remove floaters

Remove pulp

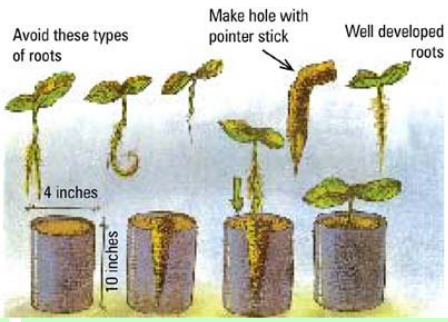
Wash seeds

A number of steps are necessary for production of good seedlings.

- Select and gather seeds from a mother plant that has been consistently prolific, with short internodes, with uniform size of cherries, and about 5-8 years old. Gather seeds that are free from pests and diseases and from high yielding trees. For a one hectare area, 750 grams of quality seeds is needed, however, a 50% allowance of seeds must be considered for ungerminated seeds and for replanting.
- Stir berries in a bucket of water and remove floaters. Those that sink are the good ones.
- Remove pulp by pulping machine or hand, then soak beans in water for 24 hours to hasten the removal of mucilage.
- Wash beans and check for more floaters discard.
- Dry the parchment slowly in shade on raised platforms or trays with good air movement. Keep dried parchment in cool dry place or mix with charcoal to preserve its viability.
- Prepare a germination bed that is about 8 inches (20 cm) high and 3 ft (1 m) wide to avoid floating. For preparing the seed bed use a soil and sand mixture of 50% forest soil and 50% river sand. Level the soil to the height of the sides of the seedbed. A bed of 6 x 1m will be sufficient for 750 grams of seeds.
- Using a pointed stick, make furrows 0.5 inch (12 mm) deep across the bed and 4 inches (100 mm) apart.
- Plant seed flat side down, with seeds 1 inch (25 mm) apart within the row and cover with fine soil.
- Cover seed with soil mixture to level the seedbed - seed should be about 0.5 inch (12 mm) deep after planting.
- Cover beds with a thin layer of rice straw mulch or cut grasses with a thickness of about 5 cm to ensure uniform temperature and to regulate moisture retention.
- Water the germination bed daily or when necessary to keep the soil moist. Depending on soil temperature, seeds sprout in about 40 days.
- The seedlings are transplanted to polythene bags at the button (butterfly) stage when two pairs of leaves have appeared. The seedlings are cared for in the nursery until they are ready to be planted in the field, when they have six to eight pairs of leaves.

Dry seeds under

Plant seeds

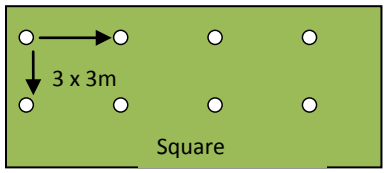


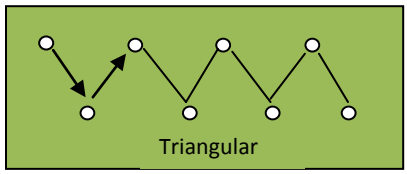
Transplant seedlings at

Site Preparation and Out-planting

Site preparation is needed for creating favorable growing conditions for coffee seedlings and to facilitate planting procedures. Ideally, site preparation should begin before the seedlings are planted out. Methods and intensity of vegetation clearing vary depending on intended use, topography and vegetation of the area. The partial removal of vegetation (e.g., patch clearing) such as grasses and weeds is recommended for the site preparation. The slash and burn technique (the traditional way of kaingin farming) as a means of clearing forest land on hillside plots should be avoided. On sloping land (greater than 15% slope), additional measures (e.g., contour planting/terracing or grass strips) to control soil erosion may be necessary.

Preparation of planting holes: Holes measuring 50cm x 50cm x 50cm are dug as early as one month before planting. The holes should be set at a square, rectangular (applied on plains or flat areas) or triangular pattern (sloping areas) by following the planting distance of the Arabica variety to be planted.





Time of outplanting: The best time for outplanting is at the beginning of the rainy season, provided, the soil is moist enough to ensure early survival of the seedlings. Planting towards the end of the rainy season will not give the seedlings enough time to be established prior to the dry season, thus, resulting in high mortality.

Spacing/population density per hectare: Spacing varies depending on site conditions and the variety to be planted. Tall arabica varieties (e.g.,Typica and Bourbon) are planted in rows measuring 2m x 3m or 3m x 3m. Dwarf Arabica varieties (e.g ., San Ramon) are planted at a spacing of 1m x 1.5m. The total number of seedlings to be planted on a hectare (10,000 sqm) basis can be computed as follows: Total no. of seedlings = 10,000 sq m/ spacing in sq m.

Example: No. of seedlings needed for 1 hectare at a planting distance of 3m x 3m.

10,000 sqm/9 sqm (3m x3m) =1111 seedlings

Transplanting seedlings into the field:

The key to successful planting is the ability of the root system to quickly take up water and nutrients.

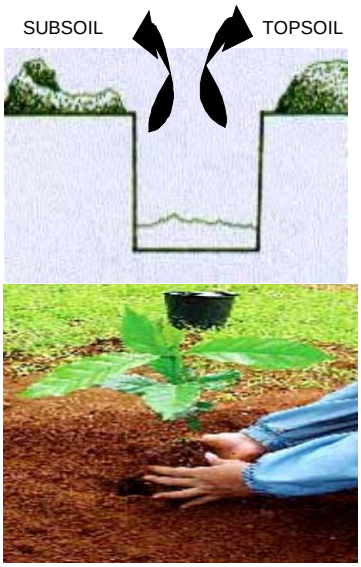


Figure 8. Planting of seedlings

Steps in planting seedlings

- Dig 50 x 50 x 50 cm holes on staked spots one month before planting.
- Before planting, ring weed about 1m around the center of the planting hole.
- While digging holes, separate the top soil from the subsoil. Pile topsoil to one side of the hole, subsoil to other side of hole.
- Add a generous amount of dry farmyard manure or compost or (at least 2 kg) before refilling the holes. Mix into loose soil at the bottom of the hole and into the pile of topsoil. In order to correct acidic soils, spread 225 g finely ground limestone over the soil in the planting hole and then dig in.
- Place the seedling upright in the hole. Do not remove the earth from the rootball. Plant the seedling as deep as the root collar. It is were the roots and the stem came together.
- Put back topsoil first and then the subsoil next. Fill the hole with soil until it is even with the ground level.

Weeding and Mulching

Coffee trees are shallow-rooted, which means that most feeder roots are near the surface. Working the soil to regulate weeds should be avoided to prevent doing damage to the surface roots of the coffee plant. Hoes should not be used. Remove weeds by hand or cut them off at the surface as soon as they appear. They compete with coffee plants for nutrients, sunlight and water. Weeding should be done at least 3-4 times per year, especially in the wet season.

Figure 9. Coffee seedling with mulch

Mulching will reduce the amount of weeding required. Place organic wastes (e.g., rice straw, grasses, leaves from nitrogen fixing trees) around the base of young plants by keeping mulch material 4 inches away from the trunk . Depending on the mulch material used, the depth of mulch should be between two to three inches. Dead or dry weeds can also be used as mulch. Mulching lessens growth of weeds, decreases soil erosion, improves soil structure as well as organic matter content of the soil, and improves the water absorption and water holding capacity of soils.

Fertilization

Figure 10. Nutrient deficiency symptom, deficient nutrient: potassium

Fertilizer application is important to add nutrients needed by the coffee plants. They need various nutrients for optimum growth, fruit and root development and for resistance to pests and diseases. Nutrients accumulated in the fruits will be removed when cherries are harvested. Nitrogen (N) Phosphorus (P) and Potassium (K) constitute the primary nutrients because of the large amounts required by the coffee plant. Mineral deficiencies can usually be detected visually from looking at the coffee leaves (see Fig.10).

The type and rates of fertilization depends on the tree size, vigor, soil type and stage of the coffee plant. Whatever type of fertilizer is to be applied, e.g., mineral or manure, application rates must be guided by soil analysis.. Watching plant growth, testing the soil, or analyzing the plant tissue are ways to assess nutrient needs. For instance, the average nutrient requirement of 800 kg green coffee per hectare is roughly 51.5,10.6 and 37.5 kg of N, P_2O_5 & K_2O respectively. It is recommended to actively supply fertilizer to help the long-term balance of nutrients when

- Out-planting seedlings: Every plant hole should receive a generous amount of fully decomposed compost.
- Pruning: After the coffee trees have been pruned, so that the new growth can develop.
- Coffee price is high: In this time, both time-consuming and labor-intensive cultivation practices such as using additional fertilizers can be justified.

Figure 11. Fertilizer placement

The most common and efficient method of fertilizer application is placement in drip-cycle. Fertilizers should be spread evenly on the soil around the drip line (the outside edge of the canopy) of the coffee plant, as this is where most feeder/hair roots are found (Fig. 9). Leaf mulch beneath coffee is swept towards base and fertilizers are applied in a broad circular band about 30 cm away from the main stem. They are incorporated into soil with a fork and covered by mulch. In sloping areas, the fertilizers should be applied in the upper half of the drip circle. Fertilizer application can be scheduled as follows: 1st- onset of the rainy season, 2nd –Mid of rainy season, 3rd-End of the rainy season, or 1th- onset of rainy season and 2nd –before the end of the rainy season.

In absence of soil analysis, consider the following general recommendation for fertilization of coffee.

The minimum amounts of manure to use are:

Year 2 1.5 lb/tree (0.7 kg)

Year 3 2.2 lb/tree (1 kg)

Year 4 4.4 lb/tree (2 kg)

Year 5 onwards 5.5 lb/tree (2.5 kg)

Shade and shade regulation

Figure 12. Arabica coffee grown under Alnus

Arabica varieties are frequently grown under shade trees. *N-fixing tree* species like *Alnus spp*. should be planted with coffee in the Cordillera because they enrich the soil with organic matter and nutrients from leaf fall, and fix nitrogen from the air. Shade also protects young coffee plants from drought stress and over exposure to sun. The shade grown coffee enjoys the advantages of extended crop life, enhanced soil fertility, lower nutritional requirements, lower water requirements and lower soil erosion. Shade also promotes a better balance between flowering and growth resulting in better berry production. Permanent shade trees are usually planted at a distance of 12-15 m.

Arabica requires around 50% of filtered shade for maintaining good consistent crop yield. Therefore, permanent shading trees need to be regulated by lopping the branches at a height of approximately 30 feet to create and maintain an optimum amount of shade. Leave litter and pruning material from shade trees should be used for composting or mulching if possible.

Pruning

Pruning is critical for consistent coffee production. Coffee trees are pruned to enhance their productivity and facilitate harvesting and other cultural operations. A major goal is to have regular annual bearing, avoid overproduction and the resulting biennial bearing pattern, and discourage conditions that result in overbearing dieback.

Every variety of coffee needs different pruning. There are basically two systems of pruning –the single stem (mainly applied to Arabica coffee) and the multiple stem system (mainly applied to Robusta Coffee). The single stem system involves cutting back older secondary and tertiary branches that have carried two crops. This encourages growth of new lateral branches.

Pruning is best done before general flowering or after harvest. In order to avoid poor development of branches, wait until sufficient moisture (after a rainfall) is present in the soil.

> Pruning is the removal of unnecessary and unproductive branches (excess, old, and dead branches) including undesirable sprouts.

Reasons for pruning are

-keeping the tree in a state of vigorous and productive growth,

-maintaining good tree shape and controlling the height to make harvesting easier,

-promoting better aeration and light penetration,

-moderating the tendency for the tree to produce a heavy crop one year and a light crop the following year, and

-preventing overbearing and dieback.

Pruning requirements for the single stem system (see Fig. 13 & 14)

Year 1 Desucker to maintain a single stem system and avoid competition from suckers.

Remove 'fly crop' fruit (early fruit which compete with strong plant/root development) as they appear.

Year 2 Desucker to remove drooping primary branches that touch the ground. Cut back to nearest secondary branch.

Remove secondary branches within 8 inches (20 cm) of the main stem.

Remove all fruit as they appear (fly crop).

Year 3 Trees should be allowed to crop in the third year.

Cap the main stem by cutting off the top of the tree at the level of the tenth branch (about 3-4 ft) from the ground. To allow the ten branches to be productive, cut apical shoots that will sprout at the capped area.

Remove the drooping primary branches touching the ground. Cut back to nearest secondary branch.

Remove secondary branches within 8 inches of the main stem.

Cut away suckers; they are not needed.

Cut away all the dead and dry branches, and all pest or disease damaged branches.

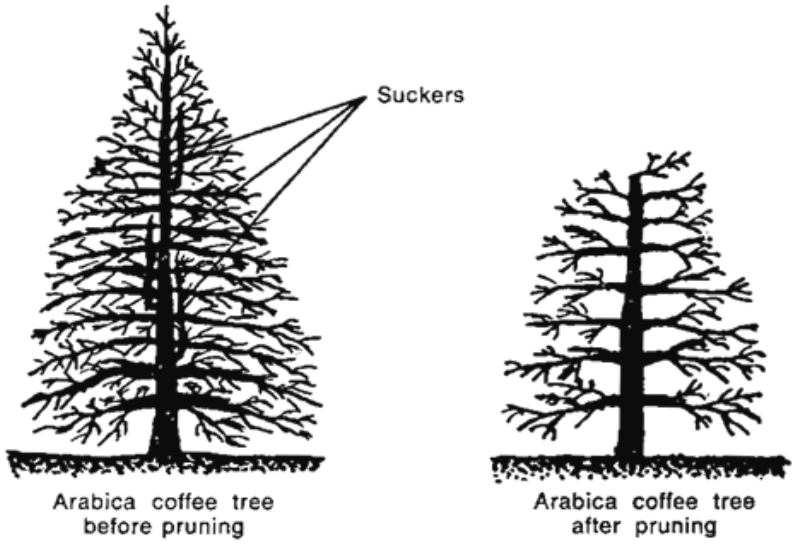


Figure 13. Arabica coffee tree before and after pruning

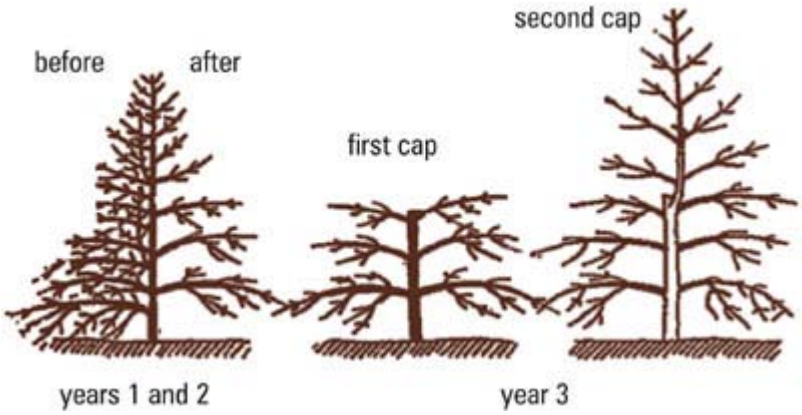


Figure 14. General pruning and desuckering of tree over years 1 and 2. Capping during year 3.

Rejuvenation (Change of cropping cycle)

A regular rejuvenation pruning is needed to maintain a source of new fruiting wood. This is done 6-8 years (depending on tree vigor and yield pattern) after the first harvest. Unless trees are renewed, yield will decline over the following years.

Three rejuvenation methods are used:

- Side pruning
- Full stumping
- Bending

Side pruning

This involves removing one side of the tree, training a new sucker and then removing the other side of tree two years later. This method is recommended for all growers, as only 50% of the crop is lost for the two-year period (Fig. 15).

Two years before stumping, remove all branches on the eastern side of tree after harvesting. Select a new sucker approximately 12 to 18 inches from the soil level, and train the shoot by thinning as described for a new planting (Stages 1 and 2) until bearing a crop (Stage 3).

Two years later, stump the older stem above the new stem. Cut at a 45° angle - do not cut straight (Stage 4).

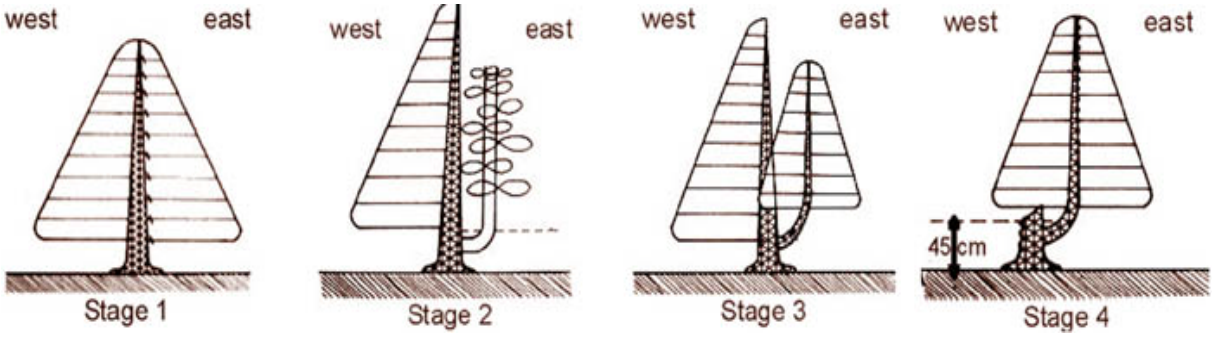


Figure 15. The four stages in side pruning a coffee tree

Full stumping

Full stumping involves cutting the tree back to knee height - about 20 inches (50 cm) from soil level, and developing a new stem from the stump (Fig. 16).

Figure 16. The full stumping procedure

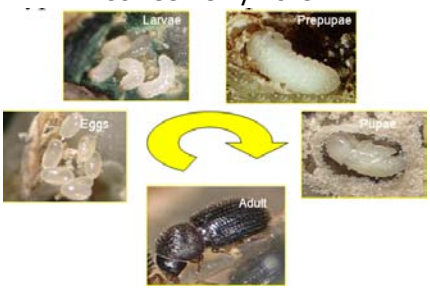
Bending

Bending is another way to rejuvenate old coffee trees. This is done by bending the stem from east to west, or along contours at a 45° angle from the ground. This will promote growth of new sprouts. Bend the stem towards the ground slowly to avoid splitting of the main stem. The tree can be fixed by using a wire. When the newly emerged sprouts are about 30 cm high, cut and separate the upper portion of the tree at knee height from the main trunk.

Insect pests and diseases control

Coffee plantations are generally confronted with various insect pests and diseases, an indication that the coffee eco-system is not balanced. Most infestations with pests and diseases are attributed to the following:

- Unsuitable locations (too low altitude, too warm, too humid, too dry, etc.)
- Degraded or poor soils, lacking organic matter
- Too high plant density (varieties planted too close together)
- Too little diversity and too few shading trees
- Unsuitable shade management, failure to trim shading trees (too much shade)

Insect Pests and Diseases		
Insect pest	**Damage/Symptom**	**Control**
Coffee Berry Borer 	The berry borer (black beetle) cause damage by boring and depositing eggs into the berry. Larvae hatch and feed on the seed or bean, destroying it. Fruit drop of young, green berries. Berries that do not drop often have defective, damaged beans.	Collect all the remaining berries after harvest. This breaks the cycle of the pest. Collect and dispose of all infested berries on the tree and on the ground. They may be buried a least 20cm deep in the soil. Proper pruning should be done to avoid heavy shading. "Living most of its life inside the berry makes this pest difficult to control with traditional chemical and biological controls.
Coffee Twig/Stem Borer  *Larva of twig borer*	Larva of the insect bores the twigs of coffee and kills the tree in a few weeks. Wilting of leaves and dead trees or branches. Infested branches may develop dark gray discoloration and may wilt and fall-off or dry up.	Pruning and immediately burning the infested twigs at regular intervals. Higher altitude, above 3300 ft (1000 m) seems to reduce the incidence of infestation. Less damage occurs under conditions of good shade. No effective chemical control known.

Green coffee scale 	Green oval shaped scales about 2 to 3 mm long. The scale insect infests the young shoots, stems, mostly the leaves. Infestations then produce spots of honeydew, which become covered with black sooty mould.	Spraying with tobacco and soap solution will check the spread of the pest. 2.2 lbs (1kg) strong tobacco per 0.5 gal (2.3 L) water. Soak for 2 nights. Then remove tobacco. Add 1 lb (455 g) of washing powder and make up to 4 gal (18 L). Spray weekly until scales disappear. Natural predators such as ladybugs will also reduce the level of infestation.
Mealybug 	White waxy colonies are usually found on the underside of tender leaves and in soft stem areas around berries. Mealybugs are often associated with a heavy infestation of sooty mould.	Generally, Mealybugs become a problem in the dry season when water is lacking. Infestations of mealybugs are often found where there has been use of insecticide sprays, especially highly toxic organo-phosphate sprays. These kill almost all insects, including natural enemies of mealybug.
Disease	**Damage/Symptom**	**Control**
Coffee leaf rust 	Orange-yellow powdery spots appear on the leaves only. The disease is caused by a fungus (*Hemileia vastatrix*). The disease is directly influenced by rainfall. For spore germination, water is needed, and the splashing rain aids in spore dispersal.	The old and infested trees should be rejuvenated by cutting the trunks at 30 cm from the ground. The pruned branches and leaves should be burned. Planting of rust resistant varieties (i.e., catimor). Copper fungicides (sprayed at 2-3 weeks interval) may be used for treatment of coffee rust.
Anthracnose 	The fungus can cause three different coffee diseases - twig dieback, brown blight of ripening berries and leaf necrosis. Twig dieback - yellowing and blight of affected leaves. Twigs wilt, defoliate and die at the tips. Brown blight - brown sunken lesions on fully developed cherries which turn black and hard (can be confused with Cercospora). Leaf necrosis - round brown necrotic spots up to 25 mm diameter. Worse on sun-burnt or injured leaves.	By adequate nutrient (Nitrogen, Potassium) and water supply, the disease can be kept under control. Maintain good shade (50%). Other control measures are not warranted.

Cercospora leaf spot (brown eye spot) 	Brown spots on leaves gradually expanding with reddish brown margin (occurs on young coffee seedlings in the nursery). Spots on both sides of the leaf caused by a Pythium spp. fungus. When there are many spots, leaves appear to have been burnt.	Avoid over-watering. Maintain 50% shade cover. Space plant bags to allow air movement (proper nursery management). Prevent nitrogen and potassium deficiency in the germination bed.

Figure 17. Control of Insect pests and diseases

Harvest and Post-harvest management

Harvesting

Figure 18. The red, ripe berries are ready for pulping

Harvesting takes place in the dry season at the end of the annual growth cycle of the coffee plant, which varies according the species grown (Arabica, Liberica, Robusta) and its location. The Arabica cherries, or berries, as they are usually known, ripen in 7-9 months after flowering. Harvest should commence as soon as there are sufficient ripe berries for the harvest. At this stage, the bean can be squeezed out from the pulp by applying light pressure between finger and thumb. The desired berry is shiny, red and firm to the touch. The harvesting method is dictated by a combination of the requirements of the processing method, economic considerations and availability of labor. In general, two harvesting methods can be identified: 1) selective picking (finger picking) where the picker takes only ripe berries; 2) unselective picking (stripping) where whole bearing shoots are stripped off. Selective picking of ripe red fruits produces highest quality.

It is recommended to pick the berries only when they have reached optimum maturity, i.e. picking up only the ripe berries, leaving immature berries to be harvested later when they are mature. This means that selective picking has to be carried out manually berry by berry.

Reasons for selective picking of ripe berries are

-Irregular maturation, berries do not ripen uniformely ;

-Overripe or rotten berries can spoil a batch of perfect ripe ones;

-Harvesting green or unripe berries will result in low quality beans, low price and bad cup taste.

Processing

Coffee processing transforms fresh coffee cherries into clean, green bean of 12% moisture ready for roasting. After harvesting, start processing the coffee beans immediately. There are two different procedures used to process fresh cherries into green coffee: the dry and the wet method, which are shown below.

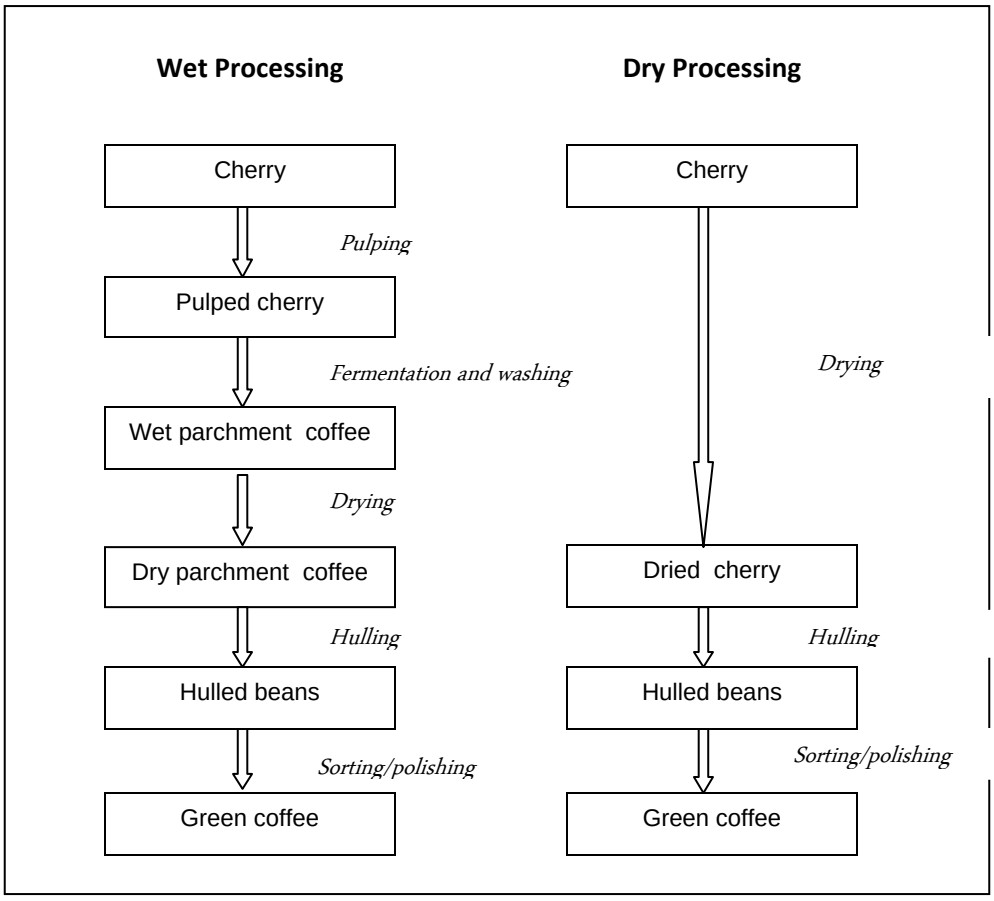


Figure 19. Flow diagram wet and dry processing

Dry processing

This is a one-step operation where the coffee bean is dried inside the whole coffee fruit to 12% moisture. The dry cherry is then hulled to produce a dry green bean. This is the low cost, traditional system resulting in a low quality coffee, and is not recommended. The essential difference between the wet and the dry method is that in the wet method the pulp of the fruit is separated from the beans before the drying stage.

Wet processing

This is the recommended processing technique for Arabica coffee. To obtain good quality coffee, berries must be de-pulped on the day of picking as any delay causes heating through fermentation and this spoils the flavor . The steps involved in wet processing are flotation, pulping, fermentation, washing, drying , dehulling and sorting.

Flotation

Soak the cherries in a large vat to separate the floaters. These are the light cherries often infested by berry borers. Black, dry cherries are processed separately and considered low grade.

Pulping

Immediately after harvest, pulp the cherries (removing the pulp) in a pulping machine, leaving two beans surrounded with their parchment as well as the sticky mucilage adhering to the parchment.

Fermentation and washing

Ferment by placing the beans in plastic containers with clean tap water to remove residual pulp and mucilage. They are left to ferment in water for 12-24 hours. The parchment is then washed off completely. Discard floaters. After fermentation, the beans are washed, leaving so-called ‘wet parchment coffee’.

Drying

After washing, dry the wet parchment coffee up to 12 % moisture content in full sun (or with the use of artificial dryers) on a hard, flat, clean surface such as concrete slabs, mats, raised tables or trays with a mesh base.

Note: Do not dry coffee beans directly on soil or dirty surfaces that lead to dirty or earthy flavors in the finished coffee. During the drying process, coffee must be covered with polythene or plastic sheets if rain occurs and every night to stop re-wetting that results in mould development. Coffee is fully dry when green bean is a translucent, jade green color and 12% moisture content. When bitten with the teeth, the bean is dry when it is barely marked, and over-dry (8 to 10% moisture) if it breaks.

Hulling

Hulling dry parchment is a mechanical process to remove the dry parchment skin and silverskin from the green bean. The beans are then sieved, polished and sorted out before being put in bags. The coffee at this stage is 'green coffee'.

Grading and Classification

The grading of coffee plays a major role in cash pricing. The coffee industry has organized itself around a system of grading that allows the market to price coffee based on consistent standards of quality. In the classification system established by the Specialty Coffee Association of America, (SCAA) for example, green coffee is divided into five defined grades. Each class is determined by the number of full defects found in a formal sampling of the coffee. A defect may consist of such imperfections as stones, sticks, hulls and spoiled or broken beans. For example, the exchange grade (Class 3) can have no more than 23 defects. The "exchange grade" of arabica coffees in the SCAA classification is comparable to the standard or constant benchmark for the pricing of coffee.

GRADE AND BASIS

Class 1	Specialty Grade (0-5)
Class 2	Premium Grade (6-8)
Class 3	Exchange Grade (9-23)
Class 4	Below Standard Grade (24-86)
Class 5	Off Grade (more than 86)

Defective Equivalents			
Primary defects	Number of defects that equal one full defect	Secondary Defects	Number of defects that equal one full defect
Full Black	1	Parchment	5
Full Sour	1	Hulls or Husks	5
Dried Cherry	1	Broken/Chipped/Cut	5
Fungus Damaged	1	Slight Insect Damage	10
Foreign Matter (stones, sticks)	1	Partial Black	3
Severe Insect Damage	5	Partial Sour	3
		Floaters	5
		Shells	5
		Small Stones/small sticks	1
		Withered beans	5
		Immature/Unripe	5

Table 1. Types of defect and defective equivalents

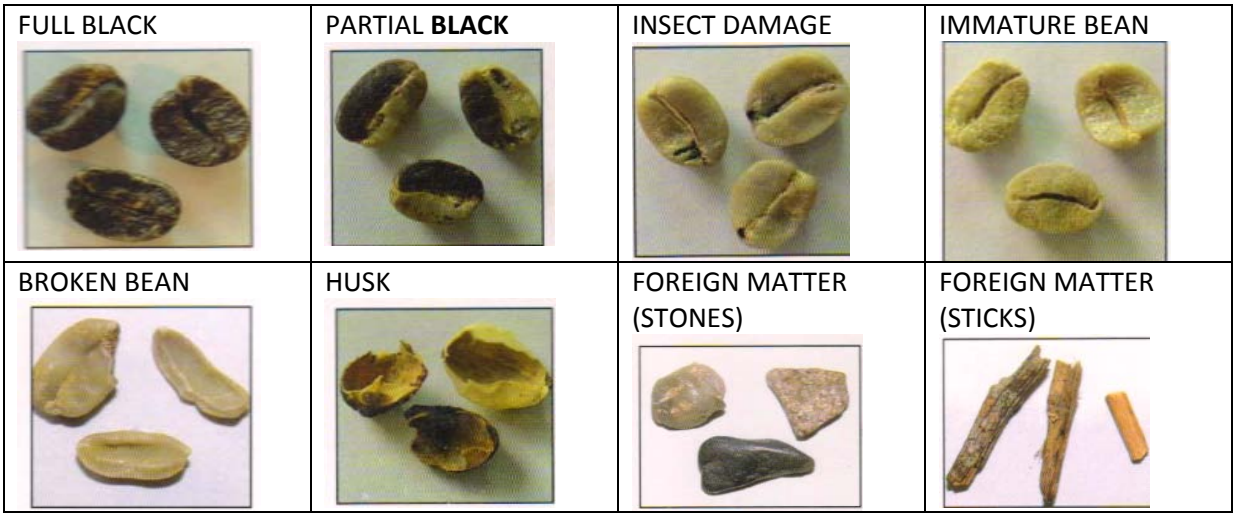


Figure 20. Examples of defects

Defect Definitions

Black Bean- Coffee bean of which half or more than one-half of the external bean is black

Insect Damaged Bean- Coffee bean with one hole or more caused by insects

Immature Bean- Unripe coffee bean of yellow-greenish color with wrinkled surface. Beans are often smaller, curved inward in a concave shape with sharp edges.

Broken Bean- Chipped/broken beans usually have reddish color due to oxidation of the area where the cut/chip took place. These beans occur during the pulping or milling process where the adjustment of equipment is faulty.

Husk- Husks are a fragment of dried pulp that has a dark red color

Foreign Matter- Foreign matter includes all non coffee items found in green coffee such as sticks, stones, nails, corn, rice, etc.

Parchment- Parchment beans are partially of fully enclosed in a thick, papery husk that is white or tan in color.

Floater- Floater beans appear distinctively white and faded. If there is any doubt, place beans in water- they float!

Shells – Shell beans are malformed; the outer section has a seashell shape and the inner section can be conical or **cylindrical**.

Storage

Figure 21. Storage of green coffee beans

For quality reasons, it is recommended that coffee be stored in parchment form as long as possible before final sale since the parchment layer provides a good physical protection of the bean. Mould can grow on stored coffee if it has not been dried sufficiently before storage or if the stored coffee absorbs moisture from the atmosphere due to humid conditions. Humidity and high temperatures are factors, which contribute to quality deterioration and should therefore be kept at a minimum during storage. Poorly ventilated warehouses and relative humidity situations over 65% can create mould problems. Bags made of jute or other natural fiber is preferred to allow flow of air and prevent moisture build-up. To allow circulation of air, coffee should be stacked in compact piles, on top of wooden pallets and a few spaces away from the wall. Storage areas must also be kept clean and free of animals and insects to avoid microbial contamination. It must also be kept isolated from the odor of strong smelling liquid such as fuels and chemicals. Target weight per bag must be 60kg net.

Recommendations to improve coffee quality

- Cherries that have dried on the tree and those that have fallen to the ground are known to be susceptible to mould growth and therefore these should not be picked.
- Process cherries as quickly as possible. Avoid storage of cherries, especially ripe and over-ripe ones, as any period of storage increases the likelihood of mould growth.
- Do not dry on bare soil. Mould spores from previous lots are known to remain on the ground and this could result in clean cherries being contaminated during drying.
- Protect beans from moisture and rain.
- Remove as many defects (husks, un-hulled cherries or mouldy beans) as possible.
- Keep cleaned dried beans separate from discarded material.
- Use clean bags for storing cleaned tried beans
- Cover bags during transport and storage to prevent re-wetting.
- Load and unload trucks in dry weather or under cover.
- Make sure that wooden floors of trucks are dry.
- Store coffee in well-ventilated and leak-proof warehouses. Store sacked coffee without contact with the floor and 30cm away from the walls.
- Provide good quality control tests and ensure that they are adhered to, especially to check for moisture and defects.
- Keep moisture content as uniform and as low as possible-below 13%.

Glossary of Terms

Cherry (or Coffee berry): The complete fruit of the coffee tree, can be either fresh or dry.
Defects: The collective name for common but undesirable particles found in bulk green coffee. Defects can include various types of beans, or parts of beans, fruit tissue and foreign matter. Numerous terms are used to describe the various defects that can be present in both green/raw and roasted coffee beans, and sometimes these are used in some producing countries and not others. In general, bean defects are caused by faulty processing, pest damage, or inclement climatic conditions leading to poor fruit development. Defects are given a weighted value to assist in the classification and grading of coffee lots under various national and international systems.
Dry processing: Treatment consisting of drying coffee cherries to give husk coffee, followed by mechanical removal of the dried pericarp to produce green coffee. The product is called ‘cherry coffee’, ‘unwashed coffee’ or ‘natural coffee’.
Dieback: Not a true disease but a physiological problem. Severe leaf loss and branch dieback. Dieback causes alternating bearing (heavy crop one year and poor crop the next).

Flotation: Cherry coffee separated by virtue of it being positively buoyant in water applied to selectively picked coffee the vast majority of which is ripe or immature.
Green coffee bean: The dried seed of the coffee plant, separated from non-food tissues of the fruit.
Hull: The dried endocarp of the coffee fruit.
Husk: Waste material resulting from the hulling of parchment or dry cherry coffee, made up of the dried pulp and outer covering of the parchment.
High Grown coffees. The coffees grown at higher elevations i.e. 4000 ft and above are known to possess a distinct flavor and acidity in cup due to slower development of beans. The coffees are of high quality with dense beans.
Mucilage: Common word to describe the fruit mesocarp, an intermediate layer of tissues between the epicarp and the endocarp (parchment). It consists mainly of pectinaceous mucilage and pulp.
Parchment: Common word to describe the endocarp of the coffee fruit. It lies between the fleshy part (or pulp) of the cherry and the silver skin. This is the thin, crumbly paper-like covering that is left on wet-processed coffee beans after pulping and fermentation. Subsequently removed during hulling.
Parchment coffee: Wet-processed beans after pulping, dried to about 12% moisture content, but before hulling has removed their hard outer covering (the endocarp/parchment).
Processing: Steps involving the transformation of harvested coffee fruits to a dry and stable condition.
Pulp: The fleshy outer layer of the mesocarp, directly beneath and including the skin, removed with a pulping machine.
Pulping: Mechanical treatment used in wet processing to remove the exocarp and as much of the mesocarp as possible.
Suckers: Suckers are unwanted verticals (shoots) that grow straight up out of an existing lateral branch. *Sucker*s should be removed when they appear in coffee trees.
Wet process (or Wet processing): A method of processing coffee cherries into dried parchment coffee. Treatment consists of mechanical removal of exocarp in the presence of water, removal of all the mesocarp by fermentation or other methods, and washing followed by drying to produce parchment coffee which is subsequently stripped of its parchment to produce green coffee.

References

CTAHR. 2009. Pruning. Retrieved from http://www.ctahr.hawaii.edu/fb/coffee/coffee_pruning.html (15.Mai 2009), University ofHawaii at Manoa.

FIBL, Naturland, SIPPO (Editor). 2002. Organic Coffee, Cocoa and Tee. Part B: Production guidelines. Published by SIPPO, Zürich, Switzerland.

Griffin, M. 2006. Improving coffee quality through education and science. Retrieved from http://www.coffeeresearch.org/agriculture (15.June 2009). Coffee Research Institute Austin, Texas, USA.

International Coffee Organization. 2002. Code of Practice: Enhancement of coffee quality through prevention of mould formation. Private Sector Consultative Board No. 36/02, London, England.

Kosalos, J. et al. 2004. Arabica Green Coffee Defect Handbook. Specialty Coffee Association of America. Long Beach, USA.

Lumagbas,G. J. 2009. Philippine Coffee Industry. Philippine Coffee Board, Inc. Manila, Philippines.

Soto-Pinto, L. et al. 2000. Shade effect on coffee production at the northern Tzeltal zone of the state of Chiapas, Mexico. Agriculture, Ecosystems and Environment 80 (2000) 61-69.

Versola L. K. 2002. Practical Guide for quality coffee Arabica production in the Cordillera. Cordillera Integrated Agricultural Research Center, Department of Agriculture- Cordillera Administrative Region. Baguio City, Philippines.

Winston, E. et al. 2005. Arabica coffee manual for Myanmar. FAO Regional Office for Asia and the Pacific. ISBN: 974-7946-72-6, Bangkok, Thailand.