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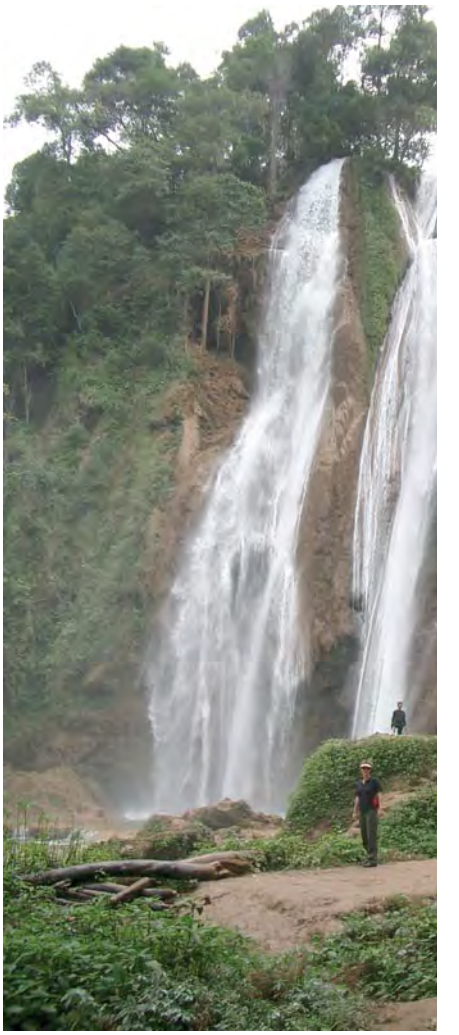
Authors

Edward Winston, Jacques Op de Laak
Tony Marsh, Herbert Lempke
Okkar Aung, Thaung Nyunt
Keith Chapman

FAO Regional Office for Asia and the Pacific, Bangkok
Food and Agriculture Organization of the United Nations



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FAO Regional Office for Asia and the Pacific
39 Phra Artit Road
Banglamphu
Bangkok 10200 Thailand

Tel: 66-2-6974000 Fax: 66-2-6974445

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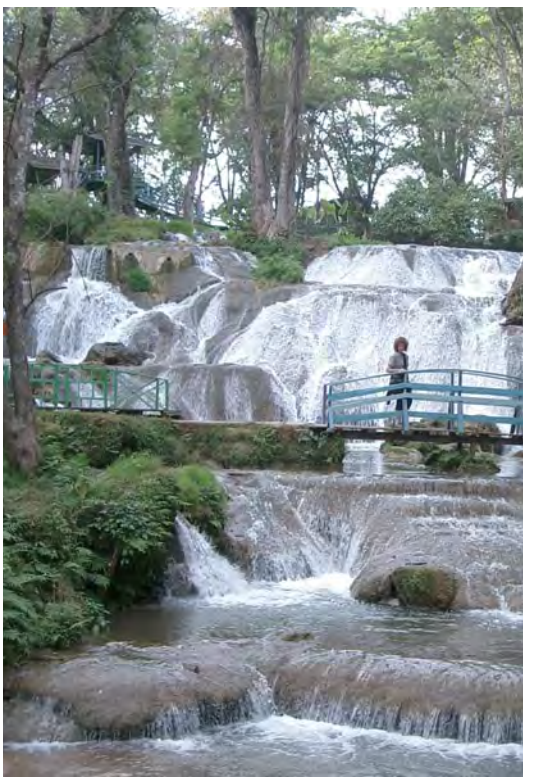

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Preface

This Arabica coffee manual for Myanmar is an activity under a FAO Technical Cooperation Program coffee project for Myanmar and has been prepared as a support base for training trainers and staff of the Coffee Research Information Extension and Training Centre (CRIETC) of Myanmar Farm Enterprises (MFE) of Ministry of Agriculture and Irrigation at Pyin Oo Lwin.

The manual has been compiled by Ted Winston, Jacques Op de Laak, Tony Marsh and Herbert Lempke (International Consultants), Keith Chapman (Industrial Crops Officer, FAO Regional Office for Asia and the Pacific) in collaboration with Thaung Nyunt (MFE and FAO National Project Director) and Okkar Aung (Director) and the staff of CRIETC.

The manual provides key information through consistent technical messages essential for high quality coffee production , processing and marketing and is intended to be a primary source of practical knowledge on Good Agricultural Practices (GAP). It is hoped that farmers, managers of coffee plantations and investors in the Arabica coffee industry will benefit greatly from this information.

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

Keith Chapman
Industrial Crops Officer
FAO Regional Office for Asia and the Pacific
Bangkok, Thailand

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

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Training farmers and entrepreneurs

Official opening of upgraded CRIETC

The CRIETC team

Training the trainers

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Doing the 'hard yards' – Jacques, Tony, Keith and Ted (below)

Field day for farmers organised by CRIETC

Chapter 1

Coffee plant & site selection

History of coffee in Myanmar

Missionaries initiated coffee growing in Myanmar in 1885, as reported by the Agriculture Burma Office in 1940. Initially, in Mergui (Myeik) and Tavoy (Dawe), two coffee experiment farms were established by the Department of Forestry, but these were terminated within a few years. Kayin State (Nancho area) also established coffee farms at the same time. Separately, Karen tribesmen developed and produced Robusta coffee, which still continues to the present day.

Roman Catholic missionaries introduced Arabica coffee in 1930 to Southern Shan State, Northern Shan State and in Pyin Oo Lwin (Maymyo). All of these areas still produce Arabica coffee today. From 1930 to 1934 a large, 120-acre, Arabica coffee plantation called 'Chaungwe,' was established at Naung Cho Township of Northern Shan State, and is still producing commercial coffee to this day. By 1935/36, the total Myanmar coffee production was 268 tons with imports of 175 tons. Roasted ground coffee production was 108 tons.

From 1932 to 1936, Myanmar exported a total of 95 tons of coffee; 60% was exported to the Madras Presidency in India, 31% to other parts of India, about 7% to the UK and the rest to other countries. In 1952, the same Chaungwe group established 60 acres of Arabica coffee (mainly the S 795 variety), near Pyin Oo Lwin in Mandalay Division. These plantings remain until the present day.

From 1968 to 1994, Industry Ministry 1 managed the coffee state farms, largely the Chaungwe, Pyin Oo Lwin, Pwe Daung and Banbwe farms, which were taken from the private sector. In 1971 the total coffee area was 6379 acres and production was 859 MT. In December 1994 the state coffee industry was handed over to Myanmar Farm Enterprises (MFE), where it remains to the present day.

In 1987, the United Nations Drug Abuse Control Programme (UNDCP) supported a coffee project as a drug replacement programme, in Southern and Northern Shan States. While the programme was largely unsuccessful, many households still have 10 to 20 coffee trees surviving today. Again, most are of the S 795 variety. Good quality coffee is still sourced from these households today, but yields are low and many coffee bushes suffer from coffee leaf rust and are not well cared for.

In the late 1980s, the Government of Myanmar (GOM) commenced a major nation-wide coffee planting programme. New varieties were

In collaboration with CRIETC, the FAO Technical Co-operation Project that is responsible for production of this manual, is targeting some key aspects of this research, development and extension process.

introduced from Costa Rica, with three tons of Catimor and Catuai seed imported in 1986. GOM increased this expansion of Arabica coffee plantings by tripling annual targets to facilitate the eradication of opium poppy growing. There was a three-phase campaign — first phase 1975 to 1981, the second 1981 to 1986, and the third 1986 to 1991. By 1984/85 the coffee growing area was about 10,000 acres with 86% consumed domestically and the balance exported. During 1977 to 1985, the average annual production was 1146 MT. By 1986, production had risen to 1417 MT from 10,100 acres.

The production area in 2003/4 totalled 35,485 acres. Many coffee plantings were still young as coffee was promoted by GOM in the past five years. In 2003/4. Actual production was 3380 MT from 15,351 acres.

Northern Myanmar (Shan States, Mandalay Division, Chin State, Kachin State, Kayin State, Bogo Division, Rakhine State, Mon State) have the potential to produce large amounts of high quality Arabica coffee by virtue of their good quality, red soil plateaus and other suitable soils, at elevations above 3300 ft (1000 m), with well distributed rainfall of 59 to 79 inches (1500 to 2500 mm) and a distinctive, essential dry season. Areas with these requirements are found at approximately latitude 20° to 24°N. For farmers in remote areas, coffee is an ideal crop which, when well-cared for, produces a good income, and because the coffee is largely non-perishable and robust, it transports easily without damage.

Coffee may also be planted on sloping lands with terraces or grass strips and contour planting. When grown under shade it is sustainable over long periods even with low inputs. Some of the earliest plantings of S 795 variety in Myanmar grown under *Grevillea robusta* shade trees, are still capable of producing reasonable yields with low inputs after 75 years.

In 2004, the GOM Heads of State laid down a strategy to extend cultivated areas of Arabica coffee up to 100,000 acres. Suitable areas of 50,000 acres in Mandalay Division (around Pyin Oo Lwin) and Northern Shan State (around Naungcho) were selected. The projections were for 20,000 acres to be planted in 2004/05, 40,000 acres in 2005/06 and 40,000 acres in 2006/07. At the end of 2004/05, the total planting of coffee was 35,485 acres and the plan was revised in 2005 (see the table on page 80). Besides the planned areas for Northern Shan and Mandalay Division, four large private companies plan to extend coffee planting over 30,000 acres in Southern Shan State (Yaksauk and Indaw/Kyakgu areas).

Upgrading. FAO has assisted CRIETC with upgrading the centre

To support these privatisation expansions, largely by smallholders and larger investors, GOM via MFE offer the following:

- Land settlement concessions over 25 year leases at US$18/acre.
- Technical support information via extension and support from the newly upgraded Coffee Research Information Extension and Training Centre (CRIETC), established near Pyin Oo Lwin with FAO help via a Technical Cooperation Project TCP/MYA/2903 over the period 2003 to 2005.
- Coffee and shade tree seedlings.
- Loans to assist farm establishment.

- Assistance with land preparation/clearing and water supply.
- Assistance with fertilisers and fuel via subsidy.

Some of the larger areas planted in the last three to four years did not follow MFE advice, and have failed because low inputs were used, poor quality Catimor varieties from China and elsewhere were planted and no established shade was provided. All coffee should be planted under shade with only the recommended varieties for given locations.

Myanmar is now at a cross-roads in the coffee expansion programme. However, with the recent, very significant injection of better production technologies, varieties and new processing methods well supported by research, information extension and training from CRIETC and vastly improved world coffee prices, Myanmar is well placed to capitalise on the production of high quality Arabicas for the world market. Recent support from FAO to CRIETC and assistance with marketing, a strategic vision for the industry, and steps to create a Myanmar Coffee Association and coffee quality standards for export, will help ensure success.

Updated real costings for establishment of new coffee plantings and cash flows as the crop grows are provided in this manual (see Chapter 12) to assist the development process by providing potential planters with good data on which to base business plans for investment. Data will be out of date after two to three years, but will provide a basis for re-calculations as a future guide for costings, cash flows and calculating rates of return on investment.

Factors affecting yield and quality

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

- Genetics (genotype-species and varieties to plant)
- Environment (site selection)
- The coffee plant and its management

Genetics (Genotype)

There are two main species of commercial coffee — *Coffea arabica* and *Coffea canephora* (robusta) and two minor 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 3300 feet (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 quality of instant coffee. Brazil and Columbia are the major producing countries.

Robusta is lower quality and prices are normally about 30 to 40% less than Arabica. Robusta is normally grown in warmer areas at lower elevations, up to approximately 3300 feet (1000 m). Robusta is used mainly in instant coffee. Vietnam, Brazil and Indonesia are the largest Robusta producing countries. Compared with Arabica, Robusta is generally more vigorous, more productive and considered resistant/tolerant to leaf 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 commercial significance in the international coffee market.

Excelsia

Coffea congensis

Caturra red

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;
- outstanding cup quality.

Varieties to plant

Coffee is a long-term crop with a lifespan of more than 10 years, and very much longer under good management, thus the choice of variety (cultivar) is very important. As quality of the coffee bean is important, 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 Northern Shan State, Southern Shan State and Mandalay division, the recommended Arabica varieties are:

- High elevation: above 3300 feet (1000 m) S 795 and Catimor
- Low elevation: 2600 to 3300 feet (800 to 1000 m) Catimor

There are a number of Catimor varieties in Myanmar, however many are not true Catimors and should not be planted. The preferred Catimor selections at present are:

- Costa Rica (T 5175 and T 8667 lines) and
- H 528 (red line, not the yellow line)

Other varieties are being tested by CRIETC at Pyin Oo Lwin and Banbwe. CRIETC will advise in the future which are suitable for planting after trials and cupping tests are completed. Varieties introduced and being held at CRIETC include:

S 795 (existing standard)
SL 28
SL 34
SL 6
SL 14
Caturra red
K7
Catuai red
Blue Mountain
Mundo Novo
Catimor H 528
Catimor H 528/46
Catimor H 420/9

Catimor P 86
Catimor P 88
Catimor P 90
Catimor H 306
Catimor C 1669
Catimor LC 1662
Catimor T 8667
Catimor T5175

Other varieties that should be considered are Java and improved S 795 (from E. Java, Indonesia), Hibrido de Timor and Bourbon.

Variety descriptions

S 795

Origin:	A long established variety in Myanmar. Selection from Balehonnur coffee station in India. 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 can be tolerant if constantly selected as has been done in Indonesia. Tolerance comes from Liberica genes which often convey more persistent tolerance to rust than genes from Robusta, as found in Catimors.
Cupping quality:	Excellent.
Comment:	Does not exhibit any Liberica characteristics.

SL 28

Origin:	Bourbon selection from Kenya. Introduced 2004.
Growth habit:	Tall, upright and open.
Yield:	Moderate to good.
Rust resistance:	Very susceptible.
Cupping quality:	Good.
Comment:	Large bean size, drought tolerant.

SL 34

Origin:	Kenya – a French Mission selection. Some present at Banbwe; re-introduced in 2004.
Growth habit:	Tall, upright and open.
Yield:	Moderate to good.
Rust resistance:	Very susceptible.
Cupping quality:	Good.
Comment:	Large bean size, drought tolerant.

SL 6

Origin:	Kenya – introduced 2004.
Growth habit:	Tall, upright and open.
Yield:	Moderate to good.
Rust resistance:	Resistance to Race II rust.
Cupping quality:	Good.
Comment:	Large bean size.

SL 14

Origin:	Kenya – introduced 2004.
Growth habit:	Tall, upright and open.
Yield:	Moderate.
Rust resistance:	Very susceptible.
Cupping quality:	Fair to good.
Comment:	Large bean size.

Caturra

Origin:	Bourbon mutant from Brazil. Introduced in the 1950s to Myanmar.
Growth habit:	Semi dwarf, dense.
Yield:	Good.
Rust resistance:	Very susceptible.
Cupping quality:	Fair.
Comment:	Both red and yellow types exist, dieback problems if management is poor.

Typica

K 7

Origin:	Kenya – a French Mission selection, and a derivative of Kent. Introduced 2004.
Growth habit:	Tall, spreading.
Yield:	Good.
Rust resistance:	Reported resistant to Race II rust.
Cupping quality:	Good.
Comment:	Large bean size.

Catuai

Origin:	Introduced in 2004. Cross between Caturra and Mundo Novo.
Growth habit:	Semi dwarf, dense.
Yield:	Very high.
Rust resistance:	Very susceptible.
Cupping quality:	Good. Good bean size.
Comment:	Later maturing. Tolerates poor management.

Blue Mountain

Origin:	Originally from Amsterdam – progeny eventually taken to the Blue Mountains, Jamaica in 1730.
Growth habit:	Tall and open.
Yield:	Moderate to good.
Rust resistance:	Very susceptible.
Cupping quality:	Very good.
Comment:	Suitable to higher and colder situations; degree of resistance to coffee berry disease (*Colletotrichum coffaenum*).

Mundo Novo

Origin:	Cross between Typica (Sumatra) and Bourbon Vermelho (Brazil) in 1943.
Growth habit:	Very vigorous; tall and open.
Yield:	Very good.
Rust resistance:	Susceptible.
Cupping quality:	Good.
Comment:	Bold, large bean size.

Java

Origin:	Not known.
Growth habit:	Upright, open; medium vigour.
Yield:	Moderate.
Rust resistance:	Medium.
Cupping quality:	Very good.
Comment:	Very long narrow bean.

Hibrido de Timor

Origin:	From cross between C. *arabica* and C. *canephora*, discovered in 1927 in East Timor.
Growth habit:	Very tall; strong root system.
Yield:	Low; highly variable with large amount of abnormal beans.
Rust resistance:	Good.
Cupping quality:	Poor.
Comment:	Hardy; will tolerate drought. Resistant to coffee berry disease (*Colletotrichum coffaenum*).

Variety collections. CRIETC (above and right)

Bourbon

Origin:	Originally from the Ethiopian highlands, it was taken to the island of Bourbon (Reunion) in 1718. Via Latin America, the progeny reached Kenya and Uganda about 1900.
Growth habit:	Compact, upright branches
Yield:	Medium to high.
Rust resistance:	Very resistant to all races of leaf rust.
Cupping quality:	Very good – better than Typica.
Comment:	More hardy than Typica.

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. Catimors of various types and origins have been introduced to Myanmar in recent years. Improved types were introduced 2004.
Growth habit:	Semi dwarf compact.
Yield:	Very high with correct management. Low yield and will die with 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 the 1970s to 1990s, there has been a concerted international effort to develop Catimor due to its rust resistance.

Both the government and private sectors have encouraged the planting of Catimor due to potentially high yield and rust resistance. There are already a number of Catimor 'selections' (Costa Rica, Vietnam, Yunnan, 7963 and Laos) planted in Myanmar. The true identity of some existing Catimors is in doubt. True Catimors do not show coffee rust, however, the Yunnan Catimor in particular, does have rust.

A disadvantage is 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 Myanmar. Catimors currently being evaluated at CRIETC include the following:

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.

Continued …

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 need to 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 3300 feet (1000 m) above sea level is required for Arabica coffee. Low elevation Arabica coffee does not possess the quality required by the world markets. In Myanmar, based on cup tests, areas above 3300 feet should be selected at the present time when there is plenty of good land available. For premium coffee, areas above 4265 ft (1300 m) clearly produce superior quality coffee.

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 between large and 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 68° to 75°F (20° to 24°C). The average mean temperatures for Pyin Oo Lwin and Banbwe in Myanmar (Figure 1) are:

Pyin Oo Lwin	67.5°F (19.7°C)
Banbwe	72.3°F (22.4°C) 1.5 years data only

Temperatures greater than 86°F (30°C) cause plant stress leading to a cessation of photosynthesis. Mean temperatures of less than 59°F (15°C), limit plant growth and are considered suboptimal. As Arabica coffee is susceptible to frost damage, use of shade trees will reduce the incidence.

Rainfall and water supply

Ideal rainfall for Arabica coffee is greater than 47 to 60 inches (1200 to 1500 mm) per year. Both the total amount and the distribution pattern are important. Annual rainfall at Pyin Oo Lwin and Banbwe (Figure 2) is:

Pyin Oo Lwin 3600 ft (1100 m)	55 inches (1400 mm)
Banbwe 2427 ft (740 m)	52 inches (1300 mm)

There is limited information for rainfall figures over a number of years and perhaps rainfall is lower than this over a longer period. Rain should be uniformly distributed over seven to nine months of the year. The period of good rainfall is only about six months in Pyin Oo Lwin and Banbwe with sizeable differences between years. Both areas would benefit from supplemental irrigation to correct this deficiency. The years 2001 to 2003 have had good rainfall compared to earlier years.

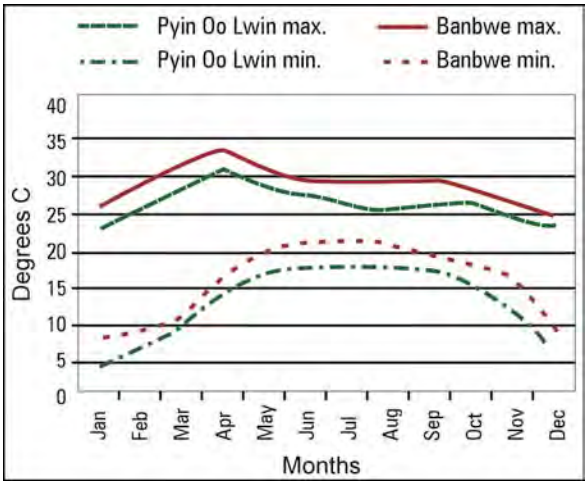


Figure 1. Mean monthly temperatures in Pyin Oo Lwin and Banbwe

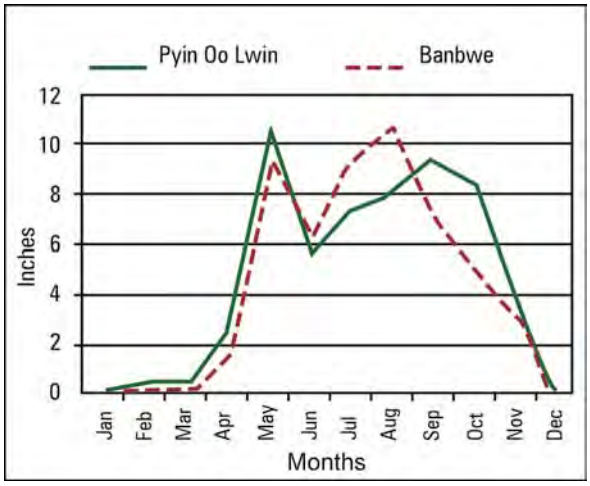


Figure 2. Mean monthly rainfall in Pyin Oo Lwin and Banbwe

Coffee needs a dry stress period with little or no rain to induce a uniform flowering. Without this stress period, flowering many extend over many months making harvesting more difficult. Myanmar coffee areas clearly have a cool, dry stress period.

Soil type

For successful production, a free draining soil with a minimum depth of 3 feet (1 m) 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 deep, sandy loam. Avoid heavy clay or poor-draining soils. Many soils in Northern Shan, Southern Shan, Mandalay Division, Chin and Kachin are suitable.

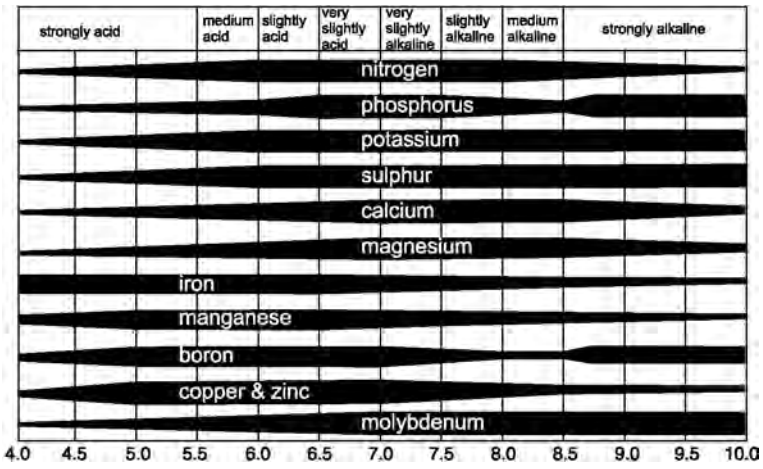


Figure 3. Effect of soil pH on nutrient availability

Coffee prefers a soil with pH of 5 to 6. Soils checked near Pyin Oo Lwin 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 (see Figure 3). Good management includes applications of dolomite or lime which can alter and improve soil pH and fertility. Most soil types need extra applications of major and minor elements at some stage through the growth cycle; these elements can be found in natural manures and compost or fertiliser.

Slope and aspect (slope % and direction)

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

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

See page 28 for establishing contour strips and contours using an A-frame for marking contours

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 be avoided, or windbreaks such as Silver Oak (*Grevillea robusta*) well-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 90). 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 newly planted trees should be irrigated (or hand watered at least twice a week if irrigation is not available) to ensure establishment. 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 suitable, well-established shade trees and mulch. These practices are discussed in later chapters.

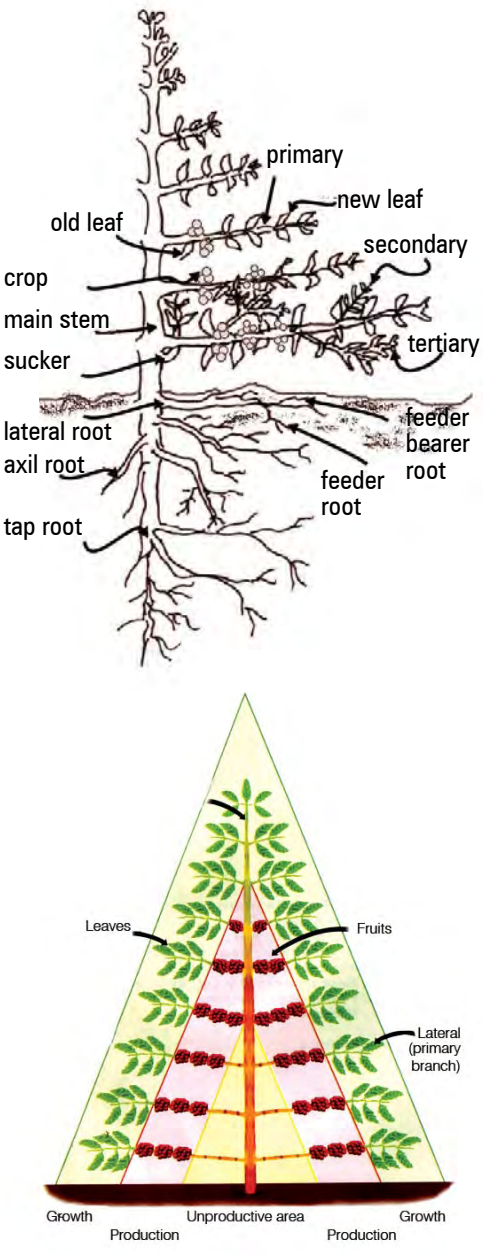


Figure 4. Diagrams showing parts of the coffee plant (top) and tree habit (bottom)

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 this manual deals with practical management of the coffee tree from planting to harvest.

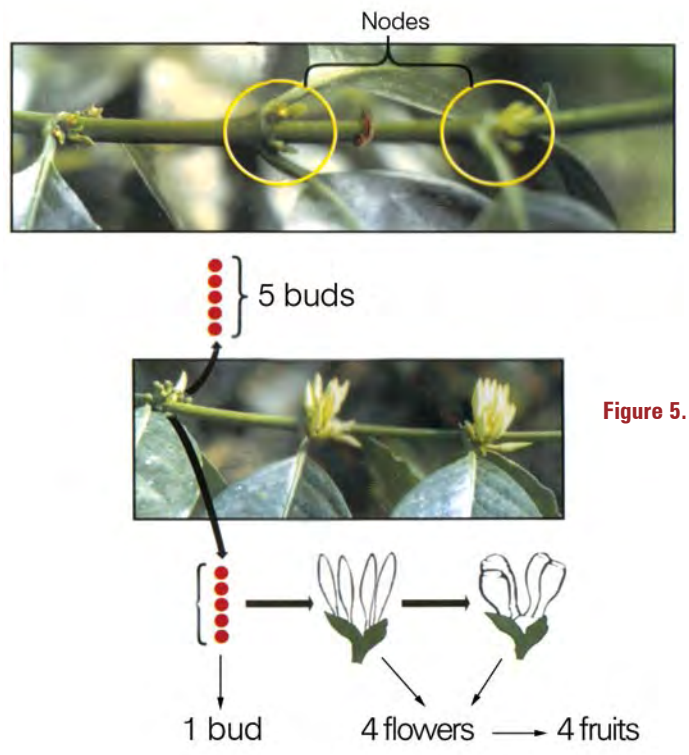
The shape of the coffee plant varies depending on the species and variety. All coffee trees consist of an upright main shoot (trunk) with primary, secondary and tertiary lateral branches. The plant has a main taproot, lateral and small feeder roots (see Figure 4). The coffee tree produces two distinct 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 $^{3}/_{8}$ to $^{5}/_{8}$ inch (10 to 15mm) 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).



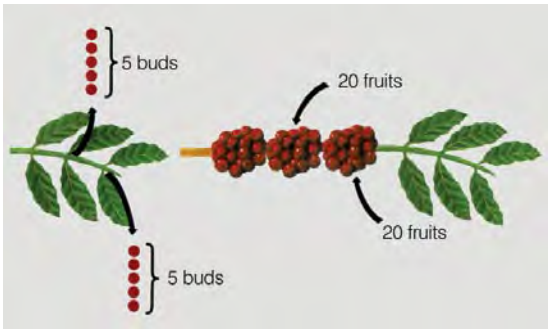


Figure 5. Potential of yields (left and diagram above)

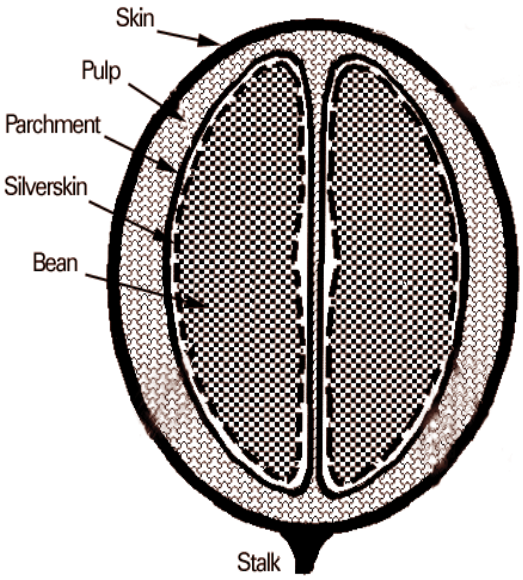


Figure 6. Coffee cherries from green to ripe (above) and diagram showing parts of the cherry (right)

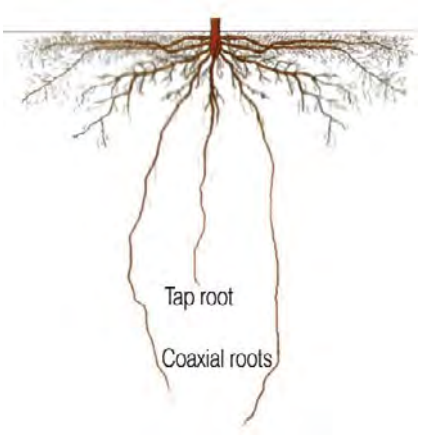


Figure 7. Root system

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 16 to 23 inches (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 12 inch (30 cm) humus-bearing layer.

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 and it is vital that plants are well supplied with nitrogen, phosphorous, calcium, magnesium and sulphur.

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 changes from vegetative — root and shoot growth, to reproductive growth — where it flowers, sets and matures fruit to harvest then begins re-growth for the next cycle.

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

The phenological cycle and field management charts on pages 90 and 91 indicate the timings for key management activities for various development stages of the coffee plant

Chapter 2

Nursery practices

Starting the nursery

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, for example, in a refridgerator.

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 overnight, 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 and silverskin still in place. It is **not** green bean from which parchment hull and silverskin has been removed.

Keep records

It is very important to keep good records of nursery operations; these will help to avoid confusion and problems arising from mis-management. The nursery record book stores the information of individual plantings of seed. The calendar for nursery management forms a useful wall chart/check list for coffee farmers on nursery activity timing and should be photocopied for this purpose, along with the nursery record book.

Nursery record book

Record the information for each new plot or shade tree planted. This page can be photocopied for use.

	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			

No.	Activity		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	Select trees for seed									*	*	*	*	*
2	Collect seed		**	**										*
3	Prepare seed nursery													
	(a)	Select site for seed beds	**	**										*
	(b)	Prepare guards and soil for seed beds	**	**										*
4	Sow coffee seed		**	**	**									*
5	Prepare seedling nursery													
	(a)	Establish nursery canopy		**	**									
	(b)	Prepare bags for transplanting			**	**								
6	Transplant seedlings				**	**	**							
7	Seedling maintenance													
	(a)	Weeding	***	***	***	***	***	**	**	**	**	**	**	**
	(b)	Apply foliar fertiliser	***	***	***	***	***	**	**	**	**	**	**	**
	(c)	Watering	***	***	***	***	***						**	**
	(d)	Spray for insect & disease	***	***	***	***	***	**	**	**	**	**	**	**
	(e)	Harden-off seedling before planting out					***	***	***					

(a) Year before * (b) This year ** (c) Next year ***

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 by sowing the seed in December in Myanmar.

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 1300 to 1800 seeds/lb (3000 to 4000 seeds/kg). The recommended planting density is 1360 plants/acre (3360 plants/ha) at a spacing of 8 x 4 ft (2.4 x 1.2 m). To calculate the area for a nursery you need to know:

- the area to be planted;
- plant spacing;
- the number of plants per acre (ha);
- how many seeds per lb (kg);
- the germination percentage of the seed.

Calculate area for seedbed, for example: To plant 1 acre of coffee at a spacing of 8 x 4 ft (2.4 x 1.2 m)

Number of plants: 1360 plants/acre (43,560 ft^2 or 8 x 4 ft)

Germination: 1500 seeds/lb with 75% germination

Therefore you need: 100 x 1360 ÷ 75 = 1800 seeds

Sow seeds in beds 3 ft wide with 1 inch between seeds and 4 inches between rows (36 seeds per 3 ft row)

Therefore you need: 1800 seeds ÷ 36 seeds/row = 50 rows

Rows are 4 inches apart. Therefore you need 50 rows at 4 inches apart. to make a nursery bed 17 ft long (5.1 m) and 3 ft (90 cm) wide.

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

Build the nursery shelter and 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. Figure 10 illustrates the stages of coffee seedling development.

Construct a shade house with timber poles and a roof about 6 ft (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.

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 30 inches (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 8 inches (20 cm) high and 3 ft (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 0.5 inch (12 mm) deep across the bed and 4 inches (100 mm) apart.
- Plant seed flat side down, with seeds 1 inch (25 mm) apart within the row (Figure 9).
- Cover seed with soil mixture to level the seedbed — seed should be about 0.5 inch (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.

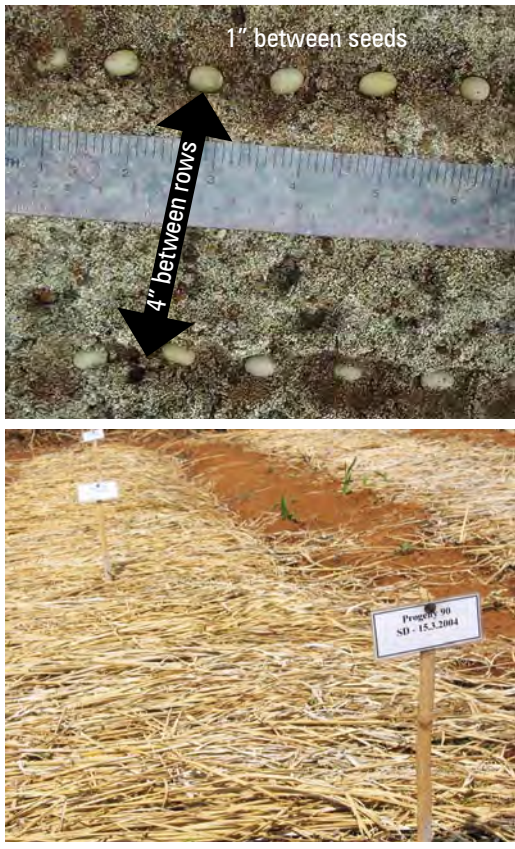


Figure 9. Planting the seed (top) and covering with mulch (bottom photograph)

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 Figure 10 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 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 1 to 2 inches (25 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.

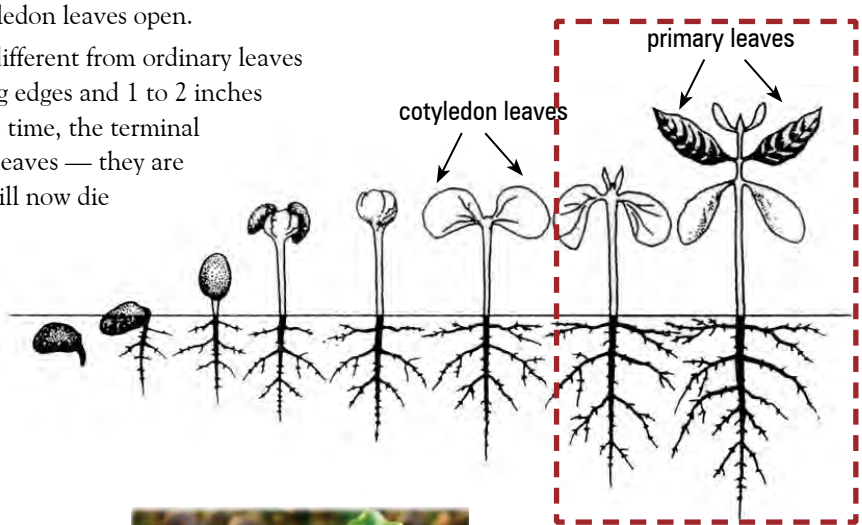


Figure 10a. Diagram of the germinating process. The last two drawings (in the box) indicate that the plant is ready for transplanting (above right)

Colyledons shown in photograph (left); the new primary leaves appear above the colyledons (far right photograph)

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 7 to 12 inches (20 to 30 cm), 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 4 x 10 inches (10 x 25 cm) when filled with soil. A mixture of fertile topsoil and manure or compost can be used. All soil, manure and compost should be fine-sieved. The following mixture could be used:

3 x 4 gal (18 L) tins of topsoil
2 x 4 gal tins of river sand
1 x 4 gal tin of good quality dry cattle manure or compost
7 oz (200 g) of rock phosphate or 0:20:0 N:P:K fertilizer
7 oz (200 g) of lime (preferably dolomite)

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

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

Choose the seedlings

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.

Figure 11. Choosing the seedlings at matchstick stage

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 2 inches (5 cm) 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).

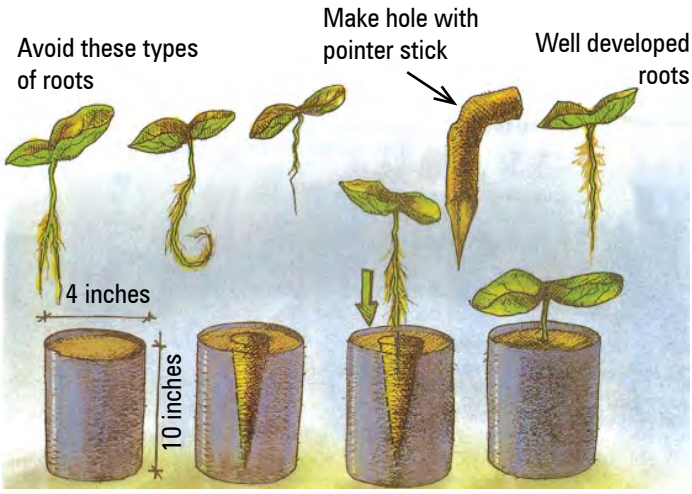


Figure 12. Planting the seedlings into plastic bags

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.
- At three months, apply urea (46:0:0, N:P:K) at 2 oz/2 gal (56 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).

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

Nursery diseases and pests

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

The main diseases and pest problems occurring in the nursery include damping-off, brown eye spot and green coffee scale (Figure 14).

Damping-off appears as areas of dying plants and 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 as they grow can also cause this problem. Damping-off can be avoided by proper preparation in the nursery. It is vitally 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 (see page 68 of *Pests and diseases*).

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. Always read the label on the chemical pack and follow directions (see page 69 of *Pests and diseases*).

Green coffee scale can also be a problem in the nursery. Scales severely affect plant health as 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. Always read the label on the chemical pack and follow directions (see page 64 of *Pests and diseases*).

Green coffee scale (below)

Planting out. Transplanting seedlings into bags in the nursery

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. A field management calendar on page 91 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 8 ft (2.4 m) apart with plants 4 ft (1.2 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 5 ft (1.5 m) high with legs 4 ft (1.2 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 8 ft (2.4 m) up or down hill from the first row. Follow the same marking procedure until the entire field is marked out.

Grevillea robusta (Silver Oak) shade trees planted with coffee

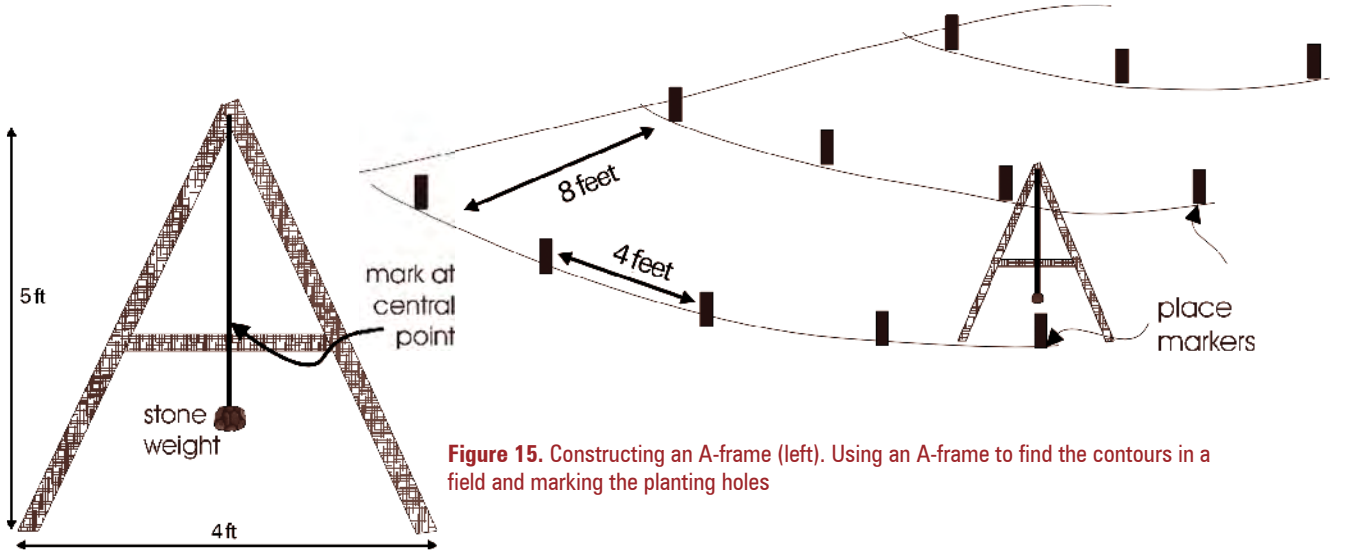
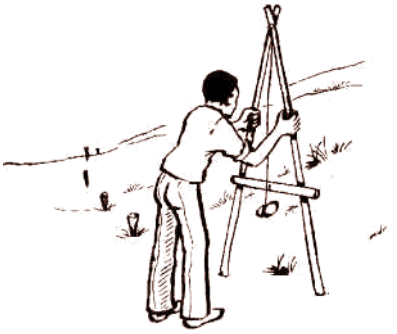


Figure 15. Constructing an A-frame (left). Using an A-frame to find the contours in a field and marking the planting holes



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 in Myanmar.

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.

Figure 16a. Erythrina shade trees

Figure 16b. Melia shade trees

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 cherry 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* (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).
- *Grevillea robusta* (Silver Oak). Used in Myanmar for more than 70 years and in Sri Lanka for tea shade since 1856. The tree can grow to 50 m if not pruned. Good shade and fuel.
- *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.

Shade tree spacing

Suggested spacing for Erythrina, Grevillea, Gliricidia and Cassia is 14 x 13 ft or 170 trees/acre (5 x 5 m or 555 trees/ha), and Melia and Paulownia is 19 x 19 ft 120 trees/acre (6 x 6 m or 277 trees/ha).

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

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 (see field management chart page 91). 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 2 x 2 x 2 ft (60 x 60 x 60 cm) (Figure 18).
3 Pile topsoil to one side of the hole, subsoil to other side of hole.
4 Mix in 4.5 lb (2 kg) of dry farmyard manure (FYM) + 3 heaped soupspoons (about 3 ozs or 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 17. Ideal size of transplant tree

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

Figure 19. Unsuitable plant with a twisted root system

At planting (one month later)

- Spread 1 milk tin (0.5 lb or 225 g) of dolomite over the soil in the planting hole and then dig in.
- The soil should be moist at time of planting.

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 it will settle down after watering. 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 1.5 to 3.5 pints (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-apply the mulch at end of wet season.
10. Pigeon pea (*Cajanus cajan*), sorghum (*Sorghum bicolor*) or other crops can provide temporary shade cover for young plants.
11. Blady grass (*Imperata cylindrica*) covers can be used for frost protection.

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

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 could be a popular source of alternate income. Prunings from legume shade trees are also a good protein food supplement for cattle.

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 covered in detail in the next chapter).

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 close to plants 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.

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 2 to 3 inches (5 to 8 cm) especially at the end of the wet season, but be sure to keep mulch materials 2 to 4 inches (5 to 10 cm) 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 re-grow, especially in wet weather if they are not dried properly before being added as a mulch.

Figure 21. Newly planted coffee trees with frost protection in place (top), frost has killed these trees in the field (centre), frost damaged leaves (bottom)

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.

Figure 22. Above: Pinto peanut ground cover with blady grass cover for frost on individual plants in the top background of photograph

Above right. Established ground cover of Pinto peanut in coffee plantation

Above. Innovative planning for planting design of shade trees and coffee

Chapter 4

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 MT 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

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.

To help determine the best nutrition practices, soil and leaf analyses are recommended. 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 6 inches (150 mm) with soil auger or spade.
- Place soil in a CLEAN bucket.
- Sample from a minimum of 20 sites across a block of 3 to 10 acres (2 to 4 ha).
- 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 fertiliser application. Scrape away any fertiliser/ lime residue from previous applications before taking a sample.
- Do not sample next to shade trees.
- Areas of different tree size, age, soil types, fertiliser 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 (in February) before flowering.

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 6" (150 mm)

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 3 to 10 acres (2 to 4 ha).
- 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 fertiliser, soil etc.
- Do not sample when leaves are wet as the paper sample bags will break!
- Do not sample after any application of foliar fertiliser sprays.
- Areas of different tree size, age, soil types, fertiliser 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 140° to 149°F (60 to 65°C) until dry and brittle.

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.

Figure 24. Leaf sampling

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.

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.

Analyses results for Pyin Oo Lwin area

Soil and leaf analyses surveys across 15 farms in the Pyin Oo Lwin area, with good and poor management have indicated that many farms have low pH, low P, K, Ca, Mg, and Zn, while most had adequate N, Mn, Cu, S and generally good organic matter levels. Boron was not measured but B deficiency has been seen in coffee and papaya in the areas. Sodium and chlorine present no problems, but Cation Exchange Capacity is lower than expected.

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.

Fertiliser programme

Coffee soils in Myanmar are low in a number of essential plant nutrients; therefore these must be supplied to promote high yielding, high quality coffee. Manure, bio-fertiliser, covercrops, 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 used 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.

There has been little or no soil and leaf analyses services available for Myanmar coffee growers. Yezin University is now able to undertake analyses and CRIETC is able to assist with determining a fertiliser programme. When such services are used, a detailed coffee fertiliser programme can be devised. Meanwhile the following fertiliser programme is suggested for Arabica coffee in Myanmar.

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 occasionally be needed.

Year	Time	Application
Year 1	(Up to 12 months in the field) September	 Before rains finish 1 oz (30 g) /tree of NPK 15-15-15
Year 2	April/May (with first rains) July September	1 oz (30 g) /tree of NPK 15-15-15 1 oz (30 g) /tree of NPK 15-15-15 1 oz (30 g) /tree of NPK 15-15-15 1.1 lbs (500 g) /tree of Dolomite
Year 3	April/May (with first rains) July September	2 oz (60 g) /tree of NPK 15-15-15 2 oz (60 g) /tree of NPK 15-15-15 2 oz (60 g) /tree of NPK 15-15-15
Year 4	April/May (with first rains) July September	3 oz (90 g) /tree of NPK 15-15-15 3 oz (90 g) /tree of NPK 15-15-15 3 oz (90 g) /tree of NPK 15-15-15 1.1 lbs (500 g) /tree of Dolomite
Year 5	Onwards April/May (with first rains) July September	 4 oz (120 g) /tree of NPK 15-15-15 4 oz (120 g) /tree of NPK 15-15-15 4 oz (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 1.1 lbs (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 carrying a crop of 1 MT/ha (expected yields / ha: 1000 kg green beans).

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

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 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 fertilisers, 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 4 inches (10 cm) 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	1.5 lb/tree (0.7 kg)
Year 3	2.2 lb/tree (1 kg)
Year 4	4.4 lb/tree (2 kg)
Year 5 onwards	5.5 lb/tree (2.5 kg)

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.

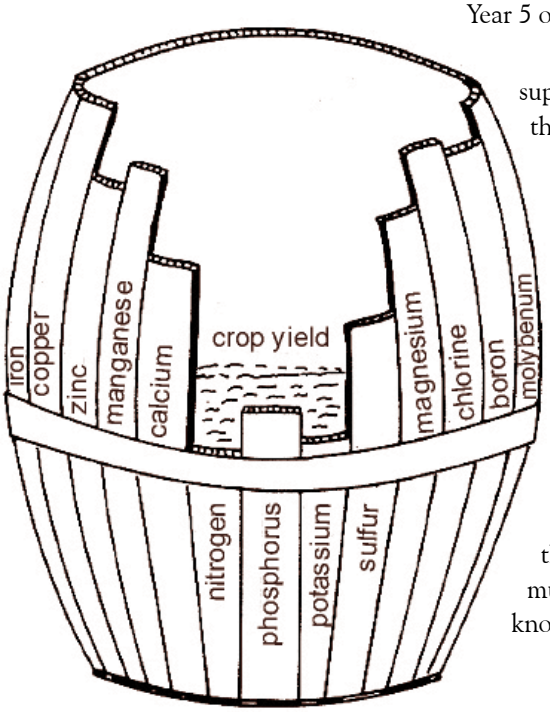


Figure 26. 'Barrel Analogy' using nitrogen as the least available nutrient

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 'Barrel Analogy' diagram, 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:

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 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 (right)
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	

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.	molybde-num	

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 internode to elongate properly, giving plants a compact appearance.	zinc	 

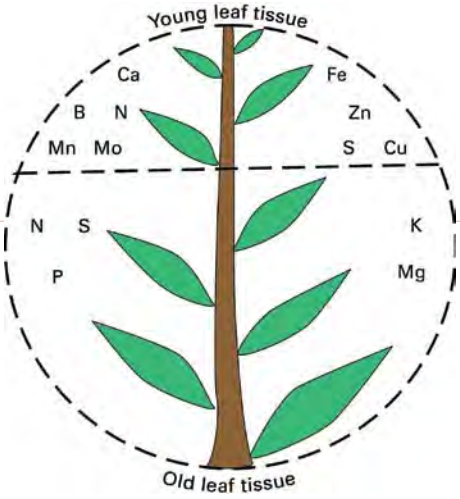


Diagram showing nutrient deficiencies affecting young and old leaves

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 8 inches (20 cm) of the main stem.

Remove all fruit as they appear (fly crop).

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

Cap the main stem by cutting above a side primary shoot at about 5 ft (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 8 inches (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. Alternate trees can be stumped by cutting off at knee height — about 20 inches (50 cm) from soil level. When these trees are producing again after two years, stump the remaining trees (see notes on stumping).

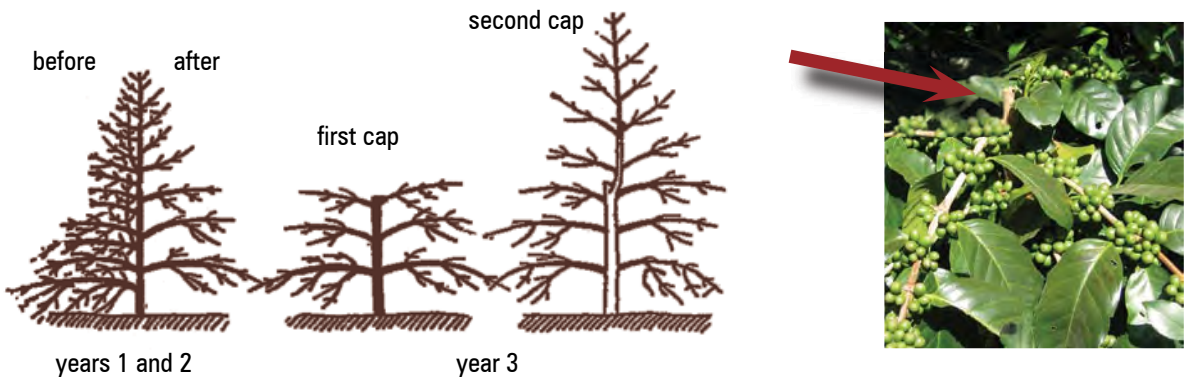


Figure 28. General pruning and desuckering of tree over years 1 and 2. Capping during year 3. Newly capped tree photo (above)

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 12 to 18 inches (30 to 45 cm) 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 29b. A coffee tree after being side pruned

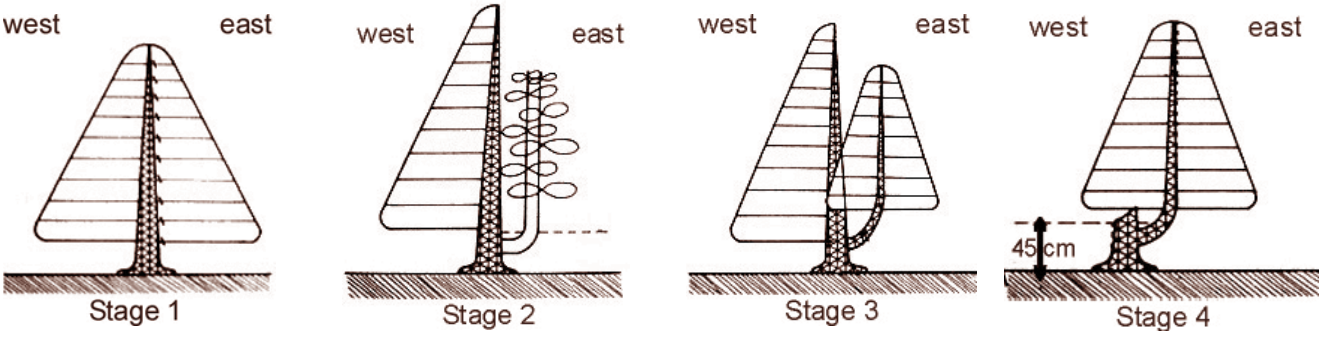


Figure 29a. The four stages in side pruning a coffee tree

Figure 30. Diagram of full stumping procedure. Choose the strongest shoot and remove the rest; note the 45° cut angle. Photograph of a stumped tree after re-growth (left)

Full stumping

Full stumping involves cutting the tree back to knee height — about 20 inches (50 cm) from soil level, and developing a new stem from the stump (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. Coffee has a water requirement of about 1 inch (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 24 inches (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. Various fruit trees such as durian, guava, lychee, cinnamon (*Cassia* spp.), avocado, low chill stonefruit, citrus and macadamia are sometimes substituted for legume trees. These of course, should be chosen to suit the altitude.

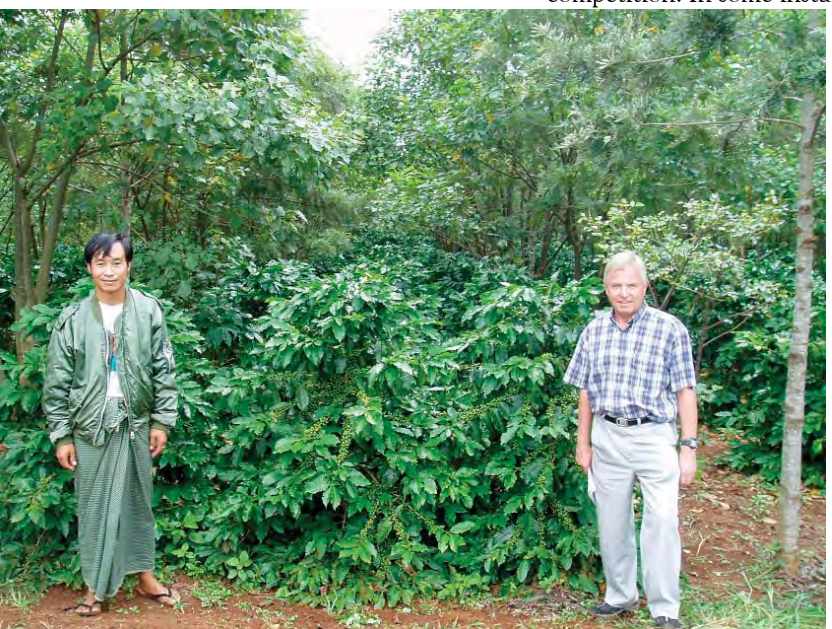


Figure 31. Young coffee trees with an intercrop of lettuce (top photograph). Pepper vines used as an intercrop on established Erythrina shade trees (middle photograph) with small coffee trees in the centre of the photograph.

Mature, bearing coffee does not allow room for inter-cropping (bottom photograph)

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 —

Harvesting for Arabica takes place from November to February (see the crop cycle and field management charts on pages 90 and 91). 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 deterioration 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 Myanmar, except for the MFE and larger plantations where full-wash processing is used, most small-holder coffee is processed naturally.

Full-wash 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 0.25 to 1 gal/lb (2 to 10 L/kg) water 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-wash process

The skin of the fresh cherry is physically removed by a pulper machine with addition of water, as with full-wash 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 Myanmar and Lao 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 8 oz water/lb (0.5 L/kg) 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 demucilager units, there is no need for fermentation tanks and washing systems. Pulper/demucilager units are recommended for semi-wash wet coffee processing. The VINACAFE machine is the cheapest pulper/demucilager tested and performs just as well as much more expensive machines from South America.

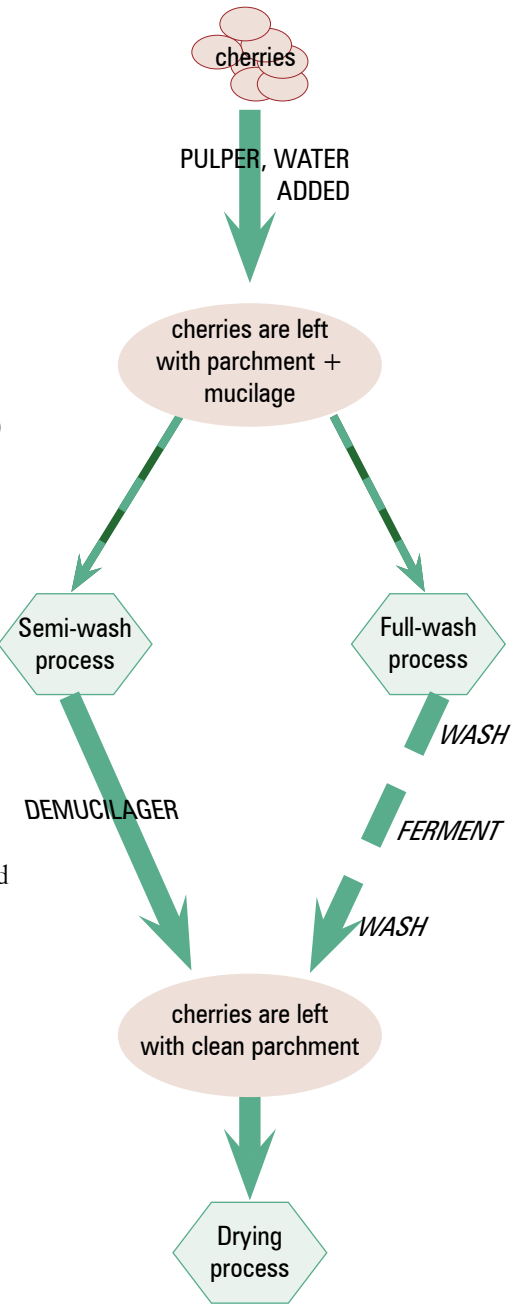


Figure 33. Simplified diagram of semi and full washing processes

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 and demucilager units produce clean parchment coffee ready for drying. VINACAFE unit is shown in photograph and is inexpensive and good for smallholders and processes 0.5 MT/hr of 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

Figure 34. The parchment is dried on a clean, flat surface in full sun

The drying process

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

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

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 process, coffee must be covered with polythene or plastic sheets if rain occurs and every night to stop re-wetting that results in mould development. Coffee is fully dry when green bean is a translucent, jade green 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 fertilisers and chemicals, as stored coffee can take on these odours that 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 silverskin 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 contamination from 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 beans 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)

Washing process for Arabica coffee

The following table shows a summary of the full-wash and semi-wash processes and potential problems for 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 cherries 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 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 flavours. Faded 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

Myanmar in 2003/2004 had a total production area of 35,485 acres with 15,351 acres in production of which 3380 MT was green bean. In the past five years the government has strongly promoted planting of Arabica coffee, and plantings of both smallholders and larger plantations is expanding.

Northern Myanmar (Shan States, Mandalay Division, Chin State, Kachin State, Kayin State, Bogo Division, Rakhine State, Mon State) has the potential to produce large quantities of high quality Arabica coffee by virtue of its high, good quality, red soil plateaus and other suitable soils, at elevations above 3300 ft (1000 m), with a well-distributed rainfall of 59 to 79 inches (1500 to 2500 mm) and a distinctive, essential dry season.

For farmers in remote areas, Arabica coffee when well-cared for, gives good incomes, and because the coffee is largely non-perishable and robust, it transports easily without damage. Coffee in Myanmar is also planted on sloping land with terraces or grass strips and contour planting, and when grown under shade is sustainable over long periods, even with low inputs. Some of the earliest plantings of S 795 Arabica coffee in Myanmar grown under *Grevillea robusta* shade trees, are still capable of producing reasonable yields, with low inputs after 75 years.

The Government is strongly supporting private investment in coffee, and if the correct varieties are planted at altitudes of 3300 ft (1000 m) and higher, and managed and processed correctly, Myanmar should be able to produce high quality Arabica coffee.

Currently, most small-holder Arabica coffee is processed as natural dried cherry. At sale, dry cherry is roughly hulled and cup quality is far from ideal. Plantations of Myanmar Farm Enterprises (MFE) and two private groups at present are the only ones doing full-wash processing.

Many of the expanded plantings of recent years are about to come into significant production in 2005/2006, and farmers must decide which way these larger volumes of coffee will be processed. Some are already doing a full-wash process, but setting up of fermentation facilities and tanks is expensive and is very wasteful of water. At least 2.5 gals (10 L) of water are used to process 2.2 lbs (1 kg) of ripe cherry that is hulled, fermented and washed before drying.

Semi-wash pulper/demucilager units are available (see Chapter 6). These machines, especially the Vietnamese VINACAFE pulper/demucilager units are inexpensive, portable and use very little water — less than 1 pt/

Sample huller (centre) and moisture meters (bottom)

Sample grading screens

2.2lbs (0.5 L/kg) of fresh cherry. The coffee produced by these machines is excellent and of equal or superior quality with better body to that of full-wash coffee. Semi-wash or demucilaged coffees produce consistently good quality as poorly controlled ferments that produce off-flavours are avoided.

The FAO coffee project has been particularly timely in emphasising the need to focus carefully on varieties, location/environment (especially altitude), production, harvesting, handling and new processing practices to produce high quality coffee. Side-bars show some photos of the processing equipment supplied by FAO. The FAO project provided CRIETC with a fully equipped coffee laboratory for testing and physical assessment of green bean samples, including hullers, a Probat sample roaster, grading screens, Santos grinder, drying ovens, pH/conductivity meter, espresso machine etc., and fully equipped wet processing (pulpers and pulper/demucilagers) and dry processing (1 MT/hr hulling, cleaning, grading, and gravimetric table) facilities. The project also provided the lab/office facility, a wet processing area with concrete drying patios, shed and storage for parchment or green bean and a meteorological station.

With these facilities, CRIETC is ideally placed to support all technical issues and give advice if needed for the emerging high quality Arabica industry.

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 100.


Coffee maker (top). Kett moisture meter (above). Setting up the table for tasting and evaluating coffee (right)

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

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

Grinding coffee

Cup quality evaluation of Myanmar coffees

Project specialists have thoroughly trained CRIETC staff in cupping as well as natural, full-wash and semi-wash processing methods and all dry processing and sampling/moisture testing methods.

The project processed a range of Arabica and Catimor varieties from various altitudes, in a standard way and sent samples to international and local buyers and roasters for assessment. The coffee samples were collected as ripe cherry from farmers and processed at CRIETC using a full-wash, wet process. Samples selected for assessment by buyers/roasters, were first assessed by FAO International consultants and CRIETC staff.

Forty-six coffee samples were produced during 2003/04 season and 61 samples during 2004/05. It was not feasible to have all samples internationally tested, so a random selection of coffee (processed using the standard full-wash) from a range of regions and varieties was selected for international evaluation. Ten samples from the 2003/04 production were tasted by CRIETC staff and international consultants. These samples were of very good quality, but unfortunately were damaged during storage and could not be assessed overseas due to off-flavours. The table on page 56 shows the results of CRIETC evaluations before damage to samples.

Seven samples from the 2004/05 production were evaluated by international coffee buyers and experts. The selected samples represented coffee from high altitude 4200 to 4600 ft (1300 to 1400 m), medium altitude 3200 to 3600 ft (1000 to 1100 m) and lower altitude 2600 ft (800 m). The table on page 55 shows the international evaluation results.

The main purpose of international cup evaluations was to determine if the CRIETC cupping lab findings correlated with international findings. International cup evaluations gave some general values to the various coffees in relation to the New York 'C' for Arabica and comments on general quality and processing, as these coffees are virtually unknown

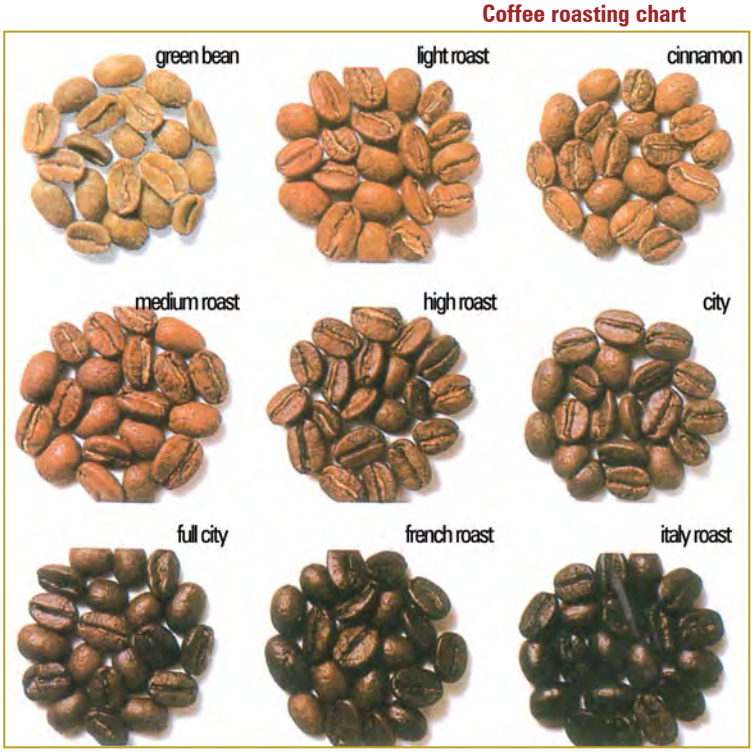
Sample roaster (top) and making expresso (bottom photograph)

outside Myanmar. All International evaluators used their own commercial terms to describe coffees tested, which made it more difficult to get specific correlations with the CRIETC lab. CRIETC cupping lab results were the combined results of group cupping sessions held with international consultants and key CRIETC staff.

Conclusions for the cupping results from the CRIETC lab were that:

- the CRIETC lab is proficient at recognizing taints and off–flavours, and personnel understand minimal international quality requirements for a clean coffee.
- detection of clean coffee attributes such as acidity and body between CRIETC lab and international evaluations correlated reasonably well.
- CRIETC lab gave higher scores for acidity where international testers rated all coffee samples as quite low on a world coffee acidity scale.
- international tasters indicate that some coffees approach Specialty grading while others are already at a Premium grading of SCAA.
- character can be a relative term in coffee tasting with various complex flavours developed by unique processes. This often results in very different interpretations, particularly when cup tasters have a commercial interest rather than a purely technical interest in the coffee. Thus dirty or earthy aromas and flavours to one buyer, can be considered as complex, interesting and very desirable to another.
- there was generally firm agreement among the international buyers of what they considered the best and the least desirable coffees.

Coffee roasting chart



Myanmar international coffee tasting assesments 2004/2005

	Variety, Location & Altitude	CRIETC		Golden Triangle		Holland Coffee		Ecom Trading		Illy Cafe
A	Catimor 528 Mogok, 4265 ft	Clean coffee. Very good acidity. Good body and flavour. Score: 79.5/100	2	Excellent. Good body and flavour. Positive acidity	1	Low acidity. Medium/good body. Good prep. Good flavour: floral, little dry	1	Best coffee. Good body. Not much character. Score: 70 /100	1	Green
B	S 795 Pwedaung farm 3600 ft 20 days drying*	Good clean coffee. Medium acidity, body and flavour. Score: 78/100	4	Good coffee. More neutral and less body. Very little acidity	3	Low acidity. Medium/good body. Good prep. Good flavour	3	Good body. Not much character Score: 69.1/100	2	Good. More scratched beans than other samples
C	S 795 Ywangan, 4265 ft +	Dirty coffee, old, stale. Low acidity and strange after taste. Score: 68/100	7	Peasy cup. Less body. No acidity	5	Low acidity. Medium/good body. Ok prep. Flavour: grassy, dirty, gritty harsh, earthy astringent. Not good	7	Good body. Light citric/ flowery character Score: 68.5/100	3	No good. Stinker, woody jute taste
D	S 795 Pwedaung farm, 3600 ft 12 days drying*	Good clean coffee. Medium acidity, body and flavour. Score: 77/100	5	Excellent. Good body and flavour. Positive acidity	2	Low acid. Medium/good body. Good prep. Flavour: a little thin, flat, astringent	4	Good body. Not much character. Flat Score 68.5/100	4	Woody taste but good aroma and body
E	Catimor 8667 Greenland farm, 3600 ft	Clean coffee. Good acidity, body and flavour. Score: 80/100	3	Good coffee. More neutral and less body. Very little acidity	4	Low / medium acid. Medium body. Good prep. Flavour: a little thin, flat, astringent	5	Good body. Pleasant not harsh, smoky character.Score 66/100	6	Dirty. No particular flavour
F	Catimor Vietnam Banbwe, 2821 ft	Clean coffee. Medium body, low acidity, flat flavour. Score: 75/100	6	Peasy cup. Less body. No acidity	6	Low acidity. Good body. Faded prep. Flavour: grassy gritty, harsh earthy flat	6	Good body. Curious light citric/flowery character Score: 65.7/100	7	Fruity – not a defect
G	S795 Pwedaung farm 3600 ft 30 days drying*	Good clean coffee. Good body, acidity, and flavour. Score: 83.5/100	1	Nothing special. Very neutral	7	Low acidity. Good body. Good prep. Flavour: good, clean strong but mellow, pleasant	2	Good body, not much character, really flat. Score: 66.67/100	5	Fruity – not a defect

* indicates 3 samples (B,D,G) from the same source of coffee (Pwedaung S 795) under the same process but with different drying times 12, 20, 30 days.

+ indicates coffee not processed by CRIETC. The outside processing was not well-controlled.

Score is the agreed consensus of CRIETC lab with FAO international consultants using the SCAA coffee quality evaluation system.

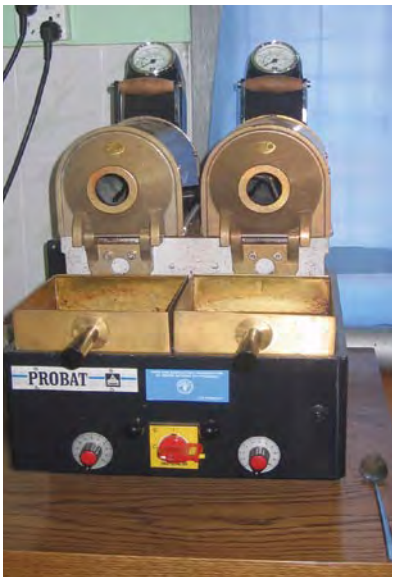
Continued …

Summarised comments from international companies

- Some of these coffees would make it into the speciality market. The value of the good samples (A, G) should be around minus 10 cents level NY 'C' on basis FOB. The other samples would be minus 20 cents.
- Price indications from another buyer: A,B –8 to +4, C,F –6, G –8, FOB basis against NY 'C' (cents/lb).
- Another company thought that generally, there was good body throughout the coffees but not much character.
- The international companies considered the coffees had low acidity.

CRIETC evaluations with international consultants

Sample	Variety, location, altitude	CRIETC evaluations	Rank
1	S 795 Chaungue Plantation, 3772 ft (1150 m)	Good balanced coffee Score: 78/100	1
2	S 795 Pwedaung, 3740 ft (1140 m)	Good coffee with a little less body than No.1 Score: 77/100	3
3	S 795 Ywangan, 4265 ft (1300 m)	Good coffee. Good acidity, but less body than No.1 Score: 77/100	4
4	Catimor 528 Kyaw Ag Zaw Ag, 3608 ft (1100m)	Fair coffee. Medium Acidity and body Score: 75/100	8
5	Caturra red Doekwin, 3608 ft (1100 m)	Medium acidity and body Score: 75/100	6
6	SL 34U Kyaw Sein, 3608 ft (1100 m)	Medium acidity and body Score: 75/100	7
7	Catimor 528 Mogok, 4593 ft (1400 m)	Good coffee with high acidity Score: 78/100	2
8	Catimor 8667 Greenland, 3600 ft (1100 m)	Large beans for Catimor. Medium acidity and body Score: 76/100	5
9	Catimor Laos SPZ Pyin Oo Lwin, 3600 ft (1100 m)	Fair coffee. Medium to low body and acidity. Lacks character Score: 73/100	10
10	Catimor Vietnam SPZ Pyin Oo Lwin, 3600 ft (1100 m)	Fair coffee. Medium to low body and acidity Lacks character Score: 74/100	9



Quality and export standards

At present Myanmar 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 industries. 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 equivalent); 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

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

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.

1.2 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.

1.3 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[2].

2) At present at the draft stage

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 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 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 sample s 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

Myanmar 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 Organization 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. Myanmar 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. There are two species of green coffee scale in Myanmar. Both species are similar in appearance but occur at different altitudes. C. *viridus* (more common) is found below 4000 ft (1200 m) and C. *alpinus* above that level.

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

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 7 fl oz/4 gal (200 ml/ 18 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 $^{2}/_{3}$ oz/2 gal (20 g/9 L) water applied as a spray. Apply weekly until scales disappear.

Traditional:

2.2 lbs (1kg) strong tobacco per 0.5 gal (2.3 L) water. Soak for 2 nights. Then remove tobacco. Add 1 lb (455 g) of washing powder and make up to 4 gal (18 L). Spray weekly until scales disappear.

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.

READ THE LABEL

Control

Generally not warranted.

Chemical:

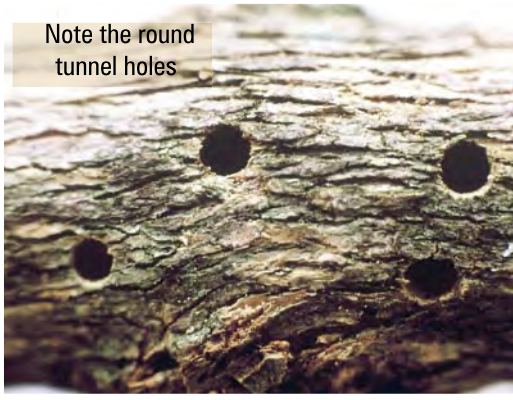
Mix 0.3 to 0.6 fl oz (10 to 20 ml) Neem oil, plus 2 teasp (7 g) soft, finely grated laundry soap in about 35 oz (1 L) water. Spray the plant taking care to cover all the underside of leaves and developing shoots.

Stemborers

There are two species of stemborer present in Myanmar.

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 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 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 3300 ft (1000 m) 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)

Continued...

Stemborer Continued...

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

Coffee berry borer (*Hypothenemus hampei*) is a relativity new, but very serious problem in neighbouring countries. **This pest has not yet been found in Myanmar, but is included here so farmers can recognize the problem.** It causes 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 cherries 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 in 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 a source 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. This and other effective parasitoids can be procured from Cenicafe in Colombia.

Interest is now focused on the commonly found fungus, *Beauveria 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 cherry. Endosulfan 35 EC at a rate of 0.3 fl oz/gal (6 ml/ 4.5L) 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 (0.01%) at 1 fl oz/3.3 gal (26 ml/15 L) 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 many 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.

READ THE LABEL

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 cherries. 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.

Mealybug. Large white mealybug

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*) and lacewings such as *Oligochrysa lutea* are also effective predators of mealybug.

Mealybug. Cherry infestation

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.

Sooty mould. The black mould is often present with mealybugs

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

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, at the rate of 2 to 3 oz/1.7 pt (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

READ THE LABEL

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).

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 planted with a spacing of 1 inch (2.5 cm) in rows 4 inches (10 cm) 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.

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)	3 oz/4 gal (80 g/20 L) water
Copper oxychloride	3 oz/4 gal (80 g/20 L) water
Copper hydroxide	1.5 oz/4 gal (40 g/20 L) water

READ THE LABEL

Close-up. Plants affected with Cercospora

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

Rust spots. Symptoms on upper leaf (top); advanced disease on undersurface (bottom)

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 (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)	3 oz/4 gal (80 g/20 L) water
Copper oxychloride	3 oz/4 gal (80 g/20 L) water
Copper hydroxide	1.5 oz/4 gal (40 g/20 L) water

READ THE LABEL

Coffee leaf rust

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

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 cherry loss and a loss of both yield and quality.

Cherries 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 3300 ft (1000 m).

Plant health: Healthy plants are less susceptible.

Leaf rust. Advanced symptom

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.

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.

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.

Twig dieback. Note the brown stems

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. Plant cannot support the extremely heavy crop

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.

Causes

Insufficient nutrition.

Insufficient shade.

Insufficient irrigation.

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

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 including the roots; healthy plant (left) plant with dieback (right)

Chapter 10

Natural enemies and IPM

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 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.

Wolf spider

Lynx spider

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.

Tachinid fly. Adult attacking a caterpillar

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 40 to 70 mm 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.

Damsel bug adult

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.

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

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

Green lacewing eggs

Chapter 11

Myanmar coffee market survey

A study of Myanmar coffee marketing, conducted by the FAO project during the 2003 to 2005 seasons, gathered information on coffee production and existing coffee market channels. This information has helped to outline key elements of a strategy for improved international marketing of high quality Arabica coffee from Myanmar.

Summary

Production. Government sources estimate the present coffee production of Myanmar at 3615 tons for the 2004/05 coffee season, comprising 2611 tons Arabica and 1004 tons of Robusta (see Tables 11.1 and 11.2). This equates to 0.05% of world production.

Markets. Based on official figures in Tables 11.2 to 11.5, most coffee is exported via border trade to neighbouring countries, with yearly variation in export volume. The three years of border trade data show a large export of Robusta in 2002/03 that appears to be at least double Robusta production which is unexplained, except perhaps by re-exports of imported Robusta. International exports via Yangon for the two years of data provided were 95% Robusta, which may indicate the ease of transport of Robusta to Yangon from the southern production areas while Arabica is mostly produced in the North and is sold as border trade.

Quality. It is estimated, that over 80% of Myanmar coffee is produced by smallholders using the most rudimentary methods of processing. Typically, the coffee is dried in the cherry to produce 'natural' coffee and is then hulled by pounding. The small amount of coffee that has reached international markets to date has created an image of generally low quality coffee from Myanmar. This coffee project assessed a wide range of Myanmar Arabica coffee and had a range of well-processed coffee samples from Myanmar sent to international buyers for tasting and evaluation. The general consensus was that these coffees have potential in the Premium and Specialty coffee market as defined by the Specialty Coffee Association of America (SCAA). See Chapter 7 for quality assessment details.

Plans. The Myanmar Government has plans for further extensive coffee plantings as described in Table 11.6. This information was extracted from the document, *Strategic Vision for Development of the*

Coffee Industry of Myanmar, presented by Myanmar Farm Enterprises (MFE) at the FAO Coffee TCP wrap-up seminar in May 2005. The plans will require clear actions and strategy to ensure producers can effectively transport, process and market their product.

Production and marketing. Exports and border trade figures vary markedly over the three years of available data – no reason is given for the wide variation. Figures of total production against consumption and exports do not balance. This may mean that either production is much lower than estimated or there are unrecorded exports, or that local consumption is much higher than estimated or coffee is being imported and re-exported.

Conclusions. While every indication points to Myanmar as a likely Specialty or Premium high quality coffee producer, investor and smallholder plantings will be governed by risk with respect to investment costs and political stability and this may slow development. The benefit/cost studies and cash flows found in Chapter 12 indicate good profitability and returns for Arabica coffee in Myanmar provided that stability prevails in the country and the economy.

Table 11.1. Production/exports of Myanmar coffee (tons)

Year	Total production (Arabica & Robusta)	Local consumption estimate	Border trade	Exports via Yangon port
2002/03	2417.57	750	1807.7	No data
2003/04	3012.00	750	473.31	186.35
2004/05	3615.98	750	372.3	372.3

Market strategy – recommendations

The Myanmar coffee industry is in its infancy. There is an opportunity for it to grow into a viable component of the agriculture sector in Myanmar and to benefit farmers. Private investors are taking the lead role in driving the coffee industry by planting new coffee farms. However, individual investors have limited knowledge of coffee marketing and need assistance. The Myanmar Government has a key responsibility in providing the enabling environment to develop the coffee industry and ensure there are marketing channels for investors to transport, process, market and export their produce. It is very difficult to develop a marketing strategy until there is sufficient quality of coffee to market. It is recommended that future Myanmar Government marketing strategies consider the following points:

Quality issues. The Myanmar Government should investigate developing and implementing coffee export standards and quality certification to give consistency to the coffee exported from Myanmar. Consistency is as vital as quality to most international buyers.

Processing facilities. The Myanmar Government should actively assist producers to process, market and export high quality coffee. This will boost world positive market awareness of the Myanmar coffee industry. Assistance with facilitation of machinery importation procedures and advice from CRIETC to producers and processors.

Market focus. The Myanmar coffee industry must strive to understand Specialty coffee market requirements. The Myanmar Government must help develop a 'market driven' coffee industry, which provides coffee that meets the demands of this market.

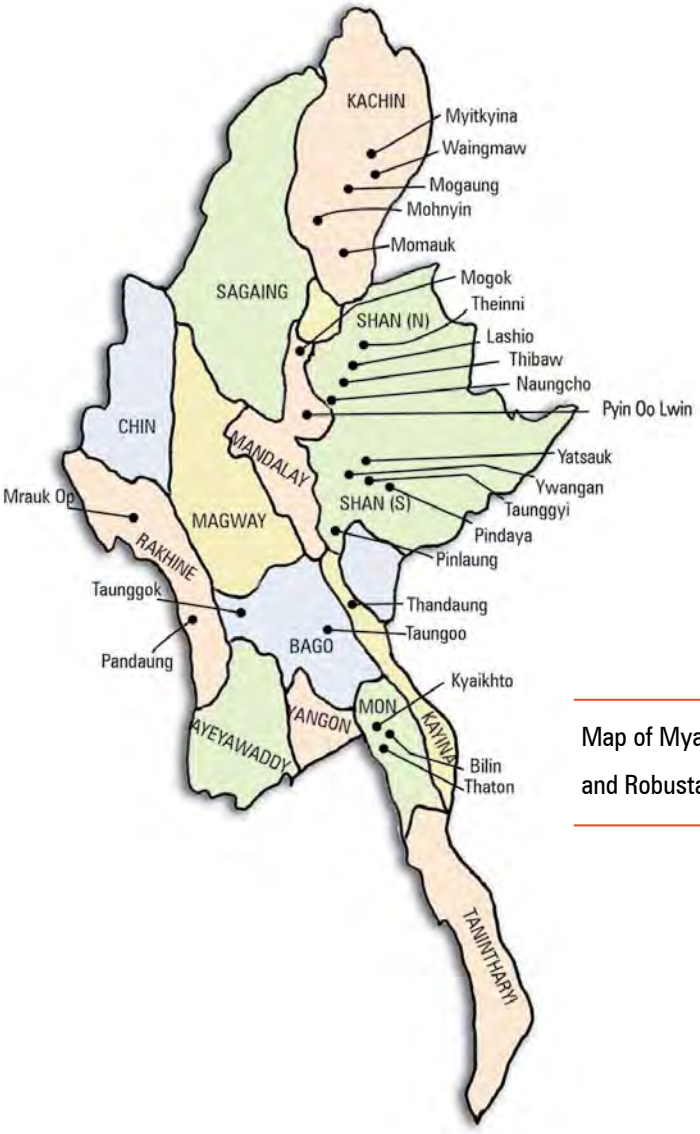
Market information. The Myanmar Government should investigate methods to improve communication about the world coffee market prices for all Myanmar coffee growers, to ensure fair prices are paid to the growers.

Minimum coffee volumes. A volume of 500 tons of high quality coffee is considered a minimum requirement for beginning a credible program to market new Specialty coffee. Coordination of coffee exports will be needed to achieve these minimum volumes, which initially will be derived from a range of growers.

Myanmar Coffee Association. The Myanmar Government should consider forming a Myanmar Coffee Association as a mechanism to create dialogue with the coffee industry. Participants could include producers, exporters and government departments.

Coffee production

Coffee production is spread over a large number of States and Divisions in Myanmar. Arabica tends to be produced in the uplands in the north while Robusta is predominantly produced in the lowland southern areas. Smallholders (average holding is less than one acre), produce 80% with the remainder from larger coffee estates, public and private, as well as larger smallholders with a few acres. This proportion is changing as a large area of coffee has been planted under the Myanmar Government coffee development strategy. Arabica production is approximately 66% while Robusta is about 33% of total production. Myanmar's production of 3600 tons equates to about 0.05% of world production.



Map of Myanmar showing Arabica and Robusta coffee production areas

(Source: Myanmar Department of Statistics)

Production data provided by MFE, gathered from the Myanmar Department of Statistics.
Production data for 2002/03 season: Combined Arabica and Robusta 2417 tons.
Production data for 2003/04 season: Combined Arabica and Robusta 3012 tons.

Table 11.2 Coffee production in Myanmar for 2004/2005

State/Division	Cultivated (acre)	Harvested (acre)	Yield per acre (ton)	Production (ton)	Coffee type
Kachin State	1604	723	0.21	153.18	Arabica
Kayar State	596	509	0.22	116.57	Robusta
Kayin State	6923	2806	0.29	838.84	Robusta
Chin State	1165	826	0.16	135.86	Arabica
Sagaing Division	517	492	0.22	135.28	Arabica
Tanintharyi Division	116	18	0.16	2.95	Robusta
Bago Division (East)	787	135	0.24	34.84	Robusta
Bago Division (West)	495	41	0.22	9.41	Robusta
Magwe Division	259	94	0.09	8.65	Arabica
Mandalay Division	8134	1926	0.22	436.28	Arabica
Mon State	69	18	0.09	1.75	Robusta
Shan State (South)	5975	4511	0.18	837.26	Arabica
Shan State (North)	7390	3710	0.23	869.20	Arabica
Shan State (East)	1645	207	0.17	35.86	Arabica
Ayeyarwaddy Division	75	-	-	-	Robusta
TOTAL	**35750**	**16016**	**0.22**	**3615.98**	
				2611.00	**Arabica**
				1004.98	**Robusta**

Marketing

Coffee production is marketed via three main channels: 1) domestic consumption, 2) exports to neighbouring countries commonly called 'Border Trade' and 3) exports through the main port of Yangon which is commonly called 'International exports'.

Domestic consumption. Discussions with leading roasters in Myanmar, estimate that domestic consumption is a maximum of 750 tons per year but there is no central database to verify this information. The three largest producers of roast and ground coffee (Premier, Maha and MFE) produced about 350 tons of coffee in 2004/05 for local consumption. There are a number of unregulated small roasters who process up to 10 tons but no figures are available for these.

Exports. Export figures have been gathered from the Ministry of Commerce and the Department of Border trade. Seasons refer to the Myanmar financial year, which runs from 1 May to 31 April.

International exports

In 2003/04, 186.35 tons of coffee was exported as green bean by five different companies in seven shipments ranging from 0.35 to 54 tons. All coffee exported was Robusta.

In 2004/05, 373.6 tons of coffee was exported as green bean by eight different exporters in eleven shipments ranging from 1.2 to 54 tons (24.2 tons of Arabica and 349.4 tons of Robusta).

Table 11.3 Coffee exports via port of Yangon (2003/2004)

Date	Company name	Product	Price /ton	Qty (ton)	Value US$	Buyer
20/5/2003	Forever Winner Ltd	Robusta	470	36	17,640	Penabh Co. Ltd
1/7/2003	Forever Winner Ltd	Robusta	475	54	25,650	Penabh Co. Ltd
22/10/2003	Sky Marketing Industry Ltd	Robusta	550	20	11,000	Ulra Advance Ltd
4/11/2003	Forever Winner Ltd	Robusta	490	30	14,700	Penggerang Pty Ltd
9/5/2004	Chan Brothers Co. Ltd	Robusta	600	0.35	210	Sannata Int'L Co. Ltd
16/3/2004	Soe Htet Tun Trading Co. Ltd	Robusta	550	45	24,750	Handan Markeing Pty Ltd
22/3/2004	Huah Tarn Trading Co. Ltd	Robusta	700	1	700	Hsien Chun Import Export Co. Ltd
		Total		186.35	94,650	

(Source: Ministry of Commerce)

Table 11.4 Coffee Exports Via Port of Yangon (2004-2005)

Date	Company name	Product	Price /ton	Qty (tons)	Value US$	Buyer name
4/5/2004	Chan Brothers Co. Ltd	Robusta	550	10	5,500	Ya Hong
4/22/2004	Forever Winner Ltd	Robusta	520	54	28,080	Penggerang Pty Ltd
4/9/2004	Soe Htet Tun Trading Co. Ltd	Robusta	550	45	24,750	Handan Markeing Pty Ltd
5/11/2004	Naing Yu Trading Co. Ltd	Robusta	510	18	9,180	Young-In Traders Pty Ltd
6/1/2004	Soe Htet Tun Trading Co. Ltd	Robusta	500	22	11,000	Handan Markeing Pty Ltd
6/2/200	Forever Winner Ltd	Robusta	540	72	38,880	Penggerang Pty Ltd
6/17/2004	Naing Yu Trading Co. Ltd	Robusta	500	19.2	9,600	Young-In Traders Pty Ltd
6/25/2004	Kyar Kabar Trading Co. Ltd	Robusta	550	54	29,700	MIG(S'pore) Enterprise
7/6/2004	Naing Yu Trading Co. Ltd	Robusta	500	19.2	9,600	Young-In Traders Pty Ltd
8/26/2004	Myo Mahar Myint Co. Ltd	Robusta	525	36	18,900	Mr.Jean-Yues Banchand. Tropico Enterprise
8/31/2004	Tin Family Tdg Co. Ltd	Arabica	1100	23	25,300	FAC System Pty Ltd
10/22/2004	Myo Mahar Myint Co. Ltd.	Arabica	1100	1.2	1,320	Vogerfreicht Int. Ltd
		Total		**373.6**	**211,810**	

(Source: Myanmar Department of Statistics)

Border trade

In 2002/03, 1807.70 tons of coffee were exported by nine different companies in nine shipments ranging from 31 to 702.3 tons (200.6 tons Arabica and 1607.10 tons Robusta). In 2003/04, 473.31 tons of coffee were exported by six different exporters in six shipments ranging from 1.2 to 54 tons (349 tons Arabica and 124.31 tons Robusta).

In 2004/05, 121.92 tons of coffee was exported by eight different exporters in eight shipments ranging from 7 to 33 tons. All exported coffee was Arabica.

Table 11.5 Border trade from Myanmar to Thailand and China

Date	Company Name	Product	Price/ton	Qty (tons)	Value US$
Through Tachilek (Shan State (East) to Thailand) 2002/2003					
	Nay Min Trading	Arabica		31.60	22120
	Shwe U Daung Trading	Arabica		114.00	79800
	Shwe Ye Kan Trading	Arabica		55.00	38500
			Total	**200.60**	**140420**
Through Kawk Thaung (Tanin Tharyi to Thailand) 2002/2003					
	Aung Trading	Robusta		702.30	316035
	Waizin Trading	Robusta		50.00	22500
	Ever Conqueror Trading	Robusta		230.00	103500
	Forever Winner Trading	Robusta		470.00	211500
	Golden Lion Trading	Robusta		44.80	20160
	Star (Kyei Sin) Trading	Robusta		110.00	49500
			Total	**1607.10**	**723195**
Through Tachilek (Shan State (East) to Thailand) 2003/2004					
	Nay Min Trading	Arabica		44.00	30800
	Shwe U Daung Trading	Arabica		168.00	117600
	Shwe Ye Kan Trading	Arabica		14.00	9800
	Universal Company	Arabica		123.00	86100
			Total	**349.00**	**244300**
Through Kawk Thaung (Tanin Tharyi to Thailand) 2003/2004					
	Aung Trading	Robusta		109.31	46190
	Sun Drew Trading	Robusta		15.00	6750
			Total	**124.31**	**52940**
Through Tachilek (Shan State (East) to Thailand) 2004/2005					
	Oak Kyaw Trading	Arabica		11.00	7700
	Shwe Ye' Kan Trading	Arabica		10.00	7000
	Shwe U Daung Trading	Arabica		33.00	23660
	Yadana Zeya Trading	Arabica		25.00	17500
			Total	**79.00**	**55860**
Through Muse (Shan State (North) to China) 2004/2005					
	Shwe Thanlwin Trading	Arabica		11.74	8802
	White Star Trading	Arabica		10.18	7638
	Kaung Mon Oo Trading	Arabica		14.00	10500
	Myanmar Padauk Trading	Arabica		7.00	2800
	Shwe Thanlwin Trading	Arabica		42.92	29740
			Total	**85.84**	**59480**

(Source: Department of Border Trade)

Coffee quality potential

Trials/coffee evaluation in Myanmar

A range of coffee trials was conducted by FAO and CRIETC staff over the 2003/04 and 2004/05 seasons. Coffee was collected from many areas and processed in a number of standard ways in order to determine which processes were most suitable for large scale and small farmer processing. Controlled processing of samples ensured that clean, taint free beans were used by the tasters so that the true potential of the coffee could be evaluated. This control was important as previous samples were often poorly processed and prepared, resulting in taints and off-flavours, making it impossible to determine the potential quality. CRIETC staff and international consultants selected about 10 of the 100 available samples for assessment.

Assessment indicated that Myanmar coffee has potential in the Premium and Speciality coffee market as defined by Myanmar Speciality Coffee Association of America (see Chapter 7 for full details).

While standard parameters are used to assess coffee quality such as acidity, body, flavour and character, the actual value of coffee is ultimately up to the buyer who also has individual preferences. International trade restrictions against Myanmar also influence potential prices for Myanmar coffee.

CRIETC now has a fully equipped cupping laboratory as well as fully equipped wet and dry processing facilities that can wet process commercial coffee at 0.5 MT cherry/hr and dry process at 1 MT/hr of parchment. Extensive tasting and testing of coffee was conducted over the last two years so that CRIETC staff can now assess coffee quality to international standards.

Myanmar Government Strategic Coffee Development Plan

In 2002, the Government embarked on a plan to plant 100,000 acres of coffee. With assistance from FAO consultants, this plan has been revised with more detail, but it is still overly optimistic in projections for the area to be planted and total coffee production. Private investment has to drive the expansion and when the rate of investment slowed, investors discovered the real costs involved when world coffee prices are low. Realistic cost/benefit studies provided by the project (see Chapter 12) should assist, as will the rapid increase (doubling) in Arabica coffee prices over 2004/05.

Table 11.6 Government planting programme plan in 2005

Plan period	Planted (area)	Area to be extended (acres)	Total area (acres)	Harvest area (acres)	Yield (ton)	Total production (ton)
Before plan						
2004-05	35,750	-	35,750	16,016	0.22	3,615
Period						
2005-2006	35,750	10,000	45,750	17,000	0.23	3,910
2006-2007	45,750	10,000	55,750	18,000	0.23	4,140
2007-2008	55,750	20,000	75,750	19,000	0.24	4,560
2008-2009	75,750	20,000	95,750	27,500	0.24	6,600
2009-2010	95,750	20,000	115,750	36,000	0.25	9,000
2010-2011	115,750	20,000	135,750	52,000	0.3	15,600
2011-2012	135,750	20,000	155,750	68,000	0.4	27,200
2012-2013	155,750	20,000	175,750	84,000	0.5	42,000
2013-2014	175,750	30,000	205,750	100,000	0.5	50,000
2014-2015	205,750	30,000	235,750	116,000	0.5	58,000
Total		**200,000**				

(Source: Strategic Vision for Coffee Development in Myanmar)

Chapter 12

Myanmar coffee economics

The Government of Myanmar (GOM) is offering low cost, 25-year land leases for coffee planting. Coffee is a perennial crop that requires substantial investment. Farmers and investors require realistic guidelines on calculating costs and returns, cash flows etc., to make decisions on whether to grow coffee. This chapter provides the essential data to make such decisions.

Conclusions

A model for a 50 acre coffee farm has been developed, and based on key assumptions, the following conclusions can be drawn (see Table 12.1).

- Establishment cost per acre will be US$3000 (incurred over 3 years).
- A positive cash flow will begin in year 4.
- At year 9, the venture will begin to make net profits (i.e., profit after all establishment and other costs have been taken into account).
- At year 10 and onwards, net profit for each acre will be US$760.

Model assumptions

This model is based on a 55-acre plot of land leased from the GOM for a period of 25 years with 50 producing acres of coffee.

- 5 acres are for roads, water-ways, farm buildings and farm use.
- The land requires clearing of low bush and not heavy forest.
- The land is gently undulating slope with no major difficulties to develop.
- Soil is a good quality, red earth or red loam, water is obtained from bores on the land, and the land is within one mile of a good road.
- The investor does not have to borrow money to develop the farm. No interest cost is included.
- Good management and technical expertise are applied.

Key assumptions

Costs to produce coffee. All costs are based on present day (2005) costs of existing coffee farms in Myanmar. An inflation factor has not been included. See Tables 12.3 to 12.9 on pages 85 to 89 for details.

Coffee production/yields. Yields will average 650 kg of green bean per acre. However, it is possible that this could range between 500 kg to 1000 kg (see Table 12.2).

Coffee sale price. Green bean FOB sale price received by the grower at the port of Yangon, net of all brokerage costs, is estimated at US112 cents/lb (US$2464 /MT).

Production costs for Arabica coffee

All costs, including capital costs are accounted for when they are incurred. A table summarising the actual cash flow (profit and loss) for each year clearly indicates the years in which income exceeds costs. This model separates costs into four major categories:

Summary of cash flow model (see Table 12.1)

Direct field costs (years 1 to 3). Includes establishment and maintenance costs such as land clearing, planting, establishing and maintaining the coffee until fruit bearing (Tables 12.3 to 12.5).

Direct field costs (year 4 to 10). Includes maintaining, harvesting, processing coffee (Table 12.6).

Capital investment (years 1 to 3). Includes staff housing, sheds, farm equipment, fencing, roads and drainage (Table 12.7).

Annual overhead. Includes management salaries, health and welfare, fuel and lubricants (Table 12.8).

Green bean processing and export (yearly for years 4 to 10). Includes dry processing fees, export costs and taxes (Table 12.9).

Production assumptions

- Planting density of the coffee is 1360 trees/acre and shade trees are planted at 122 trees/acre.
- Coffee begins bearing in year 4 (from seedlings planted in the field) and reaches full production at year 6.
- Full production yield is 650 kg of clean green bean per acre achieved in year 6 after planting.
- Fresh cherry coffee is wet processed to dry parchment on the farm.
- Parchment coffee is processed to exportable green bean by contract processing at a larger coffee mill.
- Coffee is sold as a high quality coffee (Commercial or Speciality grade) to the international coffee market.
- No other commercial crops are produced on the land.
- The farm owner provides substantial management supervision and technical assistance along with off-farm co-ordination and purchasing of inputs. This time is not costed. Daily operations are carried out by a farm manager and supervisory staff.
- Costs are based on present values (May 2005).
  - 1000 Kyat is assumed to equal US$1.
  - The daily labour rate for men and women is 1000 Kyat/day.
- Costs are calculated for a single acre. This allows for calculation of larger or smaller farm sizes and for comparison with other crops and other coffee operations.

Coffee sale price assumptions

- Selling price is a key variable in determining profitability.
- This model assumes that the growers will access the international market with sale of green bean to an international buyer through a local broker.
- In the past there has been a substantial cross border trade of coffee to China and Thailand. However, evidence shows that these prices tend to be lower than the international market price.
- Selling fresh cherry or parchment at farm gate to local traders is possible, but is unlikely to provide maximum return to the grower.

Good clean parchment coffee

- Production of consistently high quality coffee and market access to international buyers through the port of Yangon are assumed possible.
- International prices for Arabica coffee have varied widely over the last 10 years from 50 c/lb to 150 c/lb. In the last three years prices have increased from NY 'C' prices of 70 c/lb to 125 c/lb. It is predicted that with the continued strong growth in coffee consumption and the continuing demand for good quality coffee, that prices should stay relatively constant for the medium term.
- Good quality, well-prepared coffee from Myanmar has a potential sale price of between minus 15 to plus 5 of the NY 'C' value FOB. This will depend on the variety, growing location and quality of processing. This assumption is based on recent FAO studies in Myanmar and international buyer assessment of Myanmar coffee.
- Fair trade organizations consider that a fair and viable price for coffee is 120 to 130 c/lb FOB.
- The grower's sale price for coffee in this model is assumed to be 112 c/lb FOB, Yangon. This is based on an international buyer price of 120 c/lb for best quality coffee. However, it is assumed that 90% of the coffee will be purchased at this price but 10% will be lower quality and sold in the international market at 80% of this price thus giving an average price of 118 c/lb. As growers will be unlikely to find their own international markets, they will have to use a broker/exporter with international marketing experience. It is assumed that the broker/exporter fee will be 5% of the FOB price thus giving an FOB price to the grower, for this model, of 112 c/lb.

Associated investment risks

Arabica coffee has been grown in Myanmar for over 75 years mainly as a low-yielding, backyard crop. However, Myanmar is not an established large scale, high production country and there are many associated risks with coffee production. Good management should anticipate these risks and lessen major problems by appropriate planning.

Key risks

Climatic. Frost, drought and wind can severely affect Arabica coffee growing. Frost is one of the major risks in this region. However, climatic change over the last 30 years has reduced the incidence of frost and has allowed coffee to be grown in a wider range of locations.

Technical. Good knowledge of coffee physiology, agronomy and pest and disease problems are essential to successful production. Selection of suitable land and varieties to be planted are critical to minimise the risk. The ability of investors to process and market their green bean is essential for farm profitability. CRIETC now has the ability to provide good technical support to coffee development in Myanmar.

Market. World coffee prices are always been volatile. While this can be expected it is generally accepted that good quality Arabica should be able to maintain prices around the present levels for the medium term, at least.

Political. The GOM is providing significant financial incentives in the form of low cost leased land. There is a risk that once coffee production becomes profitable, these incentives could be removed.

From a small coffee plant to a well organised and profitable plantation

Table 12.1 Cash flow profit and loss for growing 1 acre of coffee*

Assumptions: After 10 years production is constant at 0.65 MT/acre. Prices in US$

Growing Year	Green bean MT/ acre	Direct field costs /acre	Capital costs /acre	Overhead costs /acre	Total field cost /acre	Export /MT	Gross costs /acre	Gross sale/MT	Annual profit	Cumu-lative Profit/loss
Year 1	0.00	560.86	1,142.80	197.72	1,901.38	0.00	1,901.38	0.00	-1,901.38	-1,901.38
Year 2	0.00	275.36	0.00	197.72	473.08	0.00	473.08	0.00	-473.08	-2,374.46
Year 3	0.00	268.94	234.00	197.72	700.66	0.00	700.66	0.00	-700.66	-3,075.12
Year 4	0.25	292.55	0.00	197.72	490.27	92.83	583.10	616.00	32.90	-3,042.22
Year 5	0.40	331.55	0.00	197.72	529.27	148.53	677.80	985.60	307.80	-2,734.41
Year 6	0.65	396.55	0.00	197.72	594.27	241.36	835.63	1,601.60	765.97	-1,968.44
Year 7	0.65	396.55	0.00	197.72	594.27	241.36	835.63	1,601.60	765.97	-1,202.47
Year 8	0.65	396.55	0.00	197.72	594.27	241.36	835.63	1,601.60	765.97	-436.50
Year 9	0.65	396.55	0.00	197.72	594.27	241.36	835.63	1,601.60	765.97	329.47
Year 10	0.65	396.55	0.00	197.72	594.27	241.36	835.63	1,601.60	765.97	1,095.45
Export cost/MT = US$371.32			Sale price/MT = US$2464							

*figures are based on 1 acre from a 50 acre farm

Table 12.2 Production schedule – yield per acre projections

Year planted	Plant no. Yield/ acre	Years 1	2	3	4	5	6	7	8	9	10	Cherry (kg)	Green bean (MT)
1	Plant no.	1360											
	Yield/ac												
2	Plant no.	300	1060										
	Yield/ac												
3	Plant no.		300	1060									
	Yield/ac												
4	Plant no.			300	1060								
	Yield/ac				1625							1625	0.25
5	Plant no.				300	1060							
	Yield/ac					2600						2600	0.40
6	Plant no.						1360						
	Yield/ac						4225					4225	0.65
7	Plant no.							1360					
	Yield/ac							4225				4225	0.65
8	Plant no.								1360				
	Yield/ac								4225			4225	0.65
9	Plant no.									1360			
	Yield/ac									4225		4225	0.65
10	Plant no.										1360		
	Yield/ac										4225	4225	0.65
									Ratio cherry:green bean 6.5:1				

Assumptions: Replant 300 coffee trees in year 2 creating production lag

Table 12.3 Direct field cost for establishing one acre of coffee (year 1)

Activity			Cost for 1 acre (US$)	
	Unit	Amount	Cost/unit	Total
Labour cost				
Land Preparation (Hand labour clearing vegetation)	acre	1	50.00	50.00
Land levelling (Hand labour)	acre	1	12.00	12.00
Ploughing (60hp tractor for 2 hours)	acre	1	13.00	13.00
Harrowing (60hp tractor for 1 hour)	acre	1	6.50	6.50
Line pegging for coffee	peg	1360	0.00	2.72
Line pegging for shade	peg	212	0.00	0.42
Digging the planting holes (for shade)(2'x2'x2')	hole	212	0.04	8.48
Digging the planting holes (for coffee)(2'x2'x2')	hole	1360	0.04	54.40
Refilling the planting holes with soil & manure	hole	1572	0.01	15.72
Transport, plant & firm sticks to coffee and shade	plant	1572	0.01	15.72
Weed the whole farm (May to December)	acre	8	7.00	56.00
Watering (4 times x 5 months @ 2 gal/tree/)	acre	20	3.00	60.00
Fertilizer application (3 times per year) (3 x 1360)	plant	4080	0.00	12.24
Circle weeding coffee plants (3 times per year) (3 x 1360)	plant	4080	0.00	12.24
Making frost/heat canopy (includes local material)	plant	1360	0.04	54.40
Spraying insecticide, fungicide & foliar (4 x 1360)	plant	5440	0.00	5.44
Labour cost Year 1				**379.28**
Material costs				
Cattle manure (10 ton for hole filling)		1	80.00	80.00
Urea (50 kg bag)	bag	1	16.00	16.00
Triple super phosphate (50 kg bag)	bag	1	8.00	8.00
Potash (50 kg bag)	bag	1	8.00	8.00
Pegs to firm coffee plant & shade trees	peg.	3144	0.00	9.43
Insecticide	Litre	1	2.00	2.00
Fungicide	kg	1	3.20	3.20
Foliar spray	kg	1	1.70	1.70
Caster waste (soil inoculum)	kg	100	0.15	15.00
Silver oak seedlings	plant	42	0.02	0.84
Dadap seedlings	plant	170	0.02	3.40
Coffee plant seedlings	plant	1360	0.03	34.00
Material costs Year 1				**181.57**
Total field cost/acre Year 1				**560.86**

Table 12.4 Direct field costs for maintaining 1 acre of coffee (year 2)

Activity			Cost for 1 acre (US$)	
	Unit	Amount	Cost/unit	Total
Labour Costs				
Weeding whole farm (8/year)	acre	8	7.00	56.00
Fertilizer application (3/year x 1360)	plant	4080	0.00	12.24
Spraying insecticide, fungicide foliar (4/year)	plant	5440	0.00	5.44
Caster waste compost application (1/year)	plant	1360	0.00	2.72
Watering (3 md x 4 x 5 months @ 2 gal plant)	acre	20	3.00	60.00
Mulching (using cut weeds)	plant	1360	0.00	2.72
Circle Hand weeding	plant	1360	0.00	2.72
Making frost and heat cover	plant	1360	0.04	54.40
Removing frost cover	plant	1360	0.00	2.72
Replanting the missing plants	plant	300	0.01	3.00
Total labour cost Year 2				**201.96**
Material cost				
Urea: 110lb (50 kg) bag	bag	1	16.00	16.00
T-Super: 110 lb (50 kg) bag	bag	1	8.00	8.00
Potash: 110 lb (50 kg) bag	bag	1	8.00	8.00
Insecticide	litre	1	2.00	2.00
Fungicide	kilo	1	3.20	3.20
Foliar spray	kilo	1	1.70	1.70
Caster waste compost	kilo	100	0.15	15.00
Diesel (tractor/trailer field use)	gal	5	2.40	12.00
Coffee plant	plant	300	0.03	7.50
Total material costs				**73.40**
Total field costs per acre Year 2				**275.36**

Table 12.5 Direct field costs for maintaining 1 acre of coffee (year 3)

Activity			Cost for 1 acre (US$)	
	Unit	Amount	Cost/unit	Total
Labour cost				
Weeding the whole farm (7 md x 8/year)	ac	8	7.00	56.00
Fertilizer application (3/year)	plant	4080	0.00	8.16
Spraying insecticide, fungicide, foliar (4/year)	plant	5440	0.00	5.44
Compost fertilizer application (1/year)	plant	1360	0.00	1.36
Watering (3 md x 4 x 5 months @ 2 gal/plant)	ac	20	3.00	60.00
Mulching (1 per year)	ac	1360	0.00	2.72
Circle hand weeding (3/year)	plant	4080	0.00	8.16
Making frost cover	plant	1360	0.04	54.40
Removing frost cover	plant	1360	0.00	2.72
Picking young berry	plant	1360	0.00	2.72
Topping & desuckering	plant	1360	0.00	1.36
Total labour costs Year 3				**203.04**

Material cost				
Urea (50 kg bag)	bag	1	16.00	16.00
T-Super (50 kg bag)	bag	1	8.00	8.00
Potash (50 kg bag)	bag	1	8.00	8.00
Insecticide	litre	1	2.00	2.00
Fungicide	kilo	1	3.20	3.20
Foliar spray	kilo	1	1.70	1.70
Composted caster waste	kilo	100	0.15	15.00
Diesel	gal	5	2.40	12.00
Total material costs				**65.90**
Total field costs per acre Year 3				**268.94**

Table 12.6 Direct field costs for production (years 4 to 10)

Activity			**Cost for 1 acre (US$)**			
	Unit	**Amount**	**Cost/unit**	**Total**		
Labour cost						
Weeding 1 acre (8/year)	ac	8	7.00	56.00		
Circle weeding	plant	2720	0.00	5.44		
Fertilizer application (4/year)	plant	5440	0.00	10.88		
Spray fungicide, insecticide foliar (4/year)	plant	5440	0.00	5.44		
Irrigation (3 md x 2 x 5 months)	ac	10	3.00	30.00		
Topping & desuckering	plant	1360	0.00	2.72		
Fire break (farm perimeter)	ac	0.3	6.00	1.80		
Mulching	plant	1360	0.00	2.72	**Year 5**	**Year 6**
Harvest (ripe coffee)	kg	1625	0.02	32.50	52.00	84.50
Harvest (dry & fallen coffee for farm sanitation)	kg	100	0.06	6.00		
Process cherry to dry parchment (pulp, dry, store)	kg	1625	0.02	32.50	52.00	84.50
Total labour cost Year 4				**186.00**		
Material cost						
Urea (50kg bag)	bag	3	16.00	48.00		
T-Super (50 kg bag)	bag	1	8.00	8.00		
Potash (50kg bag)	bag	3	8.00	24.00		
Insecticide	litre	1	2.00	2.00		
Fungicide	kilo	1	3.20	3.20		
Foliar spray	kilo	1	1.70	1.70		
Coffee Seeding	plant	150	0.03	3.75		
Bamboo mats (harvest sorting)		10	0.15	1.50		
Bags (polypropylene) for harvest		20	0.12	2.40		
Diesel	gal	5	2.40	12.00		
Total material costs Year 4			**106.55**			
Total direct field costs/acre Year 4			**292.55**			
Total direct field costs/acre Year 5			**331.55**			
Total direct field costs year/acre Year 6 and beyond			**396.55**			

a) Costs for year 5 production increase to 2600 kg cherry/acre. Harvest and processing cost increases to 0.04/kg x 2600 = $104. All other costs the same as for year 4.

b) Cost for year 6 production increase to 4225 kg cherry/acre. Harvest and processing cost to 0.04/kg x 4225 = $169. All other costs the same as for year 4.

Table 12.7 Capital costs for establishing a 50 acre coffee plantation*

Detail	Size	Units	Price/unit	Total cost	Cost year
Cost of leasing land					
Lease to Govt (10,000 kyat/acre for 25 year lease)	1 acre	55	10	550	1
Legal costs to establish lease				200	1
Water supply					
Tube well with engine and pump (200 ft deep)	4 inch	2	3,000	6,000	1
Large water storage tank 20,000 gal	20'x20'x8'	1	2,000	2,000	1
Small water tanks	8'x6'x4'	4	120	4,800	1
Pipe lines to supply fields (2 miles)	2 inch		2,500	2,500	1
Farm buildings					
Farm office (incl. electrics & water)	20'x15'	1	3,500	3,500	1
Managers house (incl. electrics & water)	20'x27'	1	5,000	5,000	1
House and office furniture			1,000	1,000	1
Labour housing (50 men. Incl. electrics & water)	60'x15'	2	3,000	6,000	1
Store (fertiliser, chemical equipment)	20'x40'	1	3,200	3,200	1
Store (dry coffee)	20'x40'	1	3,200	3,200	3
Wet coffee processing house (incl. electrics & water)		1	2,500	2,500	3
Drying patio (800sqm. Incl. fence & lights)		1	4,000	4,000	3
Access roads					
Main farm access road (gravel)	1 mile			3,000	1
Internal farm roads (formed soil)	4 miles			3,000	1
Fencing					
6' fencing around farm (concrete post, barb)	1.5 miles	1.5	3,000	4,500	1
Farm machinery and equipment					
2 inch water pump and diesel engine		1	500	500	1
Farm transporter with 1 tonne trailer		2	3,000	6,000	1
500kg/hr pulper demucilager		1	1,000	1,000	3
Electrical generator 10 kva and electrics		1	700	700	1
Electrical wiring between buildings		1	500	500	1
Motor bikes for manager and supervisors x 5		5	500	2,500	1
Walkie talkie (communications)		4	60	240	1
Knapsack sprayers		5	10	50	1
General farm tools (estimate)				500	1
Scales	100 kg	4	100	400	1
Flexible irrigation hoses + fittings (100 m each)	1.5 inch	10	50	500	1
Unforeseen costs					
Add 1000 (estimate)				1,000	3
Total cost				**68,840**	
Total cost per acre = divide by 50				**1,377**	
Cost per acre required in Year 1				**1,143**	
Cost per acre required in Year 3				**234**	

* US$1 = 1000Kyat

Table 12.8 Annual overhead costs for a 50 acre coffee plantation (years 1 to 10)

Detail	Units	Cost/unit US$	Cost US$
Salaries			
Manager Salary (B Ag) (12 x 100000)	12	100.00	1,200.00
Field supervisors 4 persons (Dip Ag) (12 x 70,000)	48	70.00	3,360.00
Night security (2 x day & 2 x night) 1000 k/day	1460	1.00	1,460.00
Overhead consumables			
Petrol (motor bikes) 20 gal/month	240	2.40	576.00
Diesel (tractors, pumps gensets) 50 gal/month	600	2.40	1,440.00
Lubricants			100.00
Tarpaulins, sacks			200.00
Telephone / fax/ communication			300.00
Office supplies / admin			350.00
Labour welfare / health			200.00
Road maintenance			300.00
Machinery maintenance (lump sum estimate)			200.00
Technical and professional			
Technical advice on soil, leaf pest			200.00
Total costs of annual operational overheads			**9,886.00**
Overhead cost per acre = divide by 50			**197.72**

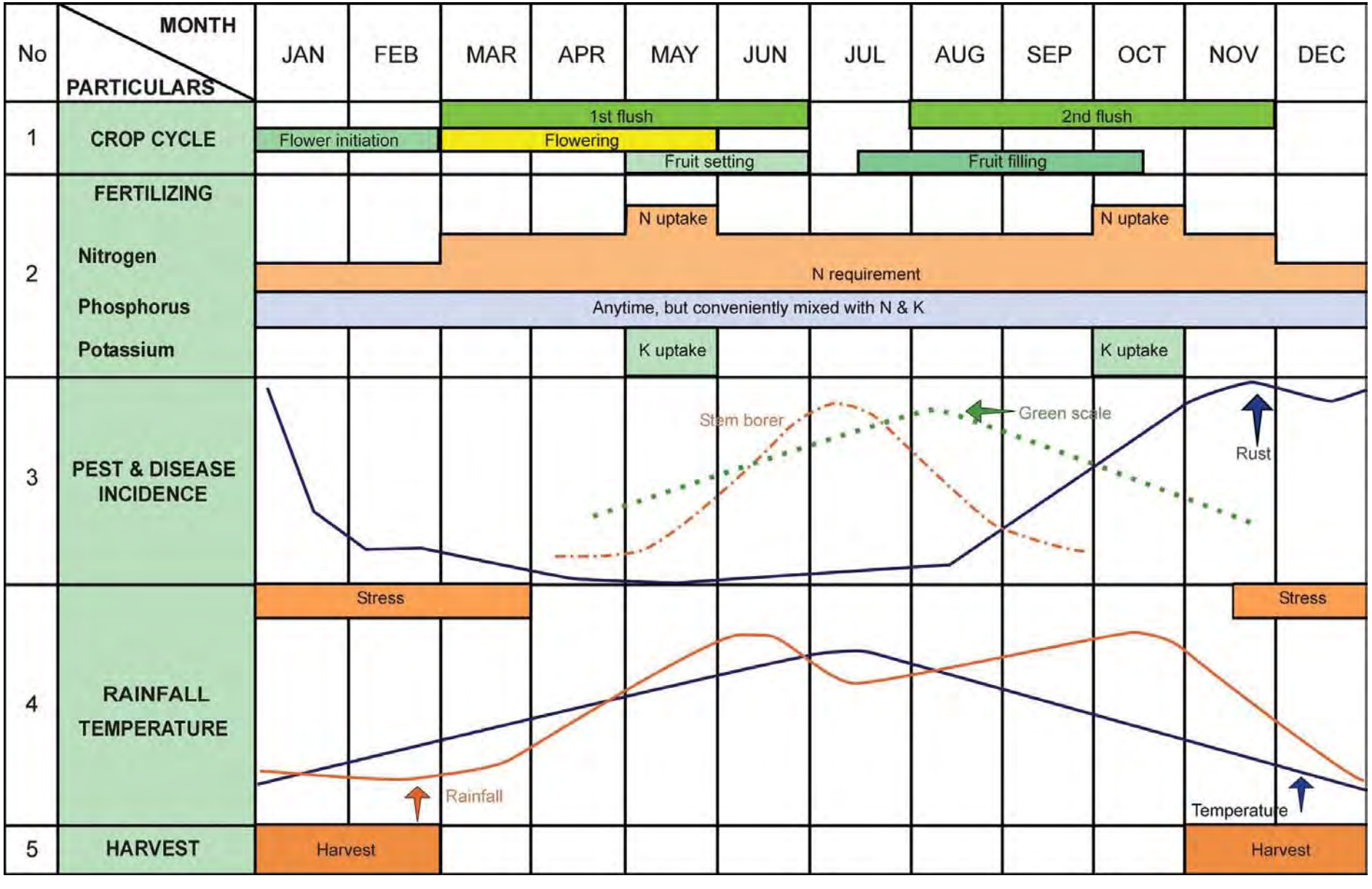
Note: No costs included for owner's time, travel or accommodation

Table 12.9 Green bean processing and export costs

Activity	Cost/ton US$
Cost of processing to green bean	
Transport to factory	10.00
Process to green bean (hull catador grade)	50.00
Hand sort to speciality grade (10 defects/300 g)	15.00
Pack in export jute bags, ready for export	20.00
Total dry processing cost	**95.00**
Cost of export through Yangon port	
Transport Pyin Oo Lwin to Yangon port	20.00
Port transport	3.50
Inspection cargo	0.45
Warehousing in port (1 month)	0.24
Labour for container stuffing	1.50
Weighing and bill of lading	0.23
Port costs and documentation	4.00
Total cost for transport and port	29.92
Government export tax	
Tax calculated at 10% FOB contract price $2464	246.40
Total cost/ton for processing, transport, port and Gov tax	**371.32**

Assumptions: Gross export sale price is calculated at an average of 112c/lb or US$2464/MT

Crop/Phenological cycle for Arabica coffee in Myanmar



Field management calendar for Arabica coffee in Myanmar

No.		Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1		**Survey site**		*										
2		**Prepare site**			*									
3		**Terrace or grass strip & hole digging**				*								
4		**Plant cover crops**					*							
5		**Plant coffee trees**						*	*	*				
6		**Intercropping: Annual / Perennial**					A*	A*	A*	A*	A*	A*	A*	
							P#	P#	P#	P#	P#	P#	P#	
7		**Field maintenance**												
	(a)	control weeds				#			#		#			#
	(b)	apply soil fertiliser					#	*				#		
	(c)	apply leaf fertiliser				**					*		*	
	(d)	water	**	**	**								*	*
	(e)	spray insecticide & fungicide						#	#	#	#	#	#	#
	(f)	mulch				#		* at planting					#	
	(h)	make frost canopy											*	
													**	
	(i)	pruning							***					
8		**Harvest**	***	***									***	***

Year 1 *	Year 2 **	Year 3 ***	All years #	A* Annual intercrop	P# Perennial intercrop (eg. fruit trees, pepper)

Index

Coffee is now an important industry in Myanmar. Currently there are 35,500 acres planted. With a very suitable climate, abundant land resources and farmers who are eager for a viable cash crop, the country has the potential to grow large amounts of high quality Arabica coffee. Myanmar has identified over 200,000 acres with soils, altitude and climate for producing Premium and Speciality Arabica coffee. The Coffee Research Information and Training Centre (CRIETC) is the key agency for coffee in Myanmar.

This manual is produced as a basis for training extension personel and farmers in growing and processing coffee. It is also a valuable resource for researchers, entrepreneurs, investors and policy makers.

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