Arabica coffee
manual for Lao-PDR

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Tad Fane Falls, near CREC, Ban Itou

Preface

This Arabica coffee manual for Lao People's Democratic Republic (Lao PDR) is an activity under a FAO Technical Cooperation Program coffee project for Lao PDR. It has been compiled by Ted Winston, Jacques Op de Laak, Tony Marsh and Herbert Lempke (International Consultants to the FAO coffee project) and Keith Chapman (Industrial Crops Officer, FAO Regional Office for Asia and the Pacific), in collaboration with the staff of the Coffee Research and Experimentation Centre (CREC).

The manual has been prepared as a support base for training of trainers and staff of the Coffee Research and Experimentation Centre. It contains key information of importance to farmers and managers of coffee plantations and is intended to be a primary source of practical knowledge on Good Agricultural Practices (GAP).

FAO sincerely thanks the authors and CREC for their dedication to the preparation of this manual.

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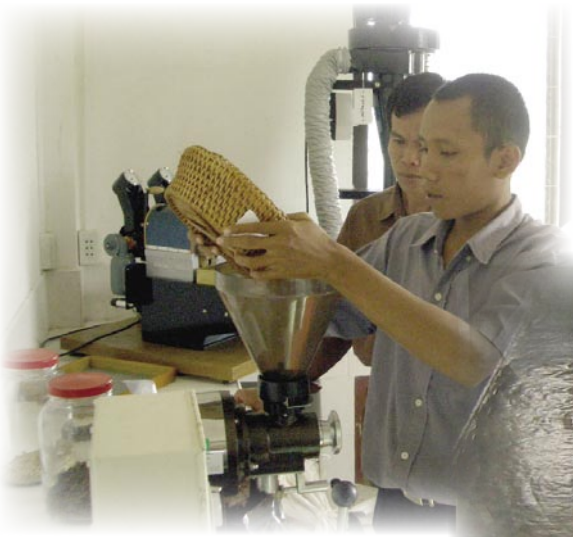
We also sincerely acknowledge the coffee farmers, plantation owners and their staff and traders of the Bolovens Plateaux, and the NGO projects assisting smallholders, for discussions and information provided.

The majority of the photographs have been supplied by the authors who also acknowledge the Department of Primary Industries, Queensland, Australia for some of the pest photographs.

We are very much indebted to Loraine Chapman, Australia, who has generously provided the English editing, indexing, design and electronic layout of the book for publication.



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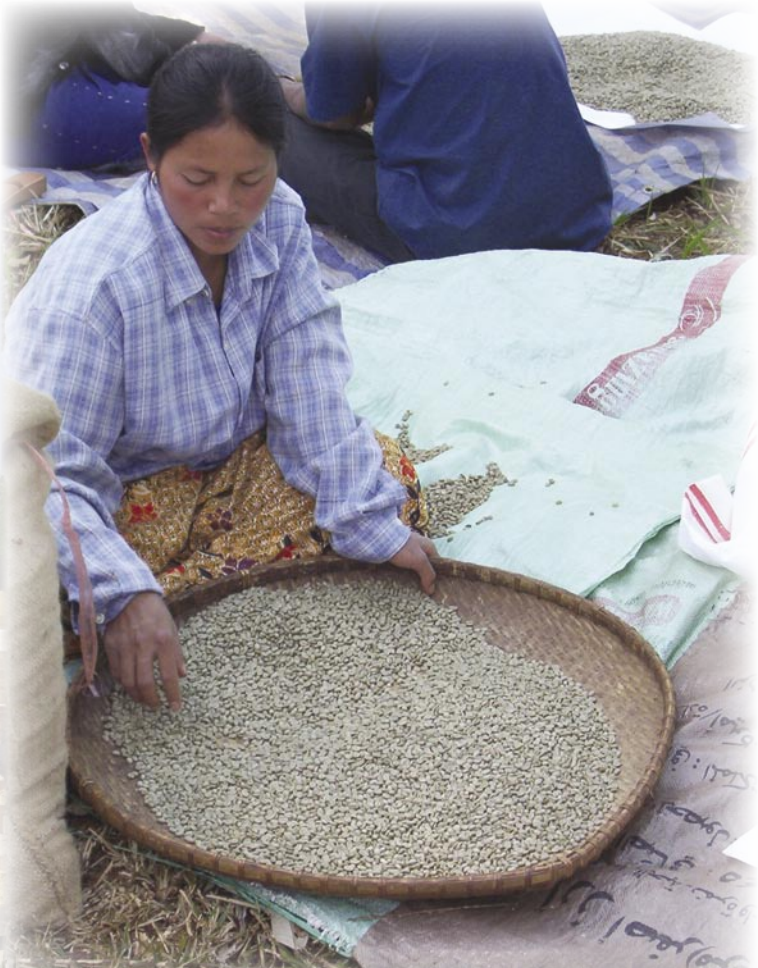


Chapter 1

Coffee plant & site selection

Coffee is a key industry of Lao PDR being the fifth largest export earner for the country. The French first planted coffee in Lao PDR in the early 1900s on the Bolovens Plateaux in southern Lao. Initially Robusta, Arabica and Liberica species were planted, but due to Arabica leaf rust disease and low prices for Liberica, Robusta has become the dominant coffee species grown. About the same time, new hybrid Arabica coffee was brought to Lao in a bid to stimulate the Arabica coffee industry. This Catimor variety of Arabica is resistant to the major disease of coffee leaf rust.

Coffee is the dominant farming system on the Bolovens Plateaux, which cover an area of about 500 sq. km, ranging across altitudes of 600 to 1300 m.a.s.l. (metres above sea level), at about latitude 15°North. This area produces about 95% of Lao coffee. Arabica coffee has been planted in recent years in a number of the northern provinces of Lao PDR, but to date the relatively small volume of coffee beans produced has not encouraged processing and marketing.

Lao is at now beginning a major change in its coffee industry. In today's world coffee market, in which Lao PDR produces 0.25% of the world production, the emphasis is to move production to higher-value Arabica rather than the lower-value Robusta coffee that is the current mainstay of the industry.

The Government of Lao-PDR plans to increase planting of Arabica to create a balance of 50:50 Arabica:Robusta. Lao 2001 figures indicate that there were 34,000 hectares planted to coffee (88% Robusta and 12% Arabica) and that 23,000 families were involved in coffee production.

The coffee industry in Lao PDR is a mixture of smallholder and large estates. Management systems range from high input intensive systems to smallholders with zero inputs and low yields. Large estates have their own processing and branding, with one company currently producing their own instant coffee.

Lao has the potential to grow large amounts of high quality Arabica coffee. It has a very suitable climate, abundant land resources and farmers who are eager for a viable cash crop. The volcanic red earth soils and climate of the upper elevations of the Bolovens Plateaux are an excellent area to develop a specialised and valuable coffee industry. Although the Government of Lao is interested in developing this industry and there is a clear market for good quality Lao Arabica coffee, it lacks funding support

In collaboration with the Coffee Research Experimentation Centre at Ban Itou, the FAO Technical Co-operation Project TCP/LAO/2903 that is responsible for production of this manual, is targeting some key aspects of this research, development and extension process.

for the essential research, development and extension to support the emerging industry.

There is also an opportunity to produce value-added 'washed/semi-washed' Robusta coffee as Lao Robustas are already sought for their clean, good bodied, neutral characters. Lao is atypical in that a large quantity of Robusta is grown at high altitudes of up to 1300 m.a.s.l. resulting in some unusual characteristics in this coffee. New processing, pulping and demucilaging technologies have been introduced by the FAO project to improve both Arabica and Robusta quality at affordable costs. These will offer some new opportunities for both coffee Arabica and Robusta coffees.

Factors affecting yield and quality

There are three factors which impact greatly on coffee yield and quality.

- Genetics (Genotype-species and varieties to plant)
- Environment
- The coffee plant and its management

Genotype species and varieties to plant

Species

There are two main species of commercial coffee — *Coffea arabica* and C. *canephora* (robusta) and two minor commercial species — *Coffea liberica* and *Coffea excelsa*.

Arabica is a higher quality and higher value coffee normally grown in cooler, elevated areas of the tropics and sub-tropics at 1000 m or more above sea level. Arabica is used in the roast and ground coffee market and is added to blends of Robusta to improve the quality of instant coffee. Brazil and Columbia are the major producing countries.

Robusta is a lower quality coffee and prices are normally about 30 to 40% less than Arabica. Robusta is used mainly in instant coffee and for blending with Arabicas to add body and crema. Robusta is normally grown in warmer areas at lower elevations unsuited to Arabica, and is considered resistant/tolerant to coffee rust. Lao PDR is an exception to this in that Robusta is grown at higher elevations (up to nearly 1300 m.a.s.l.). Vietnam, Brazil and Indonesia are the largest Robusta producing countries. Compared with Arabica, Robusta is generally more vigorous, more productive and less vulnerable to rust.

Liberica and **Excelsa** are grown mainly in low, hot climate areas. Quality is poor and markets are limited. These coffees are of local importance in a few countries and not of major commercial significance in the international coffee market. Both are present in the older Lao plantations, but have little future in the era of high quality coffee.

For Arabica, the improvement of genotype is achieved by proper choice of variety (cultivar). The variety of choice should ideally have the following characteristics:

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

Varieties to plant

Coffee is a long-term crop with a lifespan of more than 10 years, and considerably longer under good management, thus the choice of variety (cultivar) is very important. As quality of the coffee bean is crucial for production of high-grade coffee, choose only varieties that are recommended for your area. These will be the best yielding, best quality varieties that will grow productively in the local soils and climate.

For the Bolovens Plateaux the recommended Arabica cultivars are:

Catimor T 5175
T 8667
LC 1662
P 86
P 88
P 90

Arabica (especially at elevations above 1000 m.a.s.l.):
Java
Typica

Other varieties are being tested at the Coffee Research Experimentation Centre and Dao Heuang Farm near Paksong (1180 m.a.s.l.). CREC will advise in the future those varieties that are suitable for planting after trials and cupping tests are completed. Comments on these varieties and others of significance being tested at CREC and Dao Heuang include these listed below and on the following pages.

Typica

Origin:	Probably Yemen, one of original Arabica coffee types.
Growth Habit:	Upright, vigorous.
Yield:	Low to moderate.
Rust resistance:	Very susceptible.
Cupping quality:	Excellent.
Comment:	Traditional type in Laos.

Java

Origin:	Indonesia.
Growth Habit:	Upright.
Yield:	Low.
Rust resistance:	Susceptible.
Cupping quality:	Excellent.

S 795

Origin:	Introduced in 2004 from Myanmar. Selection of Balehonnur Coffee station in India. It is a cross between S 288 and Kent. S 288 is the first generation of S 26, a natural hybrid between C. Arabica and C. liberica.
Growth habit:	Tall upright and open.
Yield:	Low.
Rust resistance:	Susceptible, but more tolerant with careful selection.
Cupping quality:	Excellent.

Continued ...

Comment: Does not exhibit any Liberica characteristics. In Indonesia this variety has been selected for up to eight generations for rust tolerance and cupping quality and is an excellent variety in East Java.

Caturra

Origin: Bourbon mutant from Brazil.
Growth habit: Semi dwarf, dense foliage.
Yield: Good.
Rust resistance: Very susceptible.
Cupping quality: Fair.
Comment: Both red and yellow types exist. It succumbs to dieback problems under poor management.

Catuai

Origin: A cross between Caturra x Mundo Novo.
Growth habit: Semi dwarf and dense foliage.
Yield: Very High.
Rust resistance: Very Susceptible.
Cupping quality: Good. Good bean size
Comment: Later maturing. Tolerates poor management.

SL 34

Origin; Kenya. A French Mission selection.
Growth habit: Tall, upright and open canopy.
Yield: Moderate to good.
Rust resistance: Very susceptible.
Cupping quality: Good.
Comment: Large bean size, drought tolerant.

SL 28

Origin: A Bourbon selection from Kenya.
Growth habit: Tall, upright and open.
Yield: Moderate to good.
Rust resistance: Very susceptible.
Cupping quality: Good.
Comment: Large bean size, drought tolerance.

SL 6

Origin: Kenya.
Growth habit: Tall, upright and open.
Yield: Moderate to good.
Rust resistance: Resistance to Rust, Race II.
Cupping quality: Good.
Comment: Large bean size.

Catimor

Origin:	A cross between Caturra and Hybrido de Timor (HDT). Hybrido de Timor is a natural cross between Arabica and Robusta from East Timor.
Growth habit:	Semi dwarf compact.
Yield:	Very high with correct management. Low with poor management and will die under poor management, especially if no shade is present.
Rust resistance:	Resistant to all races of rust provided careful selection is maintained.
Cupping quality:	Fair.
Comments:	Since the rapid spread of coffee rust in 1970 to the 1990s, there has been a concerted international effort to develop Catimor due to its rust resistance.

A disadvantage is the small bean size and poorer cupping quality of the initial Catimors and the tendency of the plant to overproduce and thus suffer severe dieback and death.

In recent years, a number of countries have begun breeding programmes to back-cross Catimor to pure Arabica lines to improve cupping quality and plant growth.

Not all Catimors have the same cupping quality and work is currently underway to determine the most suitable varieties for Lao PDR. Catimors currently being evaluated include:

Catimor H 528	A back-cross between the early Catimor HW 26 (Caturra x HDT 832/1) and Catuai Amarillo (yellow).
Catimor H 528/46	Special selection from Thailand programme.
Catimor H 420/9	A back-cross between the early Catimor HW 26 and Mundo Novo. Special selection from Thailand programme.
Catimor P 86	Originally from Columbia.
Catimor P 88	Originally from Columbia.
Catimor P 90	Originally from Columbia.
Catimor H 306	A back-cross between the early Catimor HW 26 and SL 28).
Catimor C 1669	(Catimor x Villa Sarchi). Villa Sarchi is a mutant from Costa Rica. Semi dwarf.
Catimor LC 1662	HDT 832/1 x Caturra, from Brazil.
Catimor T 8667	From Costa Rica.
Catimor T 5175	From Costa Rica.

Environment (site selection)

To grow and produce good quality coffee, several important environmental factors should be taken into account. These include:

- Elevation and temperature;
- Rainfall and water supply;
- Soil;
- Aspect and slope.

Elevation

Elevation influences a number of these factors and must be considered along with temperature, rainfall and water supply, soil, slope and aspect when determining where to plant coffee. An elevation greater than 1000 m above sea level (m.a.s.l.) is required for Arabica coffee. Low elevation Arabica coffee does not possess the quality required by the world markets. In Lao PDR, areas above 1000 metres are preferred for

production of superior quality coffee and the Bolovens Plateaux have ample areas of land at 1000 to 1300 m.a.s.l.

High elevation improves the quality of the bean and potential cupping quality. Due to a delay in ripening brought about by cooler weather associated with higher altitudes, the inherent characteristics of acidity, aroma and bold bean can develop fully. (Bold bean is classified as being the size between a large and a medium sized bean, with its width/length ratio bigger than that of a large bean).

Temperature

Arabica coffee prefers a cool temperature with an optimum daily temperature of between 20° to 24°C. The average mean temperatures of selected areas of the Bolovens Plateaux (Figure 1) are:

Paksong	19.5° (1200 m.a.s.l.)
KM 42	20.5° (1100 m.a.s.l.)
Ban Itou (Km 35 to 38)	22.2° (880 m.a.s.l.)
Km 34	19.0° (1150 m.a.s.l.)

Temperatures greater than 30°C cause plant stress leading to a cessation of photosynthesis. Mean temperatures of less than 15°C limit plant growth and are considered sub-optimal. Arabica coffee is frost susceptible. Use of shade trees will reduce the incidence of frost.

Rainfall and water supply

Ideal rainfall for Arabica coffee is greater than 1200 to 1500 mm per year. Both the total amount and the distribution pattern are important. Annual rainfall on the Bolovens Plateaux (Figure 2) is:

Paksong	3474 mm
Km 42	3534 mm
Ban Itou	3236 mm
Km 34	2500 mm

Rain should to be uniformly distributed over seven to nine months of the year, as is the case especially at higher elevations on the Bolovens Plateaux. At lower elevations, the dry season is often too pronounced. Lack of rainfall in either amount or timing can be compensated for by using irrigation.

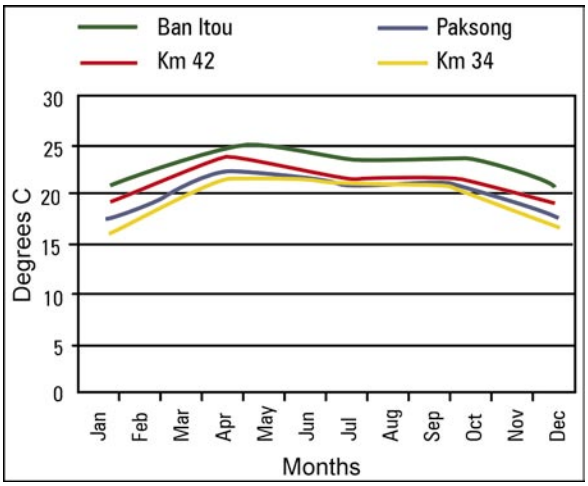


Figure 1. Mean monthly temperatures on the Bolovens Plateaux

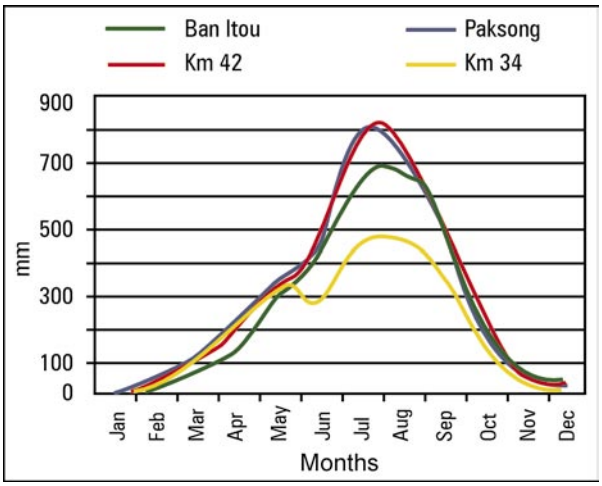


Figure 2. Mean monthly rainfall on the Bolovens Plateaux

Coffee needs a dry, stress period with little or no rain to induce a uniform flowering. Without a stress period, flowering many extend over many months making harvesting more difficult. Lao normally has such a stress period of three to four months of dry weather at elevations of 1000 m.a.s.l. or more.

Soil type

For successful production, a free draining soil with a minimum depth of one metre is required. Coffee will not tolerate waterlogging or 'wet feet'.

Coffee can be grown on many different soil types, but the ideal is a fertile, volcanic red earth or a deep, sandy loam. Yellow-brown, high silt soils are less preferred. Avoid heavy clay or poor-draining soils. Most soils on the Bolovens Plateaux are volcanic red earths suitable for coffee.

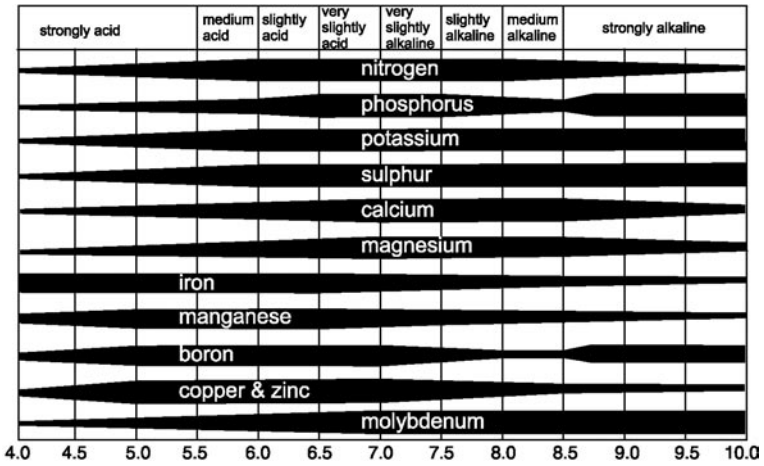


Figure 3. Effect of soil pH on nutrient availability

Coffee prefers a soil with pH of 5 to 6. Many cultivated soils of the Bolovens Plateaux are acid (less than pH 5) and need lime or dolomite. Few soil test results exist, but indicator plants point to a pH less than 5 with low available phosphorus and thus shortages of many other nutrients. Low pH will limit crop performance by upsetting the availability of key nutrients to coffee plants (see Figure 3).

Good management and applications of dolomite or lime can alter and improve soil pH and fertility.

Slope and aspect (slope % and direction)

An easterly or southern facing aspect with a slope less than 15% is preferable. Most locations on the Bolovens Plateaux have a gentle slope and no extra measures are required. Steeper slopes present a major erosion risk and require terracing or special management such as contour furrows or preferably grass strips.

See page 25 for establishing contour strips and contours using an A-frame for marking contours

A slight slope will improve air drainage and reduce damage from frost. Do not plant coffee at the bottom of a slope or in shallow dips where cold air can pool, as frost damage is more likely here. Usually it is best not to plant the bottom third of a slope as it will be colder and sometimes waterlogged.

Exposed aspects subject to strong winds, should either be avoided or windbreaks such as Silver Oak (*Grevillea robusta*) established before planting the coffee trees.

Water supply

Coffee 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.

Many plantings suffer from moisture stress at the time of year when they need adequate water for growth and cropping (see the phenological cycle page 70). The local rainfall pattern indicates that supplemental irrigation, especially to induce uniform flowering and good fruit set, would be beneficial. Unless regular rain is received, young trees should be irrigated (or hand watered at least twice a week if irrigation is not

available) to ensure establishment of the newly planted trees. Locating coffee plantings near a water supply for possible irrigation as well as for processing of cherry is desirable.

Water requirements can be reduced by use of proper, well-established, shade trees, mulch and cover crops. These practices are discussed in later sections.

The coffee plant and its management

An understanding of the coffee plant, its make up and how it grows is essential to understanding how to manage the coffee tree. Management, like the growing environment and the variety planted, has a very big influence on coffee quality and yield. Much of the rest of this manual deals with practical management of the coffee tree from planting to harvest.

The shape of the coffee plant varies depending on the species and variety. All coffee trees consist of an upright main shoot (trunk) with primary, secondary and tertiary lateral branches. The plant has a main taproot, lateral and small feeder roots (see Figure 4). The coffee tree produces two distinct types of branches:

- **Vertical** or **orthotropic branches** have nodes at a regular distance and carry opposite leaves. These branches are called suckers at the developing stage and stems at the final stage. Each leaf pair is cross-positioned to the next leaf pair. In the axil of each leaf, are four to six serial buds and directly above them, one slightly bigger bud called 'extra-axillary bud' because of its relatively distant position. This extra-axillary bud develops into a plagiotropic or lateral, horizontal branch.
- **Lateral or plagiotropic branches** grow almost at right angles from the main stems. No other bud in the same axil can grow into a lateral branch, which means that if such a branch is cut off, **no lateral regeneration can occur on the node** of a main vertical stem. Laterals are usually called primaries. Each serial bud on a primary can develop into an inflorescence (flower) or into a secondary branch, which has a similar structure to the primary branch with serial buds that develop either into flowers or tertiary branches. If a secondary branch is cut or removed, another secondary on the same axil can replace it, so **regeneration of secondaries on primaries is possible**.

Each branch has a terminal bud. In the nodes are a fixed number of buds that have the potential to form 40 fruits depending mainly on the species and nutritional conditions. At each leaf node there are 5 buds each with 4 flowers, which may form 20 fruits (Figure 5).

The white flowers appear in small bunches at the nodes. After pollination, a fruit develops into a cherry about 10 to 15 mm long containing two seeds (the coffee beans). Technically, the flowers form on the one-year-old wood that is only slightly hardened. The fruits comprise pulp (coloured skin and a fleshy mesocarp called mucilage), then parchment, then the silverskin (seed coat) and finally the coffee bean (Figure 6).

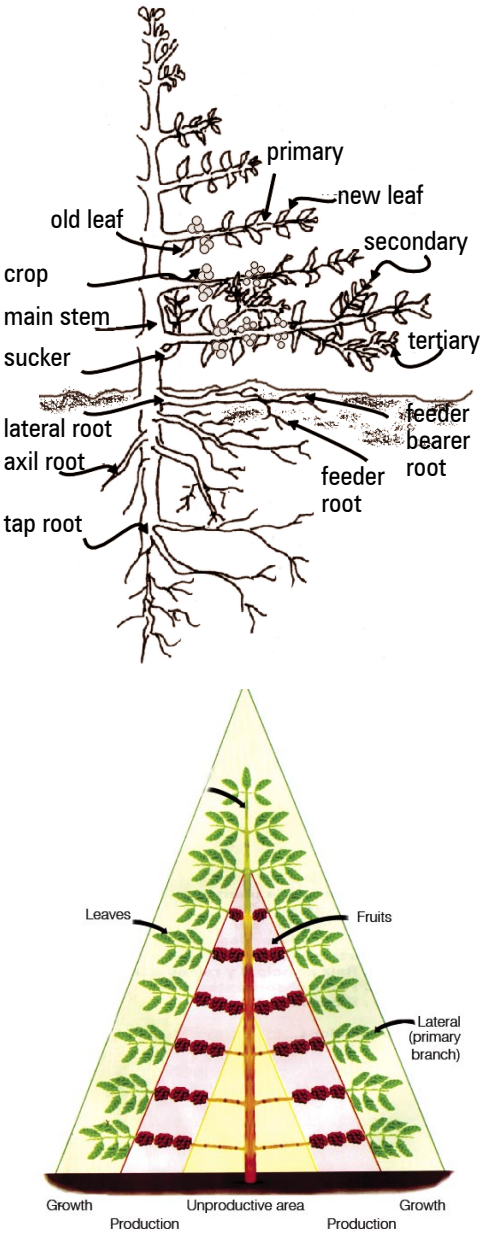
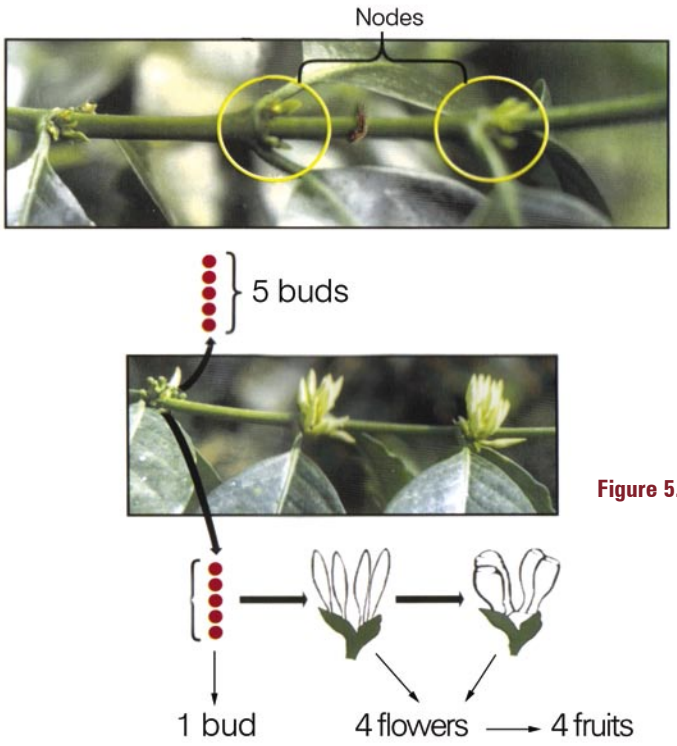


Figure 4. Diagram showing parts of the coffee plant (above) and tree habit (below)



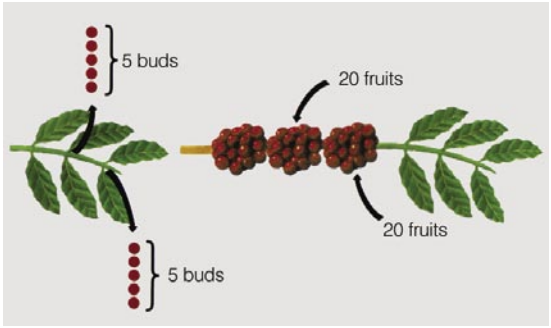


Figure 5. Potential of yields (left and diagram above)

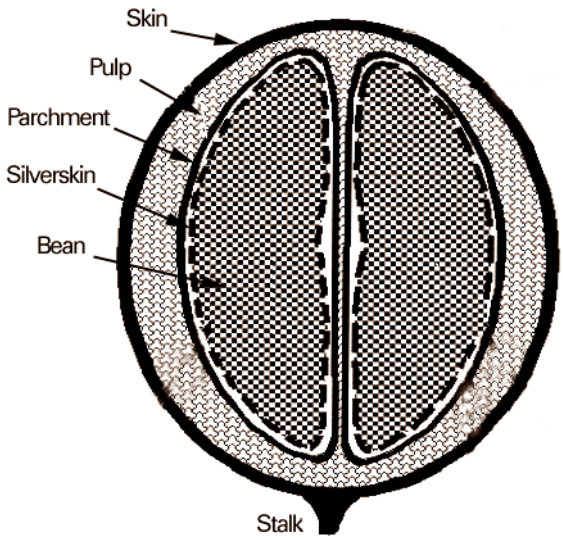


Figure 6. Coffee cherries from green to ripe (above) and diagram showing parts of the cherry (right)

The root system

The role of the root system is to ensure that the plant is firmly anchored in the soil and to take up a supply of water and minerals. The root system (Figure 7) consists of:

- a short taproot (40 to 60 cm) long;
- vertical, coaxial roots which are often very long (particularly in light soils) lateral roots with numerous absorbing root hairs, particularly in the upper, humus-bearing layer (30 cm)

It is necessary to stress the importance of growing techniques (pricking out in nurseries, weeding, mulching, irrigation and planting layouts) on the distribution and function of the roots. The first three years are critical for the root system development when it is vital that plants are well supplied with nitrogen, phosphorous, calcium, magnesium and sulphur.

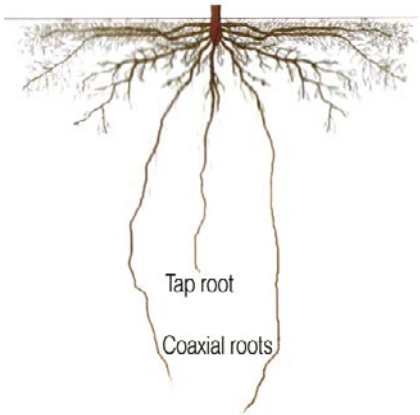


Figure 7. Root system

Phenology (Crop cycle)

The phenology of the coffee plant refers to the physical and physiological developmental stages of the coffee plant throughout the year. Phenology is often referred to as the crop cycle or the phenological cycle of the plant.

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 switches from vegetative (root and shoot growth) to reproductive growth and as the plant grows, it flowers, sets fruit, matures the fruit and is ready for harvest and re-growth for the next cycle.

The phenological cycle gives excellent indicators of when to fertilise, irrigate, withhold water, prune, take leaf and soil analyses, check for pests and diseases and apply controls for them. Timing is very important when using these practices to optimise production from the coffee tree.

The phenological cycle chart on page 70 indicates the timings for key management activities in relation to the various development stages, for example, growth, flowering, fruiting.

Chapter 2

Nursery practices

Coffee may be grown from seed or from cloned plants in the form of cuttings, grafts or tissue cultured plants. Arabica coffee is most commonly grown from selected seed unless there are special reasons for using clones. A number of steps are necessary for production of good seedlings.

- Select the seed.
- Keep records.
- When to start the nursery.
- Calculate the amount of seed needed and the area required.
- Build nursery shelter and seedbeds.
- Plant the seed.

Select the seed

Arabica coffee should be grown from fresh seed of the recommended varieties. Seed loses viability within three months and should not be used after that period unless properly stored at low temperature and high humidity.

Select ripe healthy fruit from the required variety and from plants that have good productivity, low or no incidence of rust and good cup quality. Pulp cherries, ferment for one night, wash clean, and dry the parchment slowly in shade on raised platforms or trays with good air movement for two to three days. The moisture content of the seeds should not fall below 10%, otherwise the viability will be seriously affected. The seeds should be sorted to eliminate those that are small or abnormally shaped or are infested with pests.

NOTE: Coffee seed that is used for planting is actually parchment with the parchment hull still in place. It is not green bean from which parchment hull has been removed.

Keep records

It is very important to keep good records of nursery operations. Good records will help avoid confusion and problems. The sample record on the next page can be photocopied for practical use.

Nursery record book

Record the information for each new plot of coffee or shade tree planted. *This page may be photocopied.*

	Coffee	Coffee	Shade tree #
Crop			
Cultivar			
Scientific name			
Origin of material			
Date sown			
Treatments (if any)			
Date of seed emergence			
Date of transplanting			
Growth stage at transplanting			
Other information / comments			

When to start the nursery

New seed should be planted as soon as possible after harvest. The longer it is stored, the lower the percentage of germination and the smaller the plants will be at the time of transplanting. If possible, coffee nurseries should be started in December in Lao.

Calculate the amount of seed and the area required

As coffee seed rapidly looses viability, store the seed in cool moist conditions (such as the bottom of a refrigerator). There are 3000 to 4000 coffee seeds per kilo. The recommended planting density is 3333 plants/ha at a spacing of 2 x 1.5 m for Lao. To calculate the area for a nursery you need to know:

- the area to be planted;
- plant spacing;
- the number of plants per hectare;
- how many seeds per kg;
- the germination percentage of the seed.

Calculate area needed for seedbed — for example: To plant 1 hectare of coffee at a spacing of 2 x 1.5 m

Number of plants:	3333 plants/h (10,000 m^2 ÷ 2 x 1.5 m)
Germination:	Assume 3000 seeds/kg with 75% germination
Therefore, you need:	(100 x 3000) ÷ 75 = 4,444 seeds

Sow seeds in beds 1 m wide with 2 cm between seeds and 10 cm between rows. Plant 50 seeds per 1 m of row.

Therefore, you need: 4,444 seeds ÷ 50 seeds/row of 1 m = 90 rows

Rows are 100 mm apart. Therefore, you need 90 rows x 100 mm apart or 9 m of nursery bed.

Build the nursery shelter & beds

Select a frost and flood free area with access to a suitable water supply. Completely fence the area to keep out domestic livestock.

Shade house and plastic tunnels

Coffee seed is very slow to germinate in December and January (the coldest months) and clear plastic/polyethylene should be used to accelerate germination and plant growth. (Coffee seed that is used for planting is actually parchment with the parchment hull still in place. It is not green bean from which parchment hull has been removed). Figure 10 illustrates the stages of coffee seedling development.

Construct a shade house with timber poles and a roof about 1.8 m high. The top of the shade house needs to be covered with either assorted plant material such as bamboo slats or branches, or commercial plastic shade cloth to give about 50% shade.

Figure 8. A clear plastic tunnel covering a seed bed is used for germinating coffee seed in cold weather. Note that the plastic has just been removed from the bamboo frame

To achieve faster seedling growth during cold weather, plant seed in a clear plastic/polyethylene tunnel beneath the shade (Figure 8). The tunnel is the width of sowing beds and about 75 cm high. Use bamboo hoops for the framework to support the polyethylene sheet cover. The seedbed must be fully and tightly enclosed or temperature inside the tunnel will not increase.

Seedbeds

- Use wooden planks, bricks or bamboo as sides for seed beds which should be about 20 cm high and 1 m wide. Fill beds with a soil and sand mixture of 50% forest soil and 50% river sand. Red soil by itself is too compact for a good seedbed.
- Level the soil to the height of the sides of the seedbed.

Plant the seed

Water the seedbed before planting.

- Using a pointed stick, make furrows 12 mm deep across the bed and 100 mm apart.
- Plant seed flat side down, with seeds 25 mm apart within the row (Figure 9).
- Cover seed with soil mixture — seed should be about 12 mm deep after planting.
- Cover beds with rice straw mulch to give extra heat and to retain soil moisture (see Figure 9).
- Water gently. Make sure the seed is not exposed when watering.

As germination time is highly dependent on soil temperature, it may take from 30 to 50 days before shoots appear. Use of plastic/polythene tunnels to retain heat will speed up germination.

Germination

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. See figures 10a and 10b for germinating process.

Germination is first seen in the appearance of the radicle (young root) three to four weeks after sowing. The hypocotyl (the part between

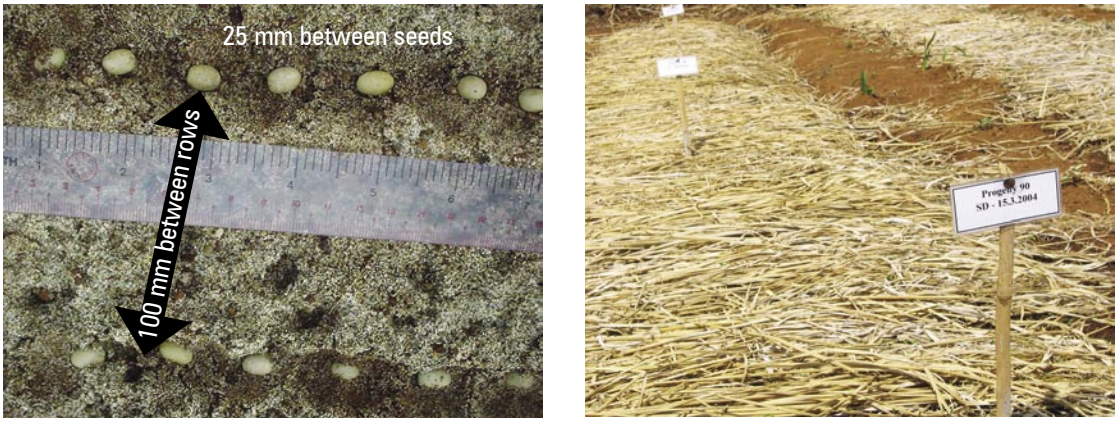


Figure 14. Planting the seed (left) and covering with mulch (right)

Figure 10a. Colyledons shown in photograph (top); the new primary leaves appear above the colyledons (bottom photo)

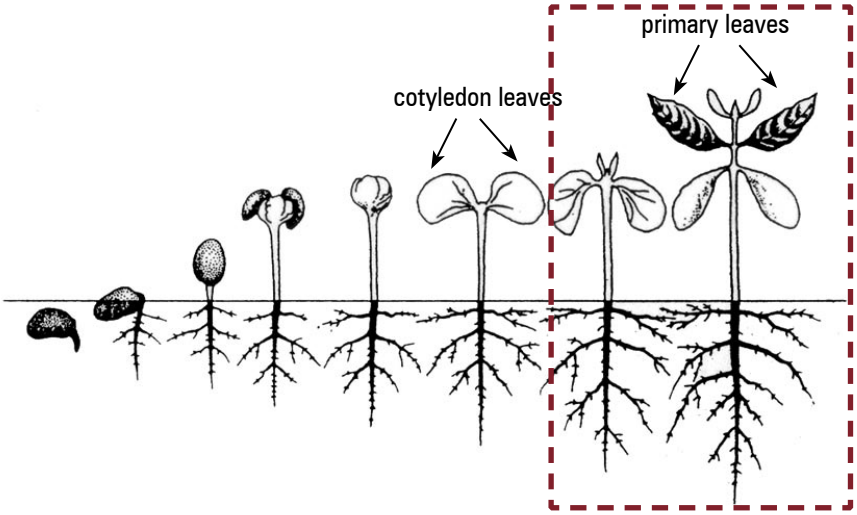


Diagram of the germinating process. The last two drawings (in the box) indicate that the plant is ready for transplanting (above right)

Figure 10b. Three stages showing seedling ready for transplanting on the right

soil and cotyledons appears 20 to 25 days later and carries the seed which is still covered in its parchment, out of the ground. Shortly afterwards, when this light covering is detached, the two cotyledon leaves open.

These cotyledon leaves look very different from ordinary leaves—they are oval-shaped with undulating edges and 20 to 50 mm in diameter. At the same time, the terminal bud appears and produces two primary leaves—they are opposite and in pairs. The cotyledons will now die having completed their nutritional role.

The root system develops actively in the first weeks of germination; the taproot penetrates deeply into the soil and forms a great number of roots and rootlets.

The first lateral branch (plagiotropic branch) appears four to six weeks after emergence; the plant will then have 5 to 11 pairs of leaves. These branches are opposite in pairs at alternate perpendicular points along the main axis. The primary branches have buds at each node that will develop either into secondary (plagiotropic/horizontal) branches or, under certain conditions, into flowers.

Do not let the soil dry out, when seedlings are developing. However, take care and do not over-water as seed can suffer from disease problems such as damping-off (see Nursery diseases and pests). At a height of 200 to 300 mm, the young plants are ready to be transplanted.

Transplant into bags

Depending on temperature, coffee seedlings are ready to be transplanted from the nursery bed into poly bags about two to three months after sowing. There are four steps in the process.

- Prepare the potting mixture.
- Choose the seedlings.
- Plant seedlings in bags.
- Care for the seedlings.

Prepare potting mixture

Strong black plastic/polyethylene bags with drainage holes should be used. Bag size should be at least 100 mm x 250 mm when filled with soil.

A mixture of fertile topsoil and manure or compost can be used. All soil, manure and compost should be sieved. The following mixture could be used:

5 x 20 L tins of topsoil.

1 x 20 L tin of good quality, dry cattle manure or compost.

200 g of rock phosphate or 0:20:0 NPK ratio fertilizer.

200 g of dolomite.

Thoroughly mix the ingredients and place in the black plastic bags. This amount will fill about 40 bags.

Make a NEW potting mixture.
DO NOT RE-USE SOIL from old bags!!

Choose the seedlings

Figure 11. Choosing the seedlings at matchstick stage

Transplant coffee when it is at the matchstick or cotyledon (butterfly) stage before the taproot is well developed (Figure 11).

- Use the best seedlings with a straight tap root. Discard seedlings with either a bent taproot (J root) or those with few root hairs.
- Do not use larger seedlings (with more leaves than the matchstick stage) as these will be too slow in growing.
- Do not use diseased seedlings.

Plant seedlings in bags

- Planting should be done in cool, cloudy weather.
- Thoroughly water the soil-filled bags to settle the soil before planting.
- Lift the seedlings using a stick or trowel to prevent breaking the roots.
    - Make a hole about 50 mm deep using either a small stick or a finger (Figure 12).
    - Insert seedling in the hole and then lift the seedling slightly to open out the roots.
    - When planting, make sure that the taproot is not bent.
    - Plant seedlings to the same depth as they were previously planted in the seedbed.
    - Water seedlings well.
    - Make sure the bags are well supported all around and in between so they do not fall over. Use a bamboo or wooden frame to contain the bags and keep them packed together (Figure 13a).

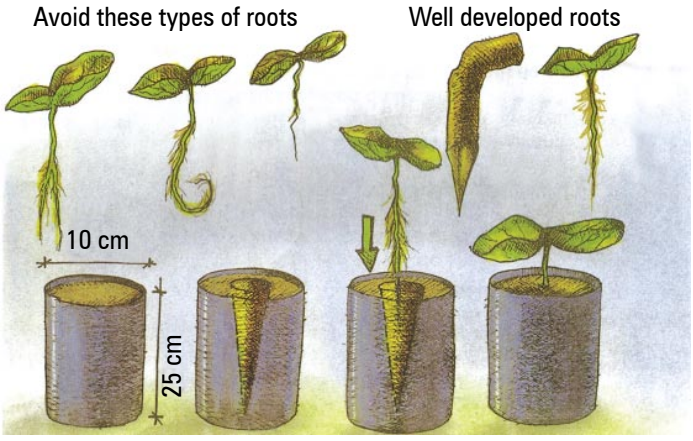


Figure 12. Planting the seedlings into plastic bags

Care for seedlings

- Remove weeds regularly.
- If soil becomes hard, soften it by using a trowel to break up big, hard clumps of soil into smaller pieces.
- Water as required to keep the soil damp. Don't over-water as this can cause damping-off — a disease caused by a fungus that will kill the plants.

Figure 13a. Make sure the plants are supported and are not crowded

Figure 13b. Healthy seedlings that are now crowded. The bags should be moved apart to allow more room for plant growth and avoid disease

- At three months, apply urea (46:0:0) at 60 g/10 L of water. This is enough for 100 seedlings. Apply every 15 days. If leaves become dark green, stop the procedure.
- If you do not use a chemical fertiliser, apply a small amount of finely crushed dry manure around the plants.
- Check seedlings every day to make sure they remain free from pests and disease. Remove bags with diseased, dead or damaged plants.
- Continue to keep plants in shade. Two months before field planting, gradually remove the shade to sun-harden the plants.
- As the plants grow, separate the poly-bags so there is sufficient space for the developing plant to spread. If bags are not separated, the plants grow tall and weak (Figure 13b).

Nursery diseases and pests

The two common diseases occurring in the nursery are:

Damping-off that appears as areas of dying plants. (See page 63 of *Pests and diseases*). Damping-off is caused by a soil-borne fungi often found in old, diseased potting mixture, over-watering, too much shade or not enough space between plants. Damping-off can be avoided by proper preparation in the nursery. It is also important that new soil is always used in the nursery beds. If the disease is found, immediate drenching with either Benlate (Benomyl) or Captan can be carried out. Always read the label on the chemical pack and follow directions.

Cercospora (brown eye spot) is a fungus, which develops when plants are under stress caused by too much shade, too much sun, nitrogen deficiency, over-watering or over-crowding. This can be avoided by following good management practices. Immediate control measures involve using copper sprays. (See page 64 of *Pests and diseases*). Always read the label on the chemical pack and follow directions.

Green coffee scale can also be a problem in the nursery. Scales severely affect plant health as the they suck the sap from the leaves. Keep the area free from ants and spray with spraying oils or Carbaryl or use traditional methods of control. (See page 59 of *Pests and diseases*).

Always read the label on the chemical pack and follow directions.

Figure 14. Seedlings affected by damping-off. New potting mix should always be used

Chapter 3

Field management & planting trees

Preparing the field

The area to be planted with coffee must be prepared at least one year before the small coffee trees are planted out. There are five procedures to follow.

- Prepare the land.
- Plant windbreaks.
- Mark out the rows.
- Establish shade trees.
- Irrigation.

Prepare the land

The land must be cleared and all old trees and their roots removed—do not leave old timber lying around as this attracts pests. With land up to 15% slope, run the rows across the slope making sure there is a fall of 1 to 2% for drainage. Ground covers should be planted to avoid erosion. When land is greater than 15% slope, contour planting must be undertaken.

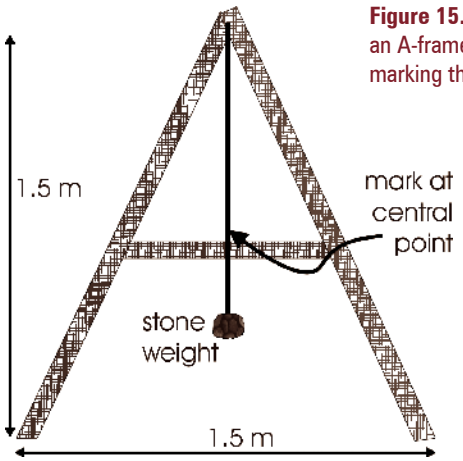
Establishing a contour strip

Coffee is planted in rows 2 m apart with plants 1.5 m apart within the row. To mark the planting holes at this spacing on sloping land, follow the steps below.

Construct a simple wooden A-frame structure measuring 1.5 m high with legs 1.5 m apart. The horizontal support cross-piece is marked at the central point. A string with a weight (stone or metal object) is attached at the apex of the 'A' and allowed to hang freely, similar to a pendulum (Figure 15).

Starting at the bottom of the slope, 'walk' the A-frame across the slope by rotating it from one leg of the frame to the other. Place a marker at each point on the ground where the pendulum lines up with the centre mark on the A-Frame cross-piece. This marker shows the planting hole for each plant on that particular row/contour. Continue for the desired length of the contour line.

Locate the next contour line 2 m up or down hill from the first row. Follow the same marking procedure until the entire field is marked out.



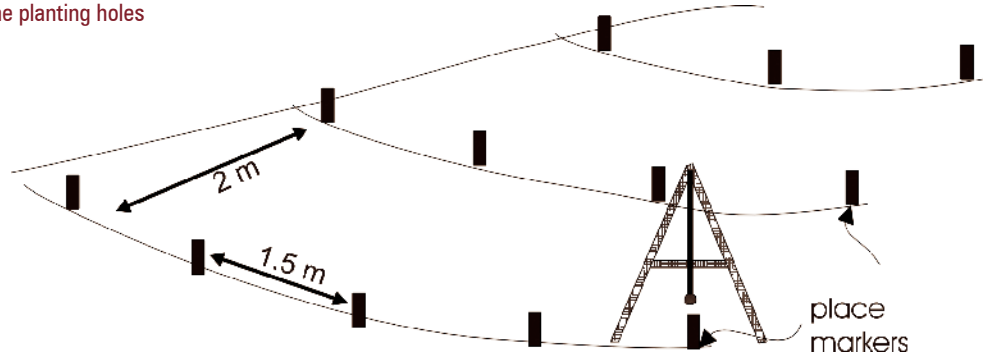
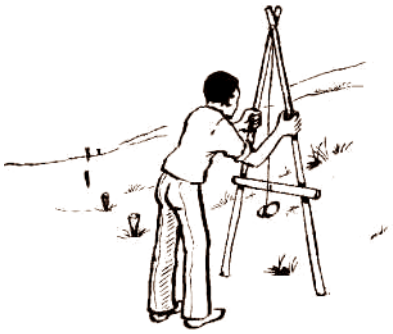


Figure 15. Constructing an A-frame (left). Using an A-frame to find the contours in a field and marking the planting holes



Plant windbreaks

In general, permanently planted windbreaks are only recommended in sites exposed to strong winds, and then only where they are needed to supplement inadequate natural forest surrounds. If required, windbreaks should be well established before planting out the coffee trees. Windbreaks are usually located along boundaries of the coffee area. Silver Oak (*Grevillea robusta*) is a preferred windbreak tree.

Mark out the rows

Row direction. Ideally a north/south direction is best as it makes most use of sunlight. Mark out where the rows are to go.

Establish shade trees

Shade trees need to be well established before coffee trees are planted out. Plant shade trees one year before planting coffee. Do not plant shade trees at the same time or after planting the coffee seedlings.

Shade protects young coffee plants from drought stress and over exposure to sun, which causes yellowing and death of leaves, tree overbearing and/or dieback in older trees. Shade also promotes a better balance between flowering and growth resulting in better berry production. Legumes used as shade trees contribute substantially to soil health by providing organic matter and nutrients from leaf fall and prunings, and fix nitrogen from the air to restore soil fertility and structure. Shade trees also reduce the incidence of frost.

Numerous species can be used as shade trees — the preferred types include:

- *Erythrina subumbrans* (Tton Tong or Dadap). Used as coffee shade and for pepper supports in many areas of S-SE Asia. It is fast growing and easily propagated from cuttings (Figure 16a).
- *Gliricidia sepium* (Khae Falang). Looses leaves and begins to flower in the dry season unless pruned in wet season to keep plant vegetative. Fixes nitrogen from the air.
- *Cassia siamea* (Khi Lek). Does not fix nitrogen and can compete with coffee for nutrients and water.
- *Melia azedarach* (Khao Dao Sang, Neem or Bead tree). A good timber tree that may provide some insect control. Seed extracts are used as the insecticide Neem (Figure 16b).
- *Paulownia tomentosa*. A quick growing, timber tree.

Figure 16a. Erythrina shade trees

Figure 16b. Melia shade trees

Shade tree spacing

Suggested spacing for *Erythrina*, *Gliricidia*, and *Cassia* is 4.5 x 4 m (555 trees/ha), while that of *Melia* and *Paulownia* is 6 x 6 m (277 trees/ha).

Plant shade trees within the coffee rows. Remove lower limbs from young shade trees as they grow.

Figure 17. Ideal size of transplant tree

Irrigation

If irrigation is to be used, it should be installed prior to planting of coffee trees. If there is no irrigation, both shade trees and coffee will need hand watering for a few weeks until established.

Planting the coffee trees

There are four procedures to follow when planting the coffee trees.

- When to plant (seedling size and time).
- Prepare the holes.
- Choose the plants.
- Planting procedure.

When to plant

Field planting can begin when the coffee plants in bags have a minimum of six to eight leaf pairs (Figure 17). Plants should be strong and healthy with no sign of pests or disease. Planting out in the field should be done on cloudy days, in June through to August during the wet season. Avoid planting trees when conditions are windy or hot and dry or during the hottest part of the day.

Prepare the holes

One month before planting

1 Mark the planting holes.
2 Dig holes of 600 x 600 x 600 mm (Figure 18).
3 Pile topsoil to one side of the hole, subsoil to other side of hole.
4 Mix in 2 kg of dry farmyard manure (FYM) + 3 heaped soupspoons (about 85 g) Triple Superphosphate (TSP).
5 Mix into loose soil at the bottom of the hole and into the pile of topsoil.
6 Start filling the hole with topsoil only. Then use both the subsoil and topsoil to complete filling the hole.
7 Re-mark the centre of the hole with a stick.

Figure 18. Procedure to follow when preparing the holes: 2 to 3 (top); 4 to 6 (bottom)

At planting

- Spread 1 milk tin (225 g) of dolomite over the soil in the planting hole and then dig in.
- The soil should be moist at time of planting.

Figure 19. Unsuitable plant with a twisted root system

Choose the plants

Check that the coffee plants:

- are healthy, with dark green, well-formed foliage and a minimum of 6 to 8 leaves;
- have no stem damage and a well-developed root system with a taproot that is not distorted. (Figure 19);
- are not root-bound by being in the pots for too long and have been hardened to full sun before planting.

Planting procedure

1. Before planting, thoroughly water the trees in the bags.
2. Remove plants from plastic bags by either cutting the bag or gently sliding the plant out of the bag.
3. Discard plants with J-roots or bent roots (Figure 19).
4. If plants have been in the bags for an extended time, roots may grow around in a circle inside the bag. It is important that these roots are gently teased out by hand or they will continue to grow in a circular manner when planted. Carefully straighten large roots and prune off badly twisted roots.
5. Be sure to remove the plastic bag! Do not plant coffee plants still in the plastic bag.
6. Place the seedling upright in the hole — do not plant at an angle. Half-fill the hole with soil, gently pressing the soil into contact with the root ball. Fill hole with water. This helps to bring the soil into close contact with the roots. Allow water to drain, then finish filling the hole with soil (Figure 20).
7. Firmly press soil down with your feet. Do not stomp on the soil as this may damage the young roots. Keep the final soil level slightly heaped above the surrounding undisturbed soil as the soil will settle down after planting. Do not plant coffee in large depressions, as these will trap water. Coffee does not like wet soil and plants can die under these conditions.
8. Water in the plants well, with 1 to 2 L of water per plant.
9. To maintain soil moisture and control weeds, mulch the newly planted coffee trees with rice straw or other suitable materials. Keep mulch away from the base of the plant to reduce the risk of disease. It is especially important to re-mulch at end of wet season.
10. Pigeon pea, sorghum or other crops can provide temporary shade cover for young plants.
11. Blady grass (*Imperata cylindrica*) covers can be used for frost protection.
12. Legume ground covers of pinto peanut (*Arachis pintoi*) or green leaf desmodium (*Desmodium intortum*), will greatly assist with weed control in young coffee. Ground covers add nitrogen to the soil, provide mulch for the shade trees and feed for cattle that are a popular source of alternate income on the Bolovens Plateaux. Prunings from legume shade trees are also a good protein food supplement for cattle.

Figure 20. Planting procedure – planting, mulching, ground covers

Field management of young trees

To achieve high yields of quality coffee, good field management practices are essential. Poorly managed coffee will take longer to produce a good crop and will suffer from dieback. There are three key procedures to follow:

- Protect from frost;
- Control weeds and mulch plants;
- Water plants.

(Nutrition and fertilising are fully covered in the next chapter).

Figure 21. Newly planted coffee trees with frost protection in place

Protect from frost

Good site location and use of shade trees will reduce the incidence of frost. Maintaining soil moisture during frost periods will offer a degree of frost protection.

Plant covers like blady grass (*Imperata cylindrica*) to protect young plants from frost (Figure 21). In cold weather, overhead irrigation applied before ice starts to form, will prevent major frost damage. Continue watering until temperature has warmed to above freezing and ice melts.

Keeping the ground free of weeds and ground covers cut short in the frosty period will also help with frost protection (Figure 22). Severe frost may kill small trees. However, on most occasions (especially with larger trees), the tree branches die back and then regrow, but one to two seasons will be lost before complete recovery.

Figure 22. Frost damaged trees in the field (above) and close-up of frost damaged leaves

Control weeds and mulch plants

Coffee trees are shallow-rooted, which means that most feeder roots are near the surface. Weeds compete for both nutrients and water, so it is essential to keep the area under the canopy of the trees, weed-free.

- Coffee plants should be mulched with rice straw or other appropriate material to a depth of 50 to 80 mm especially at the end of the wet season, but be sure to keep mulch materials 50 to 100 mm away from the trunk of the tree.
- Mulching will reduce the amount of weeding required. Weeding should be done at least four times per year, especially in the wet season, during which two or three weedings may be needed. When weeding, be careful not to damage surface roots of the coffee plant with knife or hoe.
- Dead or dry weeds can be used as mulch. Fresh weeds may regrow, especially in wet weather if they are not dried properly before being added as a mulch.

Water plants

Do not allow the plant root ball to dry out after planting. Irrigate (or hand water where irrigation is not installed), two to three times per week for the first few weeks. If planting at the recommended time (June to August) there should be a good chance of rain, so the soil moisture should be maintained.

Chapter 4

Plant nutrition & fertiliser management

Nutrients are recycled within the environment. A 'closed' environment such as a rainforest, recycles its own nutrients and is more or less self-sufficient. However, where plants are grown in a commercial situation, it is necessary to replenish the nutrients that are removed from the system. Without additional nutrients in some form of fertiliser, coffee yields will remain very low as nutrients are removed with the coffee beans. Unshaded plants of dwarf, high-yielding varieties such as Catimor, will quickly develop dieback and die if adequate nutrients and water are not added to the soil. Plants with mild to moderate dieback will recover with timely good fertilising, watering and weed management.

In India, it was found that for every 6,000 kg of ripe coffee cherry (1 tonne of green bean) removed from the plants, approximately 40 kg nitrogen (N), 2.2 kg phosphorus (P) and 53 kg potassium (K) must be replaced yearly.

There are 16 natural elements (nutrients), that are essential for plant growth (see table below). Three elements (carbon, hydrogen and oxygen) make up 94% of the plant tissues and are obtained from air and water. The other 13 elements are obtained from the soil and are divided into two broad categories — 'macro' and 'micro'. These terms do not refer to the importance of the elements; macronutrients are required in greater amounts than micronutrients for normal plant growth.

Essential minerals and their role in the coffee plant

Mineral/ Element	Chemical symbol	Main requirement/use by the plant
Macronutrients		
Nitrogen	N	Plant growth; proteins; enzymes; hormones; photosynthesis
Sulphur	S	Amino acids and proteins; chlorophyll; disease resistance; seed production
Phosphorus	P	Energy compounds; root development; ripening; flowering
Potassium	K	Fruit quality; water balance; disease resistance
Calcium	Ca	Cell walls; root and leaf development; fruit ripening and quality
Magnesium	Mg	Chlorophyll (green colour); seed germination

Mineral/ Element	Chemical symbol	Main requirement/use by the plant
Micronutrients		
Copper	Cu	Chlorophyll; protein formation
Zinc	Zn	Hormones/enzymes; plant height
Manganese	Mn	Photosynthesis; enzymes
Iron	Fe	Photosynthesis
Boron	B	Development/growth of new shoots and roots; flowering, fruit set and development
Molybdenum	Mo	Nitrogen metabolism
Chloride	Cl	Photosynthesis; gas exchange; water balance

Soil and leaf analysis

To help determine the best nutrition practices, soil and leaf analyses are recommended. While Lao currently does not have access to these services, in nearby Thailand the Mae Jo University in Chiang Mai and Department of Land Development (DLD) can offer fee-for-service analyses. The FAO project used Mae Jo University for the soil and leaf analysis survey of Arabica coffee farms in the Bolovens in 2005.

In order to standardize procedures between farms, years and personnel involved, the following practices are suggested for soil and leaf analysis.

Soil sampling

- Remove surface litter (leaves, etc.) before sampling. Do not scrape away soil (Figure 23).
- Take samples to a depth of 150 mm with soil auger or spade.
- Place soil in a CLEAN bucket.
- Sample from a minimum of 20 sites across a block of two to four hectares.
- Thoroughly mix each soil sample collected and then sub-sample to reduce volume for sample bags.
- Properly label all samples and laboratory sheets.
- Clean the auger or spade after sampling each of the sites.
- DO NOT sample after fertilizer application. Scrape away any fertilizer/lime residuefrom previous applications before taking a sample.
- Do not sample next to shade trees.
- Areas of different tree size, age, soil types, fertilizer or other major differences should be treated as separate samples.
- Samples need to be dried before sending for analysis. If laboratory ovens are unavailable, spread out each sample on a paper bag or plain paper and dry slowly on raised benches under shade and protected from rain. Samples are usually air dry in four to five days.

If possible, soil samples should be taken once per year before flowering.

The objective of sampling is to get an AVERAGE (representative sample) of soil in the block, not the best or the worst. To keep costs down, and if plantings are of the same age and appearance, three samples per two to four hectare block will be adequate, provided the three samples are composites from the 20 sites sampled.

Figure 23. Remove surface litter and old fertiliser etc., from area to be sampled but do not remove soil. Take samples to a depth of 150 mm

Leaf sampling

Figure 24. Leaf sampling

- Sample the third or fourth pair of leaves from the tip of an actively growing branch. Do not count new leaves if they are not fully expanded (Figure 24).
- Sample at the same time/growth stage each year, before flowering.
- Sample a minimum of 40 trees per block across a block size of two to four hectares.
- Sample diagonally across the block.
- Sample average trees only. Do not sample obviously sick, excessively healthy or odd/unusual coffee trees.
- Sample in the morning where possible when leaves are the most turgid (full of water).
- Use CLEAN HANDS. Do not smoke while sampling and make sure hands are free of fertilizer, soil etc.
- Do not sample when leaves are wet as the paper sample bags will break!
- Do not sample after any application of foliar fertilizer sprays.
- Areas of different tree size, age, soil types, fertilizer or other major differences should be treated as separate samples.
- Properly label all samples and laboratory sheets.
- Samples are to be stored in paper (not plastic) bags. Keep leaves cool but do not freeze!
- Samples need to be dried if they are not sent for analysis within one to two days. This is normally done at the laboratory at 60 to 65°C until dry and brittle.

The objective of leaf sampling is to get an AVERAGE (representative sample) of trees, not the best or the worst. The 40 trees per hectare samples can be bulked and three composite samples made to reduce analysis costs. A minimum of 100 leaves is needed for each composite sample.

Pre-flowering is preferred sampling time if only one sample is taken each year. More frequent sampling (every four months) is highly desirable for large plantations, especially if nutritional problems occur.

A soil and leaf sampling survey on 15 properties has recently been conducted on the Bolovens Plateaux; results were not available at the time of publication.

Optimum leaf and soil nutrient levels

Once the soil and leaf samples have been taken, it is important to analyse the results and compare them to levels that have been determined as optimum in coffee plantations around the world in order to devise a nutrition programme for the coffee.

Optimum leaf nutrient levels

Nutrient	Optimum range	Nutrient	Optimum range
N (Nitrogen)	2.5 – 3.0%	Na (Sodium)	< 0.05%
P (Phosphorus)	0.15 – 0.2%	Cu (Copper)	16 – 20 mg/kg
K (Potassium)	2.1 – 2.6%	Zn (Zinc)	15 – 30 mg/kg
S (Sulphur)	0.12 – 0.30%	Mn (Manganese)	50 – 100 mg/kg
Ca (Calcium)	0.75 – 1.5%	Fe (Iron)	70 – 200 mg/kg
Mg (Magnesium)	0.25 – 0.40%	B (Boron)	40 – 100 mg/kg

Optimum soil nutrient levels

Nutrient (extraction method in brackets)*	Suggested optimum soil levels
pH (1:5 soil/water)	5.5 – 6.0
Organic matter (Walkley Black)	1– 3 %
Conductivity (l:5 soil/water)	< 0.2 dsm
Nitrate nitrogen (1:5 aqueous extract)	> 20 mg/kg. Leaf tests more relevant
Phosphate (Colwell or bicarb)	60 – 80 mg/kg
Potassium (Ammonium acetate)	> 0.75 mg/kg
Sulphur (KCl-40)	> 20 mg/kg
Calcium (Ammonium acetate)	3 – 5 meq/100 g
Magnesium (Ammonium acetate)	> 1.6 meq/100 g
Aluminium (Potassium chloride extract)	Unknown but very low
Sodium (Ammonium acetate)	< l.0 meq/100 g
Chloride (1:5 aqueous extract)	250 mg/kg
Copper (DPTA)	0.3 – 10 mg/kg
Zinc (DPTA)	2 – 10 mg/kg
Manganese (DPTA)	< 50 mg/kg
Iron (DPTA)	2 – 20 mg/kg
Boron (hot calcium chloride)	0.5 – 1.0 mg/kg (sandy loams) 1.0 – 2.0 mg/kg(clay loams)
Cation exchange capacity	3 – 5 sandy soil > 10 heavy soil types
Cation balance	Potassium (< 10%) Calcium (65 – 80% Magnesium (15 – 20% Sodium (< 5%) Aluminium (< 1%)
Calcium : Magnesium ratio	3 – 5

* Different extraction methods would give different results and different optimum levels.

Fertiliser programme

Coffee soils in Lao PDR are low in a number of essential plant nutrients; therefore these must be supplied to promote high yielding, high quality coffee. Manure, bio-fertiliser, cover crops, compost, legume tree leaves and shoots and chemical fertilisers all supply nutrients.

Manure and compost such as coffee pulp and husks have a low nutrient content. When utilised as a source of nutrients, they must be used in large quantities to supply sufficient nutrients for coffee plants. Manure and compost help improve soil structure and organic matter.

Chemical fertilisers are higher in nutrient content than organic fertilisers and are a more effective method of applying nutrients. For optimal results, it is best to apply a combination of manure and compost and chemical fertilisers.

Fresh manure or non-composted pulp should never be used as they can burn the plants and tie up nitrogen in the soil during break-down. They also are a source of Orchratoxin A (OTA) moulds.

At present, there has been little or no soil and leaf analysis services available for Lao coffee growers. When such services are available, a detailed coffee fertiliser programme can be devised. Meanwhile the following fertiliser programme is suggested for Arabica coffee in Lao.

Year	Time	Application
Year 1	(Up to 12 months in the field)	
	September	Before rains finish 30 g/tree of NPK 15-15-15
Year 2	April/May (with first rains)	30 g/tree of NPK 15-15-15
	July	30 g/tree of NPK 15-15-15
	September	30 g/tree of NPK 15-15-15 500 g/tree of Dolomite
Year 3	April/May (with first rains)	60 g/tree of NPK 15-15-15
	July	60 g/tree of NPK 15-15-15
	September	60 g/tree of NPK 15-15-15
Year 4	April/May (with first rains)	90 g/tree of NPK 15-15-15
	July	90 g/tree of NPK 15-15-15
	September	90 g/tree of NPK 15-15-15 500 g/tree of Dolomite
Year 5	Onwards	
	April/May (with first rains)	120 g/tree of NPK 15-15-15
	July	120 g/tree of NPK 15-15-15
	September	120 g/tree of NPK 15-15-15

Note: NPK is nitrogen, phosphorus, and potassium

Explanation

1g N	=	1,288 g N (Urea)
1g Ca	=	1,399 g calcium oxide (quick burn lime)
	=	1,780 g calcium carbonate (lime or limestone)
1g Mg	=	1,658 g magnesium oxide
1g S	=	3,750 g magnesium sulphate

Higher yielding coffee plots may require 25% more fertiliser.

Use lime or preferably, dolomite (Ca + Mg) at 500 g per plant every two years and apply before the end of the rainy season. Use the last rains to wash the lime into the soil or water in well by hand or irrigation. The following table shows the nutrient uptake and consumption by different parts of coffee tree (expected yields / ha: 1000 kg green beans).

Nutrient uptake of a coffee tree

	Elements (kg)					
Parts of tree	**N**	**P**	**K**	**Ca**	**Mg**	**S**
Roots	15	2	25	9	2	2
Branches	14	2	20	6	3	1
Leaves	53	11	45	18	7	3
Fruits	30	3	35	3	3	3
Total	112	18	125	36	15	9

It is obvious from this table that leaves need the major part of the uptake—more than the flowers or fruits. However, nutrients are returned

Figure 25. Place a band of fertiliser around the drip line

While good for the soil, manure or compost may not supply the full range and amount of nutrients required by the coffee tree and some mineral fertiliser or micronutrients or other organic fertilisers may be needed occasionally.

to the soil when the leaves drop. The early years of root development are very important as branches and roots store nutrients for a long time.

Nutrients accumulated in the fruits will be removed when cherries are harvested. This loss needs to be compensated by the addition of fertilizers, organic manures, leaf fall or prunings and leaves from shade trees. Recycling of pulp to the soil after composting can help to reduce the additional (chemical) fertiliser needed.

Fertiliser placement

Spread fertiliser evenly on the soil around the drip line (the outside edge of the canopy) of the coffee tree, as this is where most feeder/hair roots are found (Figure 25). Keep fertiliser at least 100 mm from the stem of the plant; fertiliser applied closer than this can damage the coffee tree.

Manure (if not using fertiliser). The minimum amounts to apply are:

Year 2	0.7 kg/tree
Year 3	1 kg /tree
Year 4	2 kg /tree
Year 5 onwards	2.5 kg/tree

Legume shade trees, ground covers and suitable intercrops supply nutrients and organic matter through litter and leaf fall and through prunings added as mulch to the surface of the soil.

Nutrient deficiency symptoms

The overall rate of coffee growth and production depends on the least available plant nutrient. Plants will grow and produce only as much as the least available nutrient will allow them to. It does not matter how much of the other nutrients are available to the plant because it is the least available nutrient that limits growth and development. This is well illustrated in the following 'Barrel Analogy', where the barrel can hold only as much water as the shortest plank will allow (Figure 26). This is known as the 'Law of the Minimum' and is explained thus:

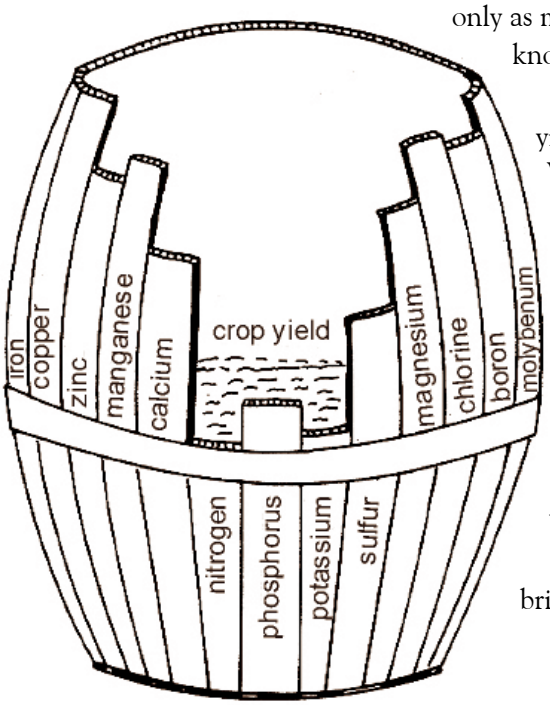


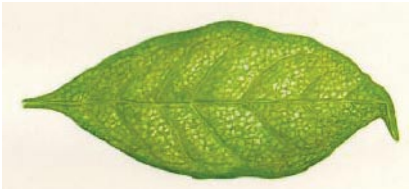
Figure 26. 'Barrel Analogy' using nitrogen as the least available nutrient

The level of water in the barrel represents the level of crop yield that is restricted by the most limiting nutrient, nitrogen. When nitrogen is added, the level of crop production is controlled by the next most limiting factor (in this example, potassium).

Poor nutrition is a major cause of coffee dieback. Plants lacking sufficient N (nitrogen) and K (potassium) suffer from dieback, especially where there is poor shade cover and insufficient water. Low soil calcium and phosphorus will hinder root development and contribute to dieback. Dieback causes loss of yield and when severe, plants can die, especially high yielding, dwarf Catimor varieties.

Each nutrient has unique deficiency symptoms. These are briefly described below and can be seen in the photographs.

Coffee nutrient deficiency symptoms

Symptoms originating in older leaves or generally on the whole plant.	Deficient nutrient	
A. Uniform yellowing over whole tree or light yellowing between the leaf veins.		
Lower leaves exhibiting slight yellowing, young leaves remaining darker green; faint yellowing between the veins of older leaves at advanced stages; small dead spots may be present.	phosphorus	 Early (left); advanced (right)
B. Localised dead tissue or yellowing between the veins on older leaves.		
Initial yellowing on the leaf edges followed by development of dead spots. Dead tissue increases until the whole leaf edge is covered. The veins and midrib remain green.	potassium	 Early (left); advanced (right)
Faint yellowing on leaf edges with sunken, yellow-brown to light brown dead spots developing in a wide band along leaf edges; yellowing between veins evident in affected leaves, particularly along the midrib.	magnesium	
Yellowing in older or middle leaves; mottling, stippling between veins; necrotic spotting along main vein.	manganese	
Bright yellow mottling between veins; leaves wither, curl and margins collapse; leaves distorted and narrow; older leaves affecter first. Rare deficiency.	molybdenum	

Symptoms originating in younger leaves near shoot tips	Deficient nutrient	
A. Uniform yellowing over whole leaf or faint yellowing between leaf veins; plants with sparse vegetative growth.		
Leaves rapidly becoming pale green; new leaves uniformly pale green with a dull green sheen. Entire plant becoming pale green, with sparse vegetative growth; leaves becoming yellow-green at advanced stages; whitish veins may be present in lower leaves.	nitrogen	 Healthy plant (left); deficient plant (right)
Leaves light green to yellow-green, with faint yellowing between veins; deficient leaves retaining shiny lustre. Whole plant may show symptoms.	sulphur	 Advanced symptoms
B. Sharp yellowing between veins of youngest leaves; older leaves unaffected.		
Leaves expanding normally, with vein network remaining green and clearly visible against the light green to yellow-green back ground; background becoming nearly creamy white at acute stages.	iron	
Leaves not expanding normally; narrow, often strap-shaped; veins visible against a yellow-green background; failure of inter-node to elongate properly, giving plants a compact appearance.	zinc	 

Symptoms originating in younger leaves near shoot tips	Deficient nutrient	
C. Bronzing, mottling or death of youngest leaves; dieback of terminal buds.		
Leaves bronzed along edges, cupped downward; new leaves dead; eventual dieback of shoot tips.	calcium	  Deficient roots (left), healthy roots (fight)
Youngest leaves light green, mottled, with uneven edges and asymmetric shape; new leaves with dead spots or tips.	boron	 
Young leaves die back, chlorosis sets in; leaves curl and roll. Shoots are weak and restricted; may be rosetted. Not common if copper sprays are used in nursery and for leaf rust and Cercospora in field.	copper	

Chapter 5

Pruning and tree management

Figure 27. Crop leaf ratio – balanced (top) unbalanced (bottom)

Pruning

Arabica coffee should be grown as a single stem system. Pruning is required to:

- supply good healthy wood for the next season's crop;
- maintain the correct balance between leaf area and crop (Figure 27);
- prevent overbearing and dieback;
- reduce biennial bearing;
- maintain good tree shape.

Desuckering

Year 1 Desucker to maintain a single stem system and avoid competition from suckers (Figure 28).

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 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 above a side primary shoot at about 1.6 m from soil level.

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

Remove secondary branches within 20 cm of the main stem.

Maintain a maximum number of well-spaced secondary branches on each primary branch.

Remove all dead, weak and spindly pest or disease damaged branches.

As plants grow, they can become too crowded and suffer loss of production. Alternative trees can be stumped by cutting off at knee height (0.5 m from soil level). When these trees are producing again after two years, stump the remaining trees (see notes on stumping).

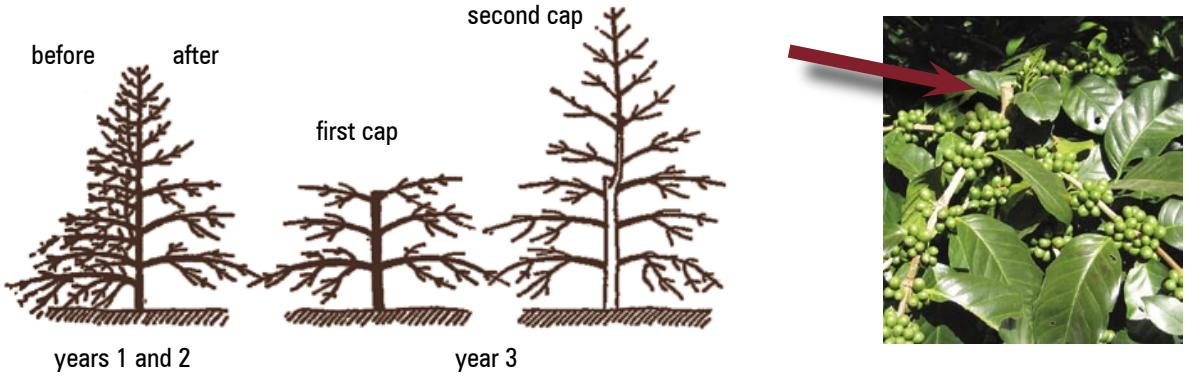


Figure 28. General pruning and desuckering of tree over years 1 and 2. Decapping during year 3. Newly capped tree (right)

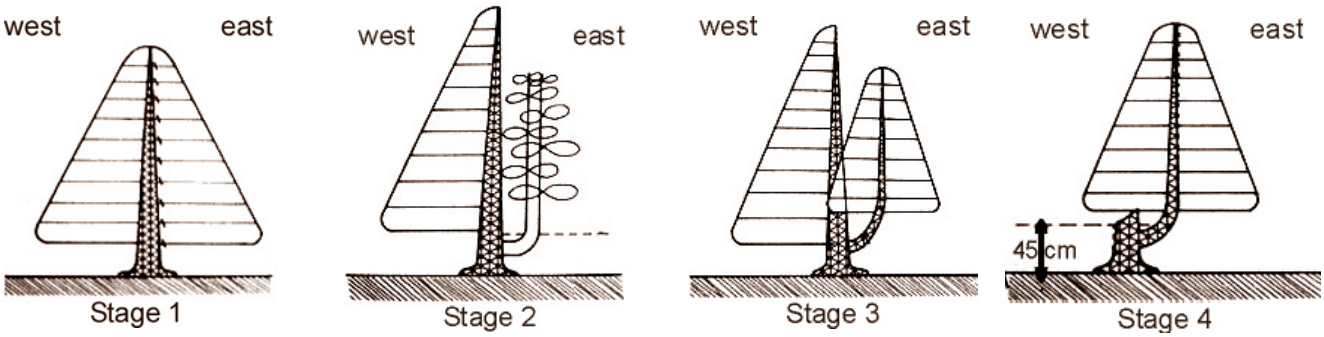


Figure 29a. The four stages in side pruning a coffee tree

Figure 29b. A coffee tree after being side pruned

Rejuvenation (Change of cropping cycle)

A regular rejuvenation pruning is needed (normally at six to seven years depending on tree vigour and yield pattern), to maintain a source of new fruiting wood. Unless trees are renewed, yield will decline over the following years.

Two rejuvenation methods are used:

- Side pruning
- Full stumping

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.

Two years before stumping, remove all branches on the eastern side of tree after harvesting. Select a new sucker approximately 300 to 450 mm 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). See Figures 29a, 29b.

Figure 30. Diagram of full stumping procedure. Choose the strongest shoot and remove the rest. Photograph of a stumped tree after re-growth (right)

Full stumping

Full stumping involves cutting the tree back to knee height (500 mm from soil level) and developing a new stem from the stump (Figure 30). This is not recommended, as the crop will be lost for one and most often two years.

Irrigation

Where possible, supplementary irrigation in the dry season will help maintain plant health and maximize yield potential. In Lao, coffee has a water requirement of about 20 to 25 mm per week, which must be supplied from either rain or supplementary irrigation. The amount of water required per hectare for irrigation is about a third to a half less if supplied by drip or under-tree micro-irrigation to the area covered by the plant leaf canopy. Remember that coffee needs to be water-stressed for about four to eight weeks before flowering to give a strong uniform flowering. Do not water trees during this period.

Intercropping in young coffee

Inter-planting young, non-bearing coffee with vegetables, annual food and cash crops, partly compensates for the high investment cost of coffee establishment, reduces soil temperature, smothers weed growth and supplies the soil with additional nitrogen (legumes) and organic matter when crop residues are turned back into the soil.

Food and cash crops suitable for intercropping include cabbage, peanut, rice, mung bean, vegetables, green beans, maize, upland rice, pigeon peas and pineapple (Figure 31). Keep a distance of 60 cm between the coffee and the intercrop to avoid nutrient and water competition. In some instances with coffee at lower altitudes, pepper vines may be trained up some of the shade trees.

In Bolovens Palteaux, various fruit trees such as durian, guava, lychee and macadamia are sometimes substituted for legume trees. These of course, should be chosen to suit the altitude.

Figure 31. Intercrop of cabbage (top). Mature, bearing coffee does not allow room for intercropping (bottom photo)

Chapter 6

Harvesting and processing

Harvesting

Careful selection of red cherries at harvesting is essential for good quality coffee. To make pulping and grading easier, process only ripe, red cherries; do not use a mixture of red, over or under-ripe cherries (Figure 32). Potential damage to coffee beans is reduced as the pulping machine can be better adjusted to the one type of red cherry.

— Unripe cherries downgrade coffee quality —

In Lao, harvesting for Arabica takes place from October through December and for Robusta, December through February (see the crop cycle —phenology, chart for details). Clean, washed bags should be used to collect the harvested fruits; NEVER use bags that have contained fertiliser or other chemicals. Cherries should be processed the same day as harvesting and should not be mixed with the previous day's harvest. Equipment and sorting areas should be checked daily and kept thoroughly washed clean. Any fermented part of cherry from the previous day will contaminate the newly harvested cherries and result in deteriotation of the entire batch. Carefully wash and sort cherries before starting the processing to remove twigs, leaves or other foreign matter.

Processing fresh cherry

Coffee processing transforms fresh coffee cherries into clean, green bean of 12% moisture ready for export or for roasting. This process involves harvesting, pulping, fermenting, washing, drying, hulling, cleaning, grading, sorting, storing and transporting green beans. The process can be broadly divided into two main components — Wet Processing (cherry to dry parchment) and Dry Processing (dry parchment to exportable green bean).

It is important to understand that each of these steps has an influence on the final quality of coffee produced. Processing is a chain of activities aimed at achieving a coffee of high quality. If any link in the chain is broken (such as over-fermentation, mould contamination, taints or odours or physical damage to the bean) then that loss in quality can never be regained.

Coffee processing methods

Three main processing methods are the basis for the range of coffee processing techniques used throughout the world—natural, semi-wash and full-wash (Figure 33 shows the last two processes).

Natural process

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. In Lao, most Robusta coffee is currently processed this way.

Full-washed process

The skin of the fresh cherry is physically removed using a pulper machine with addition of water (pulping). The sugar coating (mucilage) is allowed to ferment over one to two days and then the parchment is washed thoroughly to remove all traces of fermented mucilage. The parchment is dried until the bean inside reaches 12% moisture. This process can produce high quality coffee, but requires large quantities of water (between 2 to 10 L water per kg of fresh cherry) and requires very good management of the fermentation and washing process to ensure the coffee flavour is not damaged in the process.

Semi-washed process

The skin of the fresh cherry is physically removed by a pulper machine with addition of water, as with full-washed processing. The mucilage is then removed immediately after pulping using a demucilager. Notably this process does not ferment the mucilage as it is mechanically removed by a demucilager. Immediately after demucilaging, the clean parchment is ready for drying until the bean inside reaches 12% moisture.

Recent studies in Lao and Myanmar have shown that pulper/demucilager units are a cost efficient and an effective way to consistently produce high quality coffee without the need for fermentation and washing. These units typically use only 0.5 L of water per kg of fresh cherry and reduce the risk of over-fermentation and quality problems in the final coffee product. While there is an initial capital cost to purchase the pulper and demucialger units, there is no need for fermentation tanks and washing systems. Pulper/demucilager units are recommended for semi-washed wet coffee processing, in Lao.

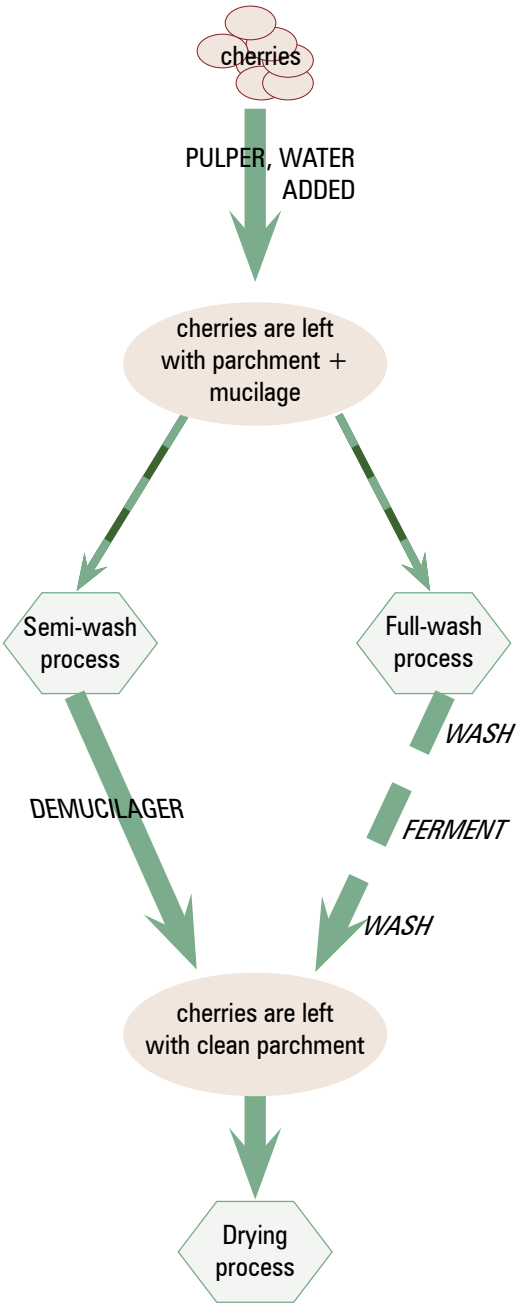


Figure 33. Simplified diagram of semi and full washing processes

Figure 32. Unripe cherries downgrade coffee quality. Do not use a mixture of red, over-ripe or under-ripe cherries

Natural process

Coffee cherries are laid out in the sun to dry

Shed and wet processing equipment supplied by FAO project to CREC for trials, demonstrations and use by CREC

Semi-wash process

Pulper (right background of photograph) and demucilager units produce clean parchment coffee ready for drying. VINACAFE unit is shown in photograph. Inexpensive and good for smallholders; processes 0.5 MT/hr cherry

Demucilaging adds body and character to coffee liquor

Full-wash process

Pulper unit removes skin

Full-wash process

Cherry is washed, fermented and washed again to remove the mucilage

The drying process

Figure 34. The beans are dried on a clean, flat surface in full sun

Drying can be done in full sun on a hard, flat, clean surface such as concrete slabs, tarpaulins, mats, raised tables or trays with a mesh base (Figure 34). Drying should remove moisture from the coffee bean in a slow and continuous process until the bean is at 12% moisture. Drying coffee directly on soil or dirty surfaces can lead to dirty or earthy flavours in the finished coffee. Rewetting of the coffee or storage of partially dried coffee due to rain is a major problem facing sun-dried coffee. Drying coffee too slowly by spreading it too thick on drying areas is also a major problem. Each of these situations can lead to fermented or fruity flavours in the coffee along with mould-growth producing mouldy or musty flavours.

The carcinogenic toxin, Ochratoxin A (OTA) can also be produced in mouldy coffee. Mouldy coffee should be avoided in all circumstances.

The European Coffee Cooperative (ECC) *Guidelines on Processing and Handling of Coffee to Minimise OTA*, provide more detailed information.

Controlling the drying process to ensure that coffee is not over-dried is important. Over-dried coffee is easily damaged during hulling and may also result in a bland flavour in the final cup. Drying cherry coffee may take 18 to 20 days. Parchment coffee dries in about 9 to 10 days. During the precess, 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 colour 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.

Figure 35. Jute bags for storing parchment coffee (top). Woven poly bags (below) for green beans in a warehouse that ideally should remain at less than 65% relative humidity. Note the low ventilation windows in the wall on the right in the photograph

Storage of dry parchment

Once parchment has been dried so that the green bean has reached 12% moisture, it can be stored while the grower / processor decides when it will be sold or hulled. 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. This can lead to mouldy or musty flavours. Storage areas must be kept isolated from strong smelling liquid such as petrol or diesel, or agricultural fertilizers and chemicals, as stored coffee can take on these odours which will continue to the final cup.

Parchment coffee or dry cherry is stored on-farm in either jute bags (Figure 35) sometimes covered with polyethylene covers, or in woven polyethylene sacks covered with a polyethylene sheet, or in special polyethylene bags or silos. If not carefully managed, parchment or green bean stored in uncovered jute sacks in a moist climate, will absorb moisture and go mouldy. Poorly ventilated warehouses and relative humidity situations over 65% will create mould problems.

Hulling and sorting dry parchment

Hulling dry parchment is a mechanical process to remove the dry parchment skin and silver skin from the green bean (Figure 36). If the huller is set incorrectly or the coffee is over-dry and brittle, coffee beans

can be damaged. If the coffee is too wet the beans can be crushed. There are a range of machines that are able to clean and sort hulled coffee by colour, size, density and aerodynamic shape (Figures 36 to 39). Ultimately the human eye is used as the final process to 'hand-sort' coffee ready for export. However, even with the wide range of machinery available, coffee that has picked up off-flavours but otherwise looks normal, cannot be sorted, and is only identified in the cup when it is too late.

Figure 36. Hulling machine (above) and beans with parchment removed after hulling (right)

Storage of green bean

Stored, green bean is very susceptible to being contaminated by nearby chemicals or fuels. Storage and shipment of green bean in jute sacks that have been made on machinery lubricated with petroleum oils, can lead to a 'baggy' or 'oily' taste in the coffee. Use clean, jute sacks specially made for coffee.

Green bean that is stored for long periods in hot and humid conditions is liable to absorb moisture from the atmosphere with resultant mould producing musty flavours. To ensure minimum spoilage, beans in jute sacks or woven poly bags should be evenly stacked in a well-ventilated area that remains at less than 65% relative humidity (Figure 35). After some time in storage, the bean surface begins to oxidise leading to 'woody' taints. Coffee should not be stored for longer than 12 months as the beans fade and mottle.

Transport

Storage and transport pose similar risks to coffee quality. Re-wetting of beans due to leaky tarpaulins, or high humidity inside hot containers standing for long periods in tropical ports, can result in the coffee developing mouldy or musty flavours. Special techniques for handling bulk or bagged green beans for container shipping are now well known.

Figure 37. Catador used to clean coffee beans after hulling

Figure 38. Green bean grading machine (left)

Figure 39. A densiometric sorting table (right)

Summary of processing factors affecting coffee quality

The following table present a summary of processing factors and their potential problems, which can influence Arabica quality in the washed / semi-washed processes.

Washing process for Arabica coffee

Process step	Factors reducing quality	Potential problem
Harvesting cherry	Harvest green cherry	Green or grassy flavour
	Harvest over-ripe cherry	Fermented or fruity flavour
	Pick fallen old cherry from the ground	Fermented or fruity flavours. Mould contamination producing mouldy or musty flavours
	Hold fresh cherry for long periods before pulping	Fermented or fruity flavours
Pulping cherry	Poor quality pulping equipment or poorly adjusted equipment	Nipped beans causing stinker beans
Fermentation	Over-fermentation	Fermented, fruity, sour or onion flavour
	Poor hygiene in fermentation tanks leaving a small number of extremely over fermented beans	Stinker beans producing foul rotted or sour flavours
Washing	Poor washing leaving mucilage on parchment	Mould growth producing mouldy or musty flavours
Drying of parchment	Contaminated by drying on the ground or dirty drying surfaces	Earthy flavours. Mould contamination producing mouldy or musty flavours
	Stored partially dry for long periods or rewet during drying	Mould growth producing mouldy or musty flavours
	Machine drying too fast, too hot, or uneven	Poor, mottled or faded colour, dull or bland flavour
	Coffee is over-dried	Poor, faded bean colour. Damages easily during hulling
Storing dried parchment	Stored dried parchment too wet	Mould growth producing mouldy or musty flavours
	Stored near fuels or chemicals	Contaminated with foul odours
Hulling dry parchment	Incorrect huller setting	Bean damage
	Coffee too dry	Bean damage
Storing hulled green bean	Storing too wet	Mould growth producing and mouldy or musty flavours
	Stored near fuels or chemicals	Contaminate with foul odours
	Stored in jute bags made on machinery lubricated by petroleum oils	Contaminated with baggy or oily taints
	Stored in hot humid condition for long periods	Mould growth producing mouldy or musty flavours. Surface oxidation of beans causing woody flavoursFaded bean colour
Transport	Rewetting of coffee due to leaky tarpaulins or containers	Mould growth producing mouldy or musty flavours
	Stored near fuels or, chemicals	Contaminated with foul odours during storage

Chapter 7

Quality assessment

Quality assessment & improvement

Currently, Lao has around 35,000 hectares of coffee—88% of Robusta and 12% Arabica. Most coffee at this stage is produced by the 23,000 smallholder families located on the Bolovens Plateaux of southern Lao. Some larger Arabica plantings comprising some 400 to 500 ha will be coming into full production in the next two to three years. The Government of Lao is encouraging the planting of higher quality Arabica coffee at higher altitudes of above 1000 m.a.s.l., with a view to moving to a 50:50 Arabica:Robusta mix.

Current production per year is approximately 750 tonnes for Arabica comprising 500 tonnes from a large plantation (Dau Heuang) and 250 tonnes from smaller landholders; included in this is 80 tonnes of Typica. Exports for Robusta are approximately 14,000 tonnes from a production of about 15,000 tonnes per year. To date, most smallholders typically process Robusta coffee as dried cherry coffee (Natural method—sun drying of the fresh cherry). At sale, the coffee is roughly hulled by modified rice hullers, usually by a contractor, with the result being a relatively poor quality green bean product. Larger operations for Robusta have more professional hulling, cleaning and grading facilities.

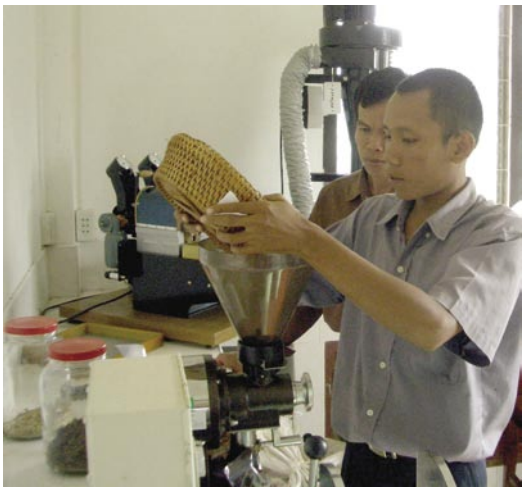
Some Arabica is processed as natural dried cherry, and some is wet-processed using a full-wash, to produce parchment which is hulled to give green bean prior to sale. Fair Trade coffee buyers, including OXFAM and J'hai Foundation, assist this wet-processing with farmer groups. However, apart from this assistance, most Arabica coffee is currently poorly processed and the resultant quality is often poor.

Cup quality evaluation of Lao coffees

Part of the focus of this FAO Coffee Project has been to emphasise coffee quality improvement via good harvesting, handling and new processing practices. Photographs of some equipment supplied by FAO are shown in sidebars and previous pages). In addition, the Project sent a range of Arabica and Catimor green beans from various altitudes for assessment by international buyers and local buyers/roasters. The coffee samples were collected as ripe cherry from farmers and processed at CREC using a standard full-wash wet process. Samples selected for assessment by buyers/roasters were first assessed by the FAO project International Consultants and CREC staff.

Huller (centre) and moisture meters (bottom)

CREC now has a fully equipped coffee laboratory for tasting and physical assessment of green bean samples, including hullers, a Probat sample roaster and 2 kg/hr DiScaf roaster, Santos grinder, drying ovens, pH meter, expresso machine as well as a fully equipped wet processing area for Arabica and Robusta pulping, pulping/demucilaging and splitting/mashing of Robusta cherry as well as a small huller and small coffee storage warehouse. The Project also supplied the large concrete drying area and fully equipped weather station. Staff members at CREC have been thoroughly trained in cupping and natural, full-wash and semi-wash processing methodologies by project specialists.



Grinding a coffee sample

Sample roaster

Sample grading screens

Quality evaluation process

In an effort to standardize the process of evaluating the cup quality of coffee samples, the Project chose to use the quality evaluation process described in the *Coffee Cuppers Handbook* by Ted Lingle (Third edition, 2001) and published by the Specialty Coffee Association of America (SCAA).

The SCAA approach is a systematic, sensory evaluation process of a coffee. The process is divided into five evaluation steps with each step scoring from 1 to 10 points. A sixth step is added to give the coffee a Cupper's Point or Balance score from –5 to +5. For convenience, 50 points is then added to the resulting score to give a score out of one hundred.

Tasting, evaluatung coffee

Six step SCAA evaluation process

	Step	Ranking on	Rating	Scale range
1	Fragrance of the ground coffee + Aroma of the coffee liquor	Preference	1 to 10	very poor to outstanding
2	Acidity of the liquor	Intensity	1 to 10	very flat to very bright
3	Flavour of the liquor	Preference	1 to 10	very poor to very bright
4	Body of liquor	Intensity	1 to 10	thin to heavy
5	Aftertaste of the liquor	Preference	1 to 10	very poor to outstanding
6	Cuppers Points or Balance	Taster's overall preference	-5 to +5	very poor to outstanding

Commercial roasting of coffee at CREC

As a guideline, this SCAA scoring system should correlate to the SCAA Green Coffee Classification Chart where:

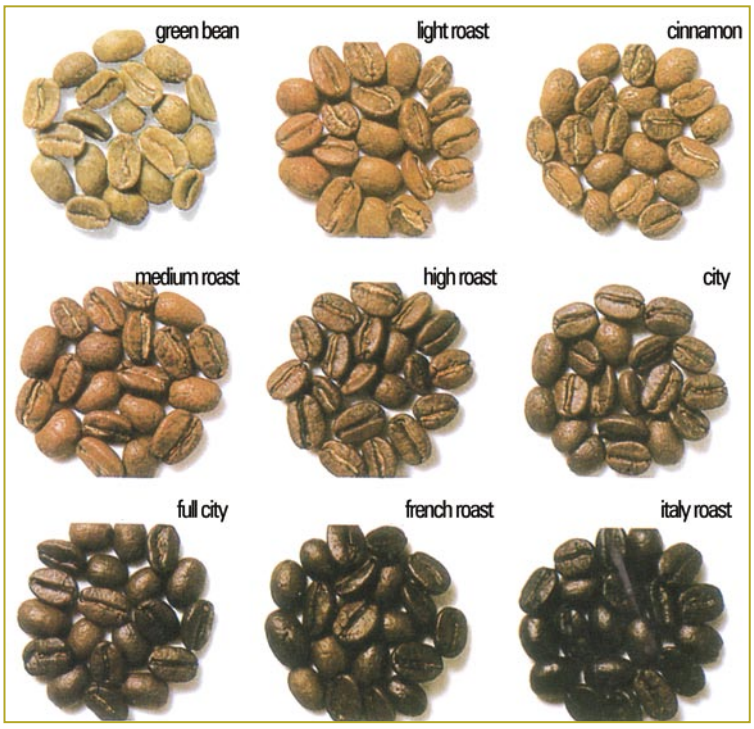
- Class 1 Specialty Grade should receive 90 to 100+ points
- Class 2 Premium Grade should receive 80 to 89 points
- Class 3 Exchange Grade should receive 70 to 79 points
- Class 4 Below Standard Grade should receive 60 to 69 points
- Class 5 Off Grade should receive 50 to 59 points

The 12 samples used in the assessment were:

Sample 1	Catimor from Dau Heuang	1083 m
Sample 2	Catimor from Intha Group	1065 m
Sample 3	Catimor from Nongkali village	1240 m
Sample 4	Catimor from Thongset village	1225 m
Sample 5	Catimor from Kataut village	1175 m
Sample 6	Catimor from Being village	1245 m
Sample 7	Caturra from Phoumon village	960 m
Sample 8	Catimor from Thong Katai village	1205 m
Sample 9	Java from Intha Group	1063 m
Sample 10	Typica from Thong Set village	1225 m
Sample 11	Typica from Being village	1200 m
Sample 12	Typica from Katuat village	1175 m

After the initial assessment, the following seven best coffees were selected for blind tasting by commercial coffee buyers.

A	Sample 1	Catimor from Dau Heuang	1083 m
B	Sample 5	Catimor from Kataut village	1175 m
C	Sample 8	Catimor from Thong Katai village	1205 m
D	Sample 11	Typica from Being village	1200 m
E	Sample 10	Typica from Thong Set village	1225 m
F	Sample 12	Typica from Katuat village	1175 m
G	Sample 9	Java from Intha group	1063 m



Coffee roasting chart

General comments on Arabica

- Coffees are very clean, but lack highlights, except for Java variety which many liked as a more balanced coffee.
- Surprisingly, Typicas could not be distinguished from Catimors by most tasters—all samples lacked acidity.
- The samples tested are only marginal as speciality coffees; most are too bland. It was suggested that Lao coffee should be semi-washed rather than full-washed to give more body and character.

Coffee evaluations by International buyers and assessors

Sample, Variety Location & Altitude	Lao Mountain Coffee	Ecom	Holland Coffee	CAFECONTROL Viet Nam	Illy Café assessed as expresso coffee
A Catimor from Dau Heuang Paxong-Attepeau Road 1083m	80/100	60.2/100 Flat, no character whatsoever	Acidity: low Body: medium Prep: good Flavour: astringent, slightly dry; not very good	Flavour: grassy Acidity: medium No.5	Very good aroma, little defect in the beans
B Catimor from Kataut Village 1175m	78/100	74.8/100 Slightly fruity	Acidity: low Body: medium Prep: overdried/faded Flavour: flat, nothing special	Flavour: medium Acidity: high No.6	Good taste, no significant defective beans
C Catimor from Thong Katai Village 1205m	88/100	74.4/100 Pleasant, round	Acidity: low Body: medium Prep: good Flavour: best of samples, floral, sweet, clean, pleasant	Flavour: medium (woody) Acidity: medium No.7	Good taste, no significant defective beans
D Typica from Be Ing Village 1200m	81/100	63/100 Smooth but thin/flat	Acidity: low/medium Body: medium Prep: good Flavour: metallic grassy, dusty unpleasant/defective	Flavour: good Acid: high Best of samples No.1	Good coffee, similar to 'A' but less aroma
E Typica from Thong Set village 1225m	83/100	63.6/100 No comments	Acidity: low Body: medium Prep: good Flavour: sour, not pleasant	Flavour: slight good Acidity: quite high No.4	No defects, no particular body
F Typica from Katuat village 1175m	72/100	73.4/100 Pleasant, balanced	Acidity: low Body: medium Prep: good Flavour: second best, little sweetness, clean pleasant but a little thin	Flavour: slight good Acidity: quite high No.3	Unfortunately green. Probably fresher than other coffees
G Java, Intha group Paxong-Attepeau Road 1063m	88/100	71.6/100 Higher acidity, fruitiness. Divided opinions between cuppers; some liked very much, others not at all	Acidity: low/medium Body: medium Prep: starting to fade Flavour: little grassy, otherwise OK, little sweetness. No. 3	Flavour: good Acidity: high. Second best of samples No.2	Woody taste

General comments on Robusta

- Semi-washed coffee produced with a VINACAFE pulper/demucilager, produced clean, consistant cup with good body and without earthy, mouldy aroma and flavour of natural-processed Robusta.
- High altitude Robusta (1,200 m) semi-washed was clearly superior in character to low altitude (600 m).
- Lao has considerable areas of high altitude Robusta which, if semi-washed may well find a specialty niche market.

Chapter 8

Quality and export standards

At present Lao has no official export quality standard. In the future, a standard will need to be adopted and enforced as a national coffee quality export standard to assist quality coffee to be better graded, to receive higher prices than low quality coffee, and attain a reputation for consistent, high quality coffee.

Each coffee exporting country usually has it own set of standards developed around its particular coffee industry. These standards might be unique to each country, but must also be understandable to local and international buyers so they can base their coffee purchases on descriptions of coffee from each country. Coffee standards usually cover physical defects, bean size, bean appearance and cup quality. Even with standards in place, internationally traded coffee is normally sold subject to the buyer receiving a representative sample of coffee before the contract is finalised.

Understanding coffee quality standards

A good basis for understanding coffee quality standards is the ICO (International Coffee Organization) minimum standards for coffee as set down in ICC Resolution No. 407/02 of 1 February 2002.

Resolution number 407 Approved at the Plenary Meeting, 1st February 2002

Coffee Quality-Improvement Programme – Implementation

WHEREAS: By Resolution number 406 the International Coffee Council established a Quality Committee to be responsible for drafting and presenting, through the Executive Board, recommendations to the Council for a Coffee Quality-Improvement Programme; The Committee has agreed a series of recommendations contained in document EB-3806/02; The Executive Board has considered these recommendations and modified them in the light of comments received; and In the light of these recommendations as modified by the Board it is deemed appropriate to take the necessary steps to implement the Programme, THE INTERNATIONAL COFFEE COUNCIL RESOLVES:

Sequencing of the Programme

1. The Programme shall comprise a first stage that shall commence on 1 October 2002. In order to make an assessment of the Programme, its progress, costs and impact on quality and prices shall be reviewed in September 2003.

ICC Resolution No. 407/02 1 February 2002 Original: English – 2 – Action from 1 October 2002

A. Minimum standards for exportable coffee

2. Exporting Members shall not export coffee that:

(a) for Arabica, has in excess of 86 defects per 300 g sample (New York green coffee classification/ Brazilian method, or equivalent1); and, for Robusta, has in excess of 150 defects per 300 g (Vietnam, Indonesia, or equivalent);

(b) for both Arabica and Robusta, has a moisture content below 8 percent or in excess of 12.5 percent, measured using the ISO 6673 method.

3. Where moisture percentages below 12.5 percent are currently being achieved, Members shall endeavour to ensure that these are maintained or decreased.

4. Exceptions to the 12.5 percent maximum moisture content shall be permitted for speciality coffees that traditionally have a high moisture content, e.g. Indian Monsooned coffees. Such coffees shall be clearly identified by a specific grade nomenclature.

B. Certificates of Origin

5. Exporting Members shall only issue ICO Certificates of Origin for consignments of coffee that meet both the minimum defect and moisture standards.

C. Cooperation by importing Members in verifying compliance

6. Importing Members shall make their best endeavours to support the objectives of the Programme.

D. Measures to be taken in cases of non-compliance

7. If coffee failing to comply with the above standards is identified through the normal course of trade, importing Members shall endeavour to notify the ICO of such shipments.

1 As an example of what is meant by 'equivalent', 20 broken beans shall be considered as equal to 1 defect rather than 5 broken beans per defect in the case of coffees containing large numbers of broken beans arising naturally, as a feature of a particular cultivar. Such coffees shall be clearly identified by a specific grade nomenclature.

E. Measures for controlling the application of the standards in exporting Member countries

8. Each exporting Member shall develop and implement national measures which ensure that no exports of green coffee fail to meet exportable standards.

9. Exporting Members shall also endeavour to ensure that sub-standard green coffee is not included in the manufacture of processed coffee (roasted and soluble) that is exported.

F. Other measures

Alternative uses

10. Members shall seek immediately to identify sources of external finance from appropriate institutions for studies and measures that support the implementation of the Programme and, in particular, efforts to identify and put into practice cost-effective alternative uses for coffee of non-exportable quality.

11. The need for a continuation of such studies and measures shall be assessed following a review in September 2003.

Labelling

12. All coffee supplied for export shall be labelled to indicate that it is coffee as defined in Articles 2 and 36 of the International Coffee Agreement 2001. Coffee by-products shall be labelled as such.

Reporting

13. Members shall report to the Council on the measures they have taken to implement this Resolution and inform the Council of any difficulties in this connection. If such be the case the Council, if so requested by a Member, may agree to give that Member time to resolve such difficulties.

Excerpt from NYBOT Coffee "C" Rules

APPENDIX II: Procedures for grading coffee and issuance of certificates of grade, as quoted in European Coffee Cooperation publication of 11 January 2005 entitled *OTA Risk Management for Green Coffee Buying*.

(f) Minimum Standards

The minimum standards for delivery under the Coffee "C" Futures Contract are as follows:

(1) The coffee is sound in the cup;

(2) The coffee is of good roasting quality;

(3) The coffee is of such bean size that (i) fifty percent (50%) of the coffee sampled screens fifteen (15) or larger, and (ii) no more than five percent (5%) of the coffee sampled screens below fourteen (14);

(4) The coffee is greenish and free of foreign odors; and

(5) The coffee contains no more than fifteen (15) full imperfections below the basis, except that in the case of Colombian coffee the maximum number of full imperfections below the basis shall be ten (10).

(g) Schedule of Imperfections

(1) The following constitute one (1) full imperfection:

one (1) full black;

one (1) full sour;

one (1) pod or cherry;

five (5) shells;

five (5) broken or cut beans;

two (2) to five (5) partly black or partly sour beans, depending upon the extent to which each bean is discolored or spoiled;

five (5) floaters;

three (3) sticks smaller than one-half (1/2) inch;

one (1) stick ranging in size from one-half (1/2) inch to one (1) inch;

three (3) stones passing through a screen size below twelve (12);

one (1) stone passing through a screen size no smaller than twelve (12);

two (2) to three (3) hulls or husks, depending upon size; and

two (2) to three (3) parchments, depending upon size.

(2) The following constitute two (2) full imperfections:

one (1) stick ranging in size from one (1) inch to two (2) inches; and one (1) stone passing through a screen size no smaller than sixteen (16).

(3) The following constitute three (3) full imperfections:

one (1) stick larger than two (2) inches; and

one (1) stone passing through a screen size over twenty (20).

(4) Any additional non-coffee item shall be one (1) full imperfection.

(h) Schedule of Bases

For purposes of these procedures, the bases of various growths of coffee are as follows:

(1) Coffee of Guatemala, Salvador, Mexico, Costa Rica, Nicaragua, Honduras, Kenya, Tanzania, Uganda, Papua New Guinea, Peru, Venezuela, Dominican Republic, Burundi, Ecuador, India, Rwanda and Panama—eight (8) full imperfections; and

(2) Coffee of Colombia—thirteen (13) full imperfections.

Excerpt from LIFFE Robusta Futures Contract

5. Grades Tenderable

5.01 Subject to these Contract terms, coffee of CTML standard grade shall be tenderable at basis or at the discount shown below:

Type 1: up to 150 defects per 500 g at basis;

Type 2: from 151 to 250 defects per 500 g at a discount of US$15 per tonne;

Type 3: from 251 to 350 defects per 500 g at a discount of US$30 per tonne;

or

Type 4: from 351 to 450 defects per 500 g at a discount of US$45 per tonne.

5.02 Defects shall be counted as follows:

(a) in respect of a lot graded prior to 1 February 2000:

Defect	Number of defects
1 black bean, or pod or cherry	1
2 half blacks, sour beans, parchments or large husks	1
1 large stone (1 cm diameter)	5
1 medium stone (about 5 mm diameter)	2
2 small stones or pieces of earth	1
1 large stick (3 cm length)	5
1 medium stick (2 cm length)	2
2 small sticks (1 cm length)	1
5 broken beans, shells withered, green or unripe beans, bleached beans, small pieces husk	1
1 mouldy bean	50
Insect damaged beans:	
2 beans half eaten away	1
5 beans slightly eaten away	1
Extraneous matter, per item	1 (or more at graders'discretion)

(b) in respect of a lot graded with effect from 1 February 2000:

1 black bean, or pod, or cherry	1
2 half blacks, sour beans, parchment or large husks	1
1 large stone (1 cm diameter)	5
1 medium stone (about 5 mm diameter)	2
2 small stones or pieces of earth	1
1 large stick (3 cm length)	5
1 medium stick (2 cm length)	2
2 small sticks (1 cm length)	1
5 broken beans, shells withered, green or unripe beans, bleached beans, small pieces husk	1
1 partially mouldy bean (i.e. less than 50% mould)	1/2
1 fully mouldy bean (i.e. 50% mould or more)	1
Insect damaged beans:	
2 beans half eaten away	1
5 beans slightly eaten away	1
Extraneous matter, per item	1 (or more at graders'discretion)

5.03 Coffee containing more than 25 per cent passing through screen 14 round and less than 10 per cent passing through screen 12 round shall be tenderable at a discount of US$60 per tonne.

6. Untenderable Coffee

6.01 Coffee is not tenderable if:

(a) it has more than 450 defects per 500 g;

(b) it is unsound, i.e. for any reason other than those already listed, as determined by the graders;

(c) it contains more than 10 per cent passing through screen 12 round;

or

(d) in respect of a lot graded with effect from 1 February 2000, it has more than 5 fully mouldy or 10 partially mouldy beans or any combination thereof such that the total exceeds the equivalent of 5 fully mouldy beans per 500 g.

Excerpt from European Coffee Cooperation *OTA Risk Management: Guidelines for green coffee buying*. 11 Jan 2005.

Green coffee – Determination of loss in mass at 105°C

1 Scope and field of application

This International Standard specifies a method for the determination of the loss in mass at 105°C of green coffee. It is applicable to decaffeinated and non-decaffeinated green coffee as defined in ISO 3509. This method of determining the loss in mass can be considered, by convention, as a method of determining the water content and can be used as such by agreement between the interested parties, but it gives results which are lower by about 1.0% than those obtained with the methods described in ISO 1447 and ISO 1446 (this latter method serves only as a reference method for calibrating methods of determining the water content).

2 References

ISO 1446, Green coffee – Determination of moisture content (basic reference method).

ISO 1447, Green coffee – Determination of moisture content (routine reference method).

ISO 3509, Coffee and its products – Vocabulary.

ISO 4072, Coffee in bags – Sampling.

3 Definition

Loss in mass at 105°C for 16h at atmospheric pressure.

4 Principle

Heating a test portion at 105°C for 26 hours at atmospheric pressure.

5 Apparatus

Usual laboratory apparatus, and in particular:

5.1 Oven, electrically heated fitted with a system of forced ventilation and capable of being controlled at 105 ± 1°C.

5.2 Dish, made of aluminium, glass or stainless steel with a close-fitting lid. The diameter should be approximately 90 mm and the height 20 to 30 mm.

5.3 Analytical balance

5.4 Dessicator, containing an efficient desiccant, for example, anhydrous calcium, sulphate or silica gel.

6 Sampling

See ISO 4072

It is important to proceed as rapidly as possible when sample are exposed to the atmosphere, in order to prevent any pickup or loss of moisture.

7 Procedure

7.1 Preparation of the dish

Dry the dish and its lid for one hour in the oven controlled at 105 ± 1°C. Remove the dish and lid from the oven and allow to cool to room temperature in the desiccator. Weigh the dish and its lid to the nearest 0.1 mg.

7.2 Test portion

Place a test portion of approximately 10 g into the preparation dish and spread the beans uniformly over the bottom of the dish. Cover the dish with its lid and weigh to the nearest 0.1 mg.

Note. If performing a series of tests, prepare dishes as described in 7.1 and place the covered and weighed dishes in the desiccator in order to avoid and pickup of loss of moisture.

7.3 Determination

Place the dish containing the test portion, with the lid removed but alongside or beneath the dish, in the oven, controlled at 105 ± 1°C, and dry for 16 ± 0.5h.

Fit the lid on the dish and place in the desiccator. Allow to cool to room temperature and the weigh to the nearest 0.1 mg.

7.4 Number of determination

Carry out two determinations on the same test sample.

8 Expression of results

The loss in mass at 105°C expressed as a percentage by mass is equal to:

$$\frac{(m_1 - m_2) \times 100}{m_1 - m_0}$$

where

m_0 is the mass, in grams of the dish and lid (7.1);

m_1 is the mass, in grams of the dish, test portion and lid before drying (7.2);

m_2 is the mass, in grams of the dish, test portion and lid after drying (7.3);

Take as the result the arithmetic mean of the two determinations (7.4).

9 Precision

an inter-laboratory test, carried out at the international level, in which 14 laboratories, each performing two determinations, participated, gave the statistical information (evaluated in accordance with ISO 5725[1]) summarised in the table.

10 Test report

The test report shall show the method used and the result obtained. It shall also mention any operating details not specified in this International Standard, or regarded as optional, as well as any circumstances that may have influenced the result. The test report shall include all the information required for complete identification of the sample (table below).

Table results expressed as percentage by mass

Sample	A	B	C	D	E
Number or laboratories retained after eliminating others	13.0	13.0	13.0	13.0	13.0
Mean	8.50	9.11	9.14	11.10	11.40
Standard deviation of repeatability (s1)	0.09	0.04	0.06	0.09	0.12
Coefficient of variation of repeatability	1.1%	0.4%	0.7%	0.8%	1.1%
Repeatability (2.83 x s1)	0.25	0.11	0.17	0.25	0.34
Standard deviation of reproducibility (sR)	0.21	0.42	0.33	0.19	0.22
Coefficient of variation of reproducibility	2.5%	4.6%	3.6%	1.7%	1.9%
Reproducibility Repeatability (2.83 x sR)	0.59	1.19	0.93	0.54	0.62

(Excerpt from European Coffee Cooperation *OTA Risk Management: Guidelines for Green Coffee Buying*-11 Jan 2005).

ISO International Standard 4072-1982 (E)

Excerpt from European Coffee Cooperation *OTA Risk Management: Guidelines for green coffee buying*-11 Jan 2005

1 Scope and field of application

This International Standard specifies a method of sampling a consignment of green coffee, shipped in ten bags or more, for the purpose of examination to determine whether the consignment complies with a contract specification.

The method may also be used for the preparation of a sample intended:

a) to serve as a basis for an offer for sale;

b) for examination to verify that the coffee to be offered for sale satisfies the producer's sales specification;

c) for examination to determine one or more of the characteristics of the coffee for technical, commercial, administrative and arbitration purposes;

d) for quality control or quality inspection;

e) for retention as a reference sample for use if required in litigation.

This International Standard applies to green coffee in bags, as defined in ISO 3509.

2 References

ISO 3509, Coffee and its products – Vocabulary

ISO 6666, Coffee triers.

3 Definitions

For the purpose of this International Standard, the following definitions apply:

3.1 Consignment. The quality of green coffee in bags dispatched or received at one time and covered by

[1] ISO 5725, Precision of test methods - Determination of repeatability and reproducibility by inter-laboratory tests.

a particular contract or shipping document. It may be compressed or one or more lots.

3.2 Lot. A part of a consignment, or a consignment, presumed to be of uniform characteristics, consisting of not more than 1000 bags of the same type, with the same marls and mass, containing green coffee assumed to have common properties of reasonably uniform character and to which a given scheme or examination can be applied.

3.3 Damaged bags. Bags whish are torn, stained, soiled or otherwise detectably contaminated, indicating possible damage to the coffee contained in them.

3.4 Sample. A part of a lot, from which the properties of the lot are to be estimated by examination.

3.5 Increment; primary sample. The quantity of 30 ± 6 g of green coffee beans taken from a single bag or a specific lot.

3.6 Bulk sample; lot sample. The quantity of not less than 1500 g of green coffee beans obtained by combining all the increments (3.5) taken from the bags of a specific lot.

3.7 Blended bulk sample; blended lot sample. The quantity of green coffee beans obtained by combining and blending all the increments (3.5) taken from bags of a specific lot.

3.8 Laboratory sample; final sample. The quantity of not less than 300 g of green coffee beans removed from the blended bulk sample (3.7) of a specific lot.

4 Administrative arrangements

4.1 Sampling personnel

Sampling shall be carried out by experienced samplers or samplers qualified by training, or shall be carried out by specialized sampling organizations.

4.2 Sampling shall be carried out on each lot in a place designed to protect the samples, the sampling apparatus and the containers and packages intended to receive the samples, from adventitious contamination, rain, etc. Special care shall be taken to ensure that the sampling apparatus is clean, dry and free from foreign odours.

The sampler shall note any evidence of damaged bags or potential contamination.

1) At present at the stage of draft

4.3 Sampling report

After preparation of the samples, a sampling report shall be prepared (see clause 11).

5 Identification and general inspection of the lot prior to sampling

Before any samples are taken, positively identify the lot.

6 Principle of the method of sampling

The method specified follows an established scheme of an arbitrary nature, based on experience.

7 Apparatus

7.1 Coffee trier. A special device for removing coffee through the bag wall without opening the bag, as specified in ISO 6666.

8 Sample containers and packages

The containers and packages mentioned in 4.2, together with their closure systems, shall be clean and dry and shall be made from materials which will not affect the odour, flavour or composition of the samples. They shall be sufficiently robust to withstand hazards during transport by the chosen method and shall have the ability to preserve the samples unchanged for the appropriate period.

9 Procedure

9.1 Taking increments

9.1.1 Unless there is a stipulation to the contrary in the contract, the number of bags selected from a lot for the purposes of taking increments of 30 6 6 g (see 3.5) shall be not less than 10 if there are 10 to 100 bags in the lot, and shall be not less than 10% of the total if there are more than 100 bags in the lot.

9.1.2 The increments shall be taken at random from individual bags from different locations on the pile, using the coffee trier (7.1). Each bag should preferably be sampled at three different points.

NOTES

1 Damaged bags should be separated from the remainder of the lot. They may be sampled separately and increments kept separate (see 9.2.1).

2 In order to obtain a bulk sample of 1500 g (see 3.6), it may be necessary to take more than three increments from each bag.

9.2 Preparation of samples

9.2.1 Bulk sample

Examine the increments as they are taken. If they are evidently homogeneous, combine them in a container. Label the bulk sample obtained (see clause 10). If there is a noticeable lack of uniformity among any of the increments, keep them separate and report this condition in the

sampling report (see clause 11). Samples taken from damaged bags shall not be included in the bulk sample (see note 1 to 9.1.2)

9.2.2 Blended bulk sample

Remove the bulk sample (9.2.1) from its container and thoroughly mix it.

9.2.3 Laboratory samples

Prepare each laboratory sample by removing a quantity of not less than 300 g from the blended bulk sample (9.2.2). Pack and label each laboratory sample obtained (see 33 clause 10).

10 Packing and marketing of samples

10.1 Precautions to be taken when packing samples. Samples intended for the determination of moisture content, or for any other test liable to be influenced by an alteration of the moisture content, shall be packed in moisture-proof containers fitted with airtight closures. The containers, in the case, shall be completely filled with green coffee and the closures shall be sealed to prevent loss or alteration of the containers.

NOTE For the examination of quality characteristic that are not liable to be influenced by an alteration of the moisture content, separate samples should be taken and placed in appropriate containers which allow access of air.

10.2 Marketing

The samples shall be identified by recording the following information on the container or package, or on a label affixed to the container or package, unless otherwise specified:

1) Date of sampling
2) Name of sampler and employer
3) Shipping document or contract number
4) Ship (or other transport vehicle)
5) Location of coffee
6) Identifying marks and numbers (including the origin of the coffee)
7) Number of bags in the lot
8) Mass of the sample

11 Sampling report

The sampling report shall give all information relevant to the method of sampling and shall refer to the presence of damaged bags, the type(s) of damage and approximate number of damaged bags in the lot. Any other pertinent observation concerning the condition of the lot shall also be included.

The report shall refer to the conditions in the location of the lot, especially with regard to any potentially contaminating material in the vicinity.

12 Precautions during storage and transport

12.1 Laboratory samples shall be dispatched to the place of examination as soon as possible after preparation and only in exceptional circumstances, more than 48 hours after preparation, non-business days excluded. A copy of the sampling report (see clause 11) shall be sent with them.

12.2 After taking the laboratory samples, the rest of the blended bulk sample from each lot shall be retained in a container labelled in accordance with 10.2 for further use if necessary (inspection, etc.), until final acceptance of the consignment by the purchaser.

Quality and OTA guidelines for Lao-PDR

Lao is encouraged to set up its own standards for coffee quality for export using the above excerpts as guidelines in consultation with the International Coffee Organisation Standards and Guidelines on Coffee Quality.

Mould and Ochratoxin A (OTA) minimisation through good handling practices should also be consulted. National maximum limits for OTA in parts per billion are quoted from ECC Guidelines. Lao needs to carefully take note of ways to minimise OTA in coffee (see page 54 for the excerpt, *OTA Risk Management: Guidelines for Green Coffee Buying 11 January 2005*.

National maximum limits for Ochratoxin A

	Green	Roasted	Instant
Czech Republic	10	10	10
Finland	5	5	5
Germany	-	3	6
Greece	20	-	-
Hungary	15	10	10
Italy	8	4	4
Netherlands	-	10	10
Portugal	8	4	4
Spain	8	4	4
Switzerland	5	5	5

The carcinogenic toxin, Ochratoxin A (OTA) can be produced in mouldy coffee. All necessary steps should be taken to avoid this problem (see page 44 for details)

Chapter 9

Pests and diseases

Insect pests

Green coffee scale

Green coffee scale (*Coccus viridis*) is a common and serious problem. Scales suck the plant sap resulting in reduced growth and crop yield. Sooty mould (a black, loose, sooty-like cover) often develops on leaves. It grows on the sweet exudate from the scales (honeydew) that also attracts ants.

Symptoms

Green oval shaped scales about 2 to 3 mm long. Often found concentrated on leaf veins and tips of new shoots. Infestations then produce spots of honeydew, which become covered with a black sooty mould. Defoliation of badly affected trees can occur.

Control

Preventative:

There are a number of natural predators of coffee scale such as wasps, ladybugs and Verticillium fungus. In many instances, these will reduce the level of scale infestation.

Chemical:

Mineral spraying oils at 200 ml/ 20 L water applied as a spray to affected plants. Only spray if 10 or more leaves are infested with one or more scales. The spray must completely wet and cover the scales. Do not use automotive oil!

Carbaryl 85 % wettable powder at 20 g/10 L water applied as a spray. Apply weekly until scales disappear.

Traditional:

1kg strong tobacco per 2 L water. Soak for 2 nights. Then remove tobacco. Add 500 g of washing powder and make up to 20 L. Spray weekly until scales disappear.

Scale. Green coffee scale on leaf (top); ants, black sooty mould and scale (below left) and severe infestation on branch (right)

Aphids

Aphids (*Toxoptera aurantii*) can occur in large numbers on new shoots in the rainy season. Aphids suck sap from young shoots and cause damage to these developing shoots.

Symptoms

Large numbers of small black aphids (2 to 3 mm long) concentrated on new growth. Often associated with black sooty mould.

Control

Generally not warranted.

Chemical:

Neem oil 10 to 20 ml/L, plus soft, finely grated laundry soap at about 7 g/L water.

Stemborers

There are two species of stemborer present in Lao PDR.

Red stemborer(*Zeuzera coffeae*). The adult has white and black spotted wings. The red coloured larvae tunnel through the coffee branches, normally in the upper part of the coffee trees. Branches and the top part of the main stem easily break off, but the tree usually survives.

White stemborer (*Xylotrechus quadripes*). The adult is a black and white banded beetle (about 1 to 2 cm long); the head of the male beetle has distinctive raised black ridges. Adults are active during daylight. Damage is caused by the white larvae, which hatch from eggs deposited in cracks and crevices and under loose scaly bark of the main stem and thick primary branches, especially on plants exposed to sunlight. Young larvae feed on the corky tissue just under the bark, which splits making the stem appear ridged. Later, larvae enter the heartwood and tunnel in all directions, even into the roots.

Symptoms

Wilting of leaves and dead trees or branches. Affected branches are easily broken off. When trees are first infested there maybe evidence of frass (sawdust-like residues) on the ground. The trunk may be ringbarked.

The lifecycle of both pests is completed during the rainy season, but often damage is more evident during the dry season.

Larvae remain inside the tree and are normally not seen. Usually damage is not economically important, although individual trees can be lost.

Control

Preventative:

Less damage occurs under conditions of good shade.

Higher altitude (above 800 m.a.s.l.) seems to reduce the incidence of infestation.

Burn affected trees or branches with borers inside.

Do not plant trees with twisted taproots. These deformed roots result in weak trees that have been shown to have a high incidence of stemborer infestation.

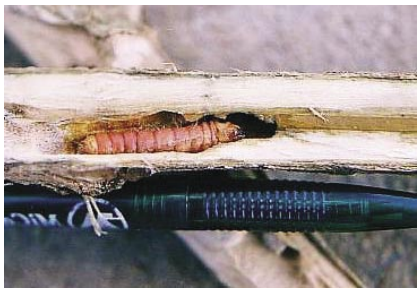
Stemborer damage. Red stemborer (top), white stemborer (centre), general severe damage in a field (bottom)

Chemical:

No effective chemical control known.

Biological control is not known at this time.

White stemborer. Adult (above) and larva (left)



Red stemborer. Adult moth and larva

Coffee berry borer

Coffee berry borer (*Hypothenemus hampei*) is a relativity new, but very serious problem in Lao. It is causing significant damage, with perhaps as high as 50% yield loss. The adult is a small black beetle (about 2.5 mm long) and covered in thick hairs. The female beetle bores into berries through the navel region. Cherries are attacked in various stages but tunnelling and laying of about 15 eggs occurs only in hard beans. The eggs hatch in about 10 days and the larvae feed on the beans making small tunnels. Beetles in the cherries either on the plant or on the ground, can survive for more than five months.

Symptoms

Fruit drop of young, green cherries. A small hole is evident on the cherry. Cherries that do not drop often have defective, damaged beans.

Control

Orchard hygiene (keeping the area clean, removing dropped cherries, removing carry-over fruit from coffee bushes are suggested), but it is reported to have limited impact and can be expensive. Cherries on the ground and old berries remaining on the trees are sources of new infection.

There are few natural enemies of the borer. One wasp (*Phymastichus coffea*) has shown promise in Columbia, but its effectiveness and that of other wasps is not yet fully known. The wasp may make a contribution in an IPM system. Lao should procure this and other effective parasitoids from Cenicafe in Colombia and technical biocontrol support.

Interest is now focused on the commonly found fungus, *Beauverai bassiana*. Research in South America has shown promising results, but it is not a cheap alternative to chemicals and has to be re-applied.

Research is required to develop the best means of bio-control.

Chemical control is difficult as the borer spends most of its life cycle deep inside the coffee berry. Endosulfan 35 EC at a rate of 6 ml/4.5 L of water applied at early fruit set (2 mm cherry size) and later 120 to 150 days after fruit set if required. Cypermetrin and Deltametrin, pyrethroids

Continued...

Coffee bearer borer. Beetle on a bean (top), damage to berries (centre) beetles (bottom)

Continued...Coffee berry borer

(0.01%) at 26 ml/15L of water are an alternative, or Chlorpyrifos used at recommended rate on label.

Quarantine. The pest cannot migrate any distance on its own. Do not allow cherries or coffee bags from other farms onto the farm property. Crop bags should be fumigated before being transported to other coffee growing areas.

Ethyl alcohol and methyl alcohol at a rate of 1:1 is effective in trapping CBB and can be used most effectively at processing/washing places to prevent re-infestation. Place traps in the first five rows of coffee growing near the processing area.

Coating pieces of plastic with axle grease and engine oil and attaching these to pulpers and machines in the coffee processing area can also be used to capture CBB.

Careful drying of coffee cherry or parchment reduces reproduction of the pest as they cannot survive in coffee beans that are properly dried to 12% moisture.

Coffee berry borer trap. There are many ways to make these simple traps

Mealybug

Mealybugs (*Planococcus* spp.) are small sucking insects (about 3 mm long) covered with a white mealy wax that feed on young shoots and young roots. There are several species similar in appearance to the naked eye. They are generally more of a problem in the dry season when water is lacking. However, serious infestations of mealybug 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.

Symptoms

White waxy colonies are usually found on the underside of tender leaves and in soft stem areas around berries. Also, they are found on young roots near the main root, especially where soil is loose around the trunk. Mealybugs are often associated with a heavy infestation of sooty mould.

Control

Biological:

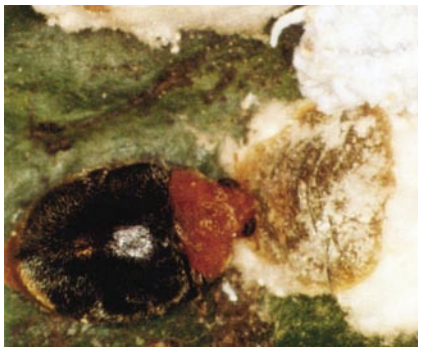
Normally sufficient. In other countries, the most important predator is the mealybug ladybird *Cryptolaemus montrouzieri*. The adults are reddish brown with black wings and about 4 mm long. A parasitic wasp, *Leptmastix dactylopii*, is also very effective. Lacewings such as *Oligochrysa lutea* are also predators of mealybug.

Chemical:

Spray Chlorpyrifos on the soil around the tree to kill ants. Ants disrupt the natural enemies of the mealybug. Malathion and Carbaryl sprays can also be effective. Apply according to label recommendations.

Mealybug. Large white mealybug a leaf

Mealybug. Cherry infestation



***Cryptolaemus montrouzieri*.** Mealybug ladybird adult feeding on scale

Sooty mould. The black mould is often present with mealybugs

Leaf miner

Leaf miner (*Leucoptera coffeina*) is often present, especially in shaded coffee.

Symptoms

Transparent areas in the leaf; larvae are present on the underside of the coffee leaf. Fully-grown larvae are about 6 mm long.

Control

Normally a minor problem with no control warranted.

Leaf miner. Leaf is also distorted

Termites

Termites (*Macrotermes* spp.) can be a problem on older coffee and shade trees with dead wood where termites breed.

Control

Plant coffee in clean ground where all tree parts, including roots have been removed. Termites cannot survive as there is no dead wood on which to feed.

Effective pruning of dead wood on coffee trees.

Remove all dead wood from the coffee plantation.

Permetrin 60 to 80 g/L sprayed on the ground and on base of coffee trees after planting will assist.

Termite attack. Dead wood encourages termites to build nests

Diseases

A number of diseases can affect coffee plants in the nursery as seedlings, in the field while young and later as bearing trees.

Nursery diseases

Coffee seedlings are susceptible to two main diseases in the nursery — Damping-off and Cercospora leaf spot (brown eye spot).

Damping-off

This disease occurs on young coffee seedlings in the germination bed, after germination and before transplanting. It is caused by a *Pythium* spp. fungus.

Damping off. Note the brown, rotting stems

Symptoms

Patches of coffee die quickly.

Coffee stem is soft and rotten.

Causes:

Soil borne fungi.

Soil too wet.

Too much shade (insufficient drying of soil).

High planting density (too many plants in a small area).

Continued...

Continued: Damping-off

Control

Preventative:

Don't use old soil from nursery beds or bags as disease is soil borne and can be carried over. Use new soil for nursery beds and potting-up.

Avoid over-watering.

Do not plant seed too close; seeds should be 25 mm apart in rows 100 mm apart.

Chemical control:

Soil drenches of either Benlate (Benomyl) or Captan (Follow label directions as formulations differ).

Seed planting. Do not plant seed too close

Cercospora leaf spot (brown eye spot)

Cercospora leaf spot is a fungus that occurs on leaves when plants are under stress. The fungus can develop both in seedbeds and after plants have been transplanted into bags. It is the most common nursery disease and a sign of poor management.

Close-up. Nursery plants affected with Cercospora

Symptoms

Brown spots on leaves gradually expanding with reddish brown margin.

Spots on both sides of the leaf.

When there are many spots, leaves appear to have been burnt.

Causes

Soil too wet.

Too much shade or too much sun.

Lack of air movement.

Lack of nitrogen and potassium.

Control

Preventative:

Avoid over-watering.

Maintain 50% shade cover.

Space plant bags to allow air movement.

Proper fertiliser application (refer section on nursery management).

Chemical:

Copper sprays such as the following will give control:

Copper Cupravit (85% WP)	80 g/20 L water
Copper oxychloride	80 g/20 L water
Copper hydroxide	40 g/20 L water

Field diseases and disorders

There are several field diseases and disorders affecting leaves and berries. Diseases include Cercospora leaf spot (all ages of coffee); coffee leaf rust (all ages but more on bearing coffee); black sooty mould (all ages) and Anthracnose (more prevalent on bearing coffee). The severe disorder, overbearing dieback, occurs on bearing coffee.

Cercospora. Affected berries (top) and leaves (bottom)

Cercospora (berry blotch & brown eye spot)

This occurs on the leaf but can also occur on berries where it is known as berry blotch.

Symptoms

Brown spots on leaves gradually expanding with reddish brown margin.

Spots on both sides of the leaf.

Brown sunken lesion on green berries surrounded by a bright red ring (berry blotch).

Causes

Low leaf nitrogen and potassium.

Insufficient shade.

Stress from drought, sun exposure, poor fertiliser management, excessive weed competition.

Control

Preventative:

Maintain well-fertilised plants with 50% shade cover.

Chemical:

Should not be needed with good management.

Copper sprays such as the following will give control in severe cases on isolated plants:

Copper Cupravit (85% WP)	80 g/20 L water
Copper oxychloride	80 g/20 L water
Copper hydroxide	40 g/20 L water

Coffee leaf rust

Coffee leaf rust (*Hemileia vatatrix*) occurs on leaves and can cause leaf drop if severe.

Rust spots. Early symptoms (top) and more advanced disease (bottom)

Symptoms

The first symptom is the formation of pale yellow spots up to 3 mm in diameter on the underside of the leaves.

As the spots expand, they become powdery and yellow to orange in colour and may reach 20 mm in diameter. Occasionally the whole leaf becomes covered with rust spots.

Older rust spores become brown at the centre surrounded by powdery orange spots.

Leaf drop occurs, which if severe, can lead to dieback and berry loss and a loss of both yield and quality.

Berries tend to be very small, not fully ripe and turn black.

Causes

Variety: Catimor is rust resistant. Java, Typica and many other Arabicas are susceptible under poorly shaded conditions and at altitudes of less than 1000 m.a.s.l.

Plant health: Healthy plants are less susceptible.

Continued …

Continued coffee leaf rust

Control

Preventive:

Plant Catimor selections or other more tolerant varieties such as good selections of S 795.

Follow the recommended nutrition programme.

Plant pure Arabica at high elevation only and always use good shade.

Chemical:

Monthly copper sprays (May to October). See label directions for rates.

Leaf rust. Advanced symptom

Sooty mould

Sooty mould (*Capnodium* spp.) develops when the plant is infested with scale, mealybugs, aphids or other sucking insects.

Symptoms

Leaves covered with black, powdery soot.

The fungus grows on honeydew produced by green coffee scale and sucking insects. Ants care for the scales and spread the sooty mould.

Control

Preventative:

Reduce levels of coffee scale, aphids and mealybugs by using recommended control procedures.

Chemical:

Not needed if sucking insects are controlled. Control the insects, not the disease.

Twig dieback. Note the brown stems

Anthracnose

Anthracnose (*Colletotrichum gloeosporioides* Penz.) is a minor flower, twig and cherry disease. It can cause three different coffee diseases — twig dieback, brown blight of ripening cherries and leaf necrosis.

Symptoms

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.

Control

Maintain healthy coffee plants.

Other control measures are not warranted.

Brown blight. Note the brown sunken lesions on berries

Overbearing or dieback

Not a true disease but a physiological problem.

Symptoms

Severe leaf loss and branch dieback.

Root dieback.

Cherries ripen prematurely and become hard and black.

Dieback causes alternating bearing (heavy crop one year and poor crop the next).

Plants decline and eventually die if the problem is not corrected in early stages.

Note

Coffee needs one leaf pair to support five to six berries through to maturity.

If there are too many cherries and not enough leaves, all the food goes from the leaf to the developing cherry. Leaves then drop off, causing dieback. Some varieties, especially dwarf Catimors, are more susceptible to this condition. Loss of leaf depletes plant carbohydrate reserves resulting in weakened plants.

Roots also die back, then the tree cannot take up enough nutrients and water, thus more leaves are lost and cherry quality is reduced.

Plant health decline continues and if plants are not well cared for with adequate watering and nutrients, the plants will succumb and die.

Overbearing. Plant cannot support the extremely heavy crop

Dieback. Note the dieback in tips and lack of leaves on stems

Causes

Insufficient nutrition.

Insufficient shade.

Insufficient irrigation.

Variety

Dwarf Catimors are much more susceptible.

Control

Preventative:

Once the problem exists it is very hard to break the cycle if it is left too long.

Maintain good plant health.

Maintain good shade (50%).

Plant only recommended varieties.

Use a well-balanced fertiliser programme and apply adequate nitrogen and potassium as recommended earlier.

Dieback. Whole plant affected through the roots; healthy plant (left) diseased plant (right)

Chapter 10

Natural enemies and IPM

Wolf spider

Lynx spider

Tachinid fly. Adult attacking a caterpillar

Natural enemies and IPM

Integrated pest management (IPM) uses natural predator insects and or diseases to control many problem insects. The full range and degree of activity of predators in Lao coffee is not yet known. Preliminary surveys have indicated the presence of a number of predators with spiders being the most common.

There is no set procedure for IPM, but a critical first step is switching from scheduled sprays to strategic sprays based on crop monitoring results. IPM can appear to be a higher risk and more complex way of managing pests and diseases. However, if done well, it can effectively cut costs and reduce damage to the environment and bio-diversity by overuse of chemicals

Main predators

Spiders

Wolf spiders (*Lycosa* spp.) are common soil predators, whereas flower spiders, lynx spiders (*Oxyopes* spp.), jumping spiders, orb weavers (*Agriope calenulta*) and many others are active predators in plant canopies. Spiders will prey on most insects including moth and butterfly eggs, small and large caterpillars and aphids. It is common for a crop grown with minimal or no sprays to have a spider's web on almost every plant.

Dwarf spider (*Atpena* spp.) Dwarf spiders are dark-coloured and tiny (less than 2 mm long), prey on mites and small insects. They are active during the day and make sheet or dome shaped webs on leaf and soil surfaces.

Harvestmen (*Phalangida*) is a spider-like insect.

Tachinid fly

Tachinid flies (*Argyrophylax nigrotibialis*) are grey-black and slightly bigger than a housefly. They lay their eggs either on foliage on which caterpillars feed, or directly into the body of the caterpillar. The fly larva bores into the caterpillar and attaches to the skin, leaving a breathing hole. The larva then grows inside the caterpillar, eventually killing it and forming a brown, oval pupal case from which the adult fly emerges.

Braconid wasp

Braconid wasps (*Apanteles* spp.) grow up to 12 mm in length. They parasitize a broad range of hosts: caterpillars, flies, wasps, beetles and aphids. After a female injects an egg into a host, the larva feeds slowly on that single host. When the host dies, the fully grown larva pupates inside or near the dead host, sometimes in a silken cocoon, to emerge later as an adult wasp.

Apanteles. Cocoons attached to dead host

Other predators

These predators are seen in small numbers.

Praying mantis

The Carolina mantid (*Stagmomantis carolina*) grows to about 4 to 7 cm in length with a large head and abdomen. The body color is a tannish-brown with light green wings.They have a pair of large forelegs that are serrated and spiny and folded back like a pocket knife.

Lacewings

Lacewing (*Chrysopa* spp.) species include the brown (*Micromus* spp.) and the green (*Mallada* spp.) lacewings The larvae are predators especially of aphids. The brown lacewing adult has brown wings and larvae are brown with white markings. Eggs are laid singly on leaves. Green lacewing adults are slightly larger than brown lacewing adults. Eggs are laid on stalks attached to the plant. Green lacewing larvae are squat and pale brown and they camouflage themselves with the carcasses of their prey.

Damsel bug

The damsel bug (*Nabis kinbergii*), preys on soft-bodied insects such as aphids, jassids, caterpillars and moth and butterfly eggs. Damsel bugs are brown, thin and up to 10 mm long.

Stick insect

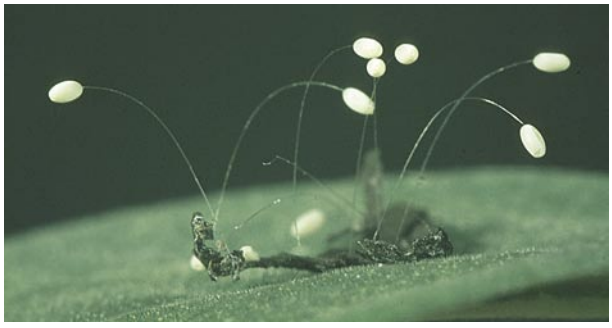
Walking-stick insects (*Pseudophasma* spp.) are among the largest insects in the world reaching over 30 cm long. Most stick insects are tropical and nocturnal. During the day, many of them lie dormant surrounded by the sticks and leaves they resemble.

Damsel bug adult

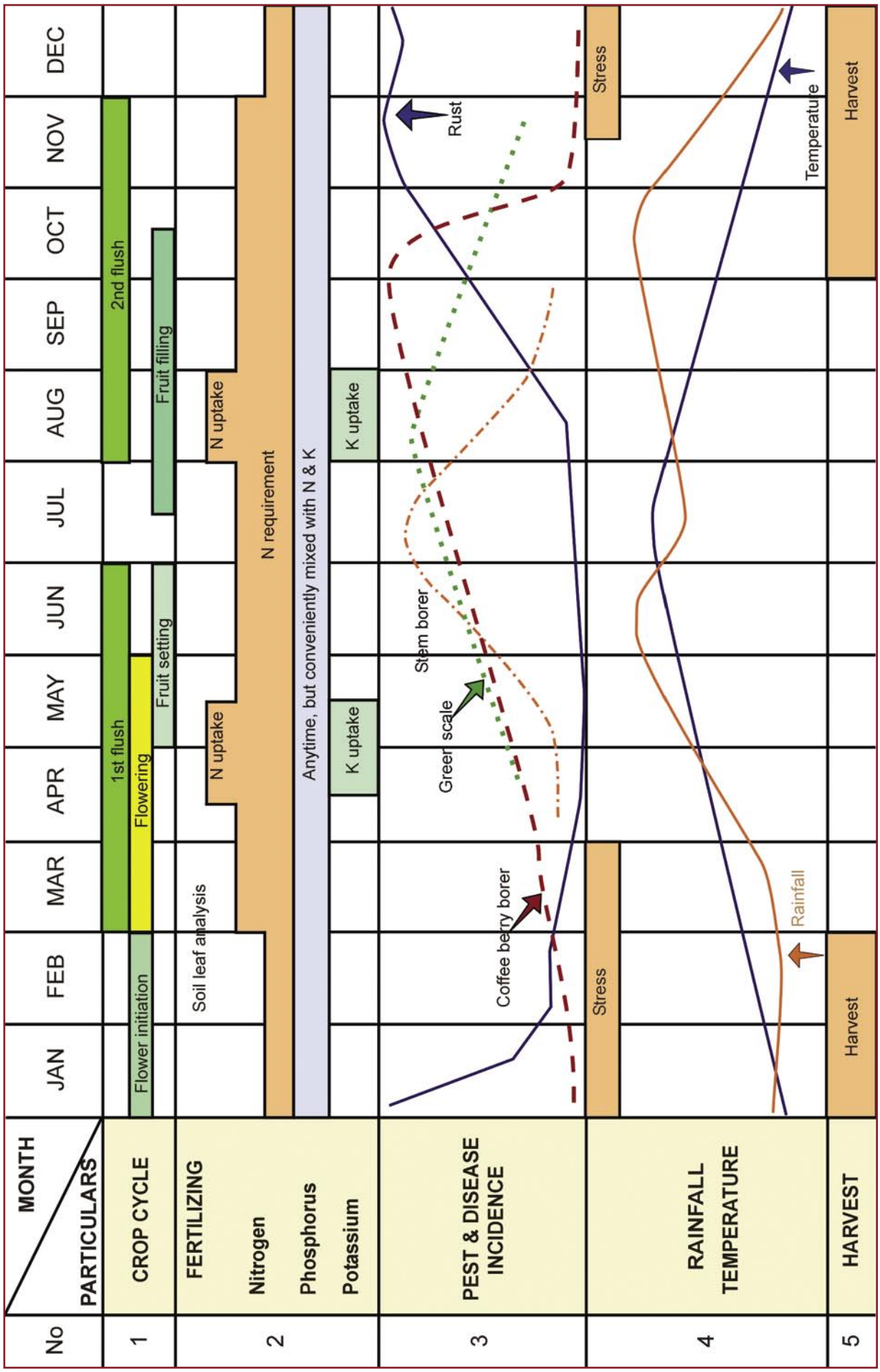
Brown lacewing. Adult lacewing (top), larva (left) and aphids

Green lacewing. Larva camouflaged with frass (left) and adult (below)

Green lacewing eggs



Crop/Phenological cycle for Arabica coffee in Lao



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