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Australian Sub tropical Coffee

Australian subtropical coffee grower's manual

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AUSTRALIAN SUBTROPICAL COFFEE GROWERS' MANUAL

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Foreword

The Australian subtropical coffee industry emerged in the 1990s and was initially developed using information gathered from overseas experiences with coffee production in tropical regions. These systems of production, harvesting and processing had limited application in Australia's subtropical growing region – there was a strong need to adapt these principles. The pioneers of this developing industry have now documented important learnings for growing coffee in the subtropics. This manual will be vital for any new entrants into the subtropical coffee industry and will also be a useful trouble shooting tool for more experienced growers from the region.

This report is an addition to RIRDC's diverse range of over 2000 research publications and it forms part of our New and Developing Plant Industries Program which aims to facilitate the development of new and developing industries based on plant or plant products that have commercial potential for Australia.

RIRDC's publications are available for viewing, free downloading or purchasing online at www.rirdc.gov.au. Purchases can also be made by phoning 1300 634 313.

Craig Burns
Managing Director
Rural Industries Research and Development Corporation

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About this manual

This Manual is intended to inform growers and particularly those intending to become growers about good practices and possible pitfalls of growing coffee in the subtropical climate along Australia's eastern seaboard. It contains a collection of information largely based on the expert knowledge of the author and the practical experiences of the contributors.

The information is presented in a practical, easy to follow format. For this reason the Manual has been designed as a 'dynamic' document readily able to be amended, updated and added to.

Any knowledge and experience you might have and would like to contribute that would benefit growers, the industry and the quality of the coffee it produces can be added to future revisions.

The greater the seed bank of knowledge from which we can sow, the greater the potential for this young industry to grow and make a productive contribution to Australia's consumers and its economy.

David Ashton
Editor and contributing author

Acknowledgements

Production of this document would not have been possible without the continued financial and practical support offered to Australia's developing coffee industry by the Rural Industries Research and Development Corporation. The research trials funded by RIRDC since 1988 have been the platform upon which the industry has been able to establish and grow.

The practical experience offered by members of the Australian Subtropical Coffee Association has been invaluable in providing an insight into the unique growing environment of Australia's subtropics.

The information gathered has been from many scientific sources and other practical guides which has been adapted for its relevance. A short reference list is provided but I also would like to broadly acknowledge the wider sources of information.

David Peasley
Principal author

Introduction

The Australian coffee industry initially developed using information gathered from overseas experiences with coffee production in tropical regions. However, these systems of production, harvesting and processing have had limited application in Australia's subtropical growing region. New technologies based on mechanical harvesting have been developed and we are seeing a radical departure from the traditional methods of coffee production used in some other coffee-producing countries.

Most of the constraints have now been overcome and the subtropical coffee industry has established production, harvesting and processing systems to suit the environmental, social and economic landscape of the local area.

Australia's *cool climate* subtropical coffee is grown in an area stretching from Coffs Harbour (30°S) in New South Wales (NSW) in the south to Noosa (26°S) in south-east Queensland in the north. It is estimated that within this region there are approximately 35 growers on 300 hectares (ha) with potential production of 600 tonnes of dry green bean per annum from 850,000 trees.

Australia is fortunate to be one of the few regions in the world to be free of the two most serious and widespread coffee diseases: coffee berry disease and coffee rust. As a result, Australian subtropical coffee plantations use fewer chemicals, enabling subtropical coffee to be produced using natural production systems.

The mild subtropical climate allows an extended maturation and ripening of the fruit which gives the coffee a distinctive character increasingly recognised for its:

- complex flavour profile
- medium to low acidity
- natural sweetness.

The local representative body is the Australian Subtropical Coffee Association (ASTCA). The former NSW Coffee Growers' Association was restructured as ASTCA in 2008 to become a broader industry group bringing together growers, harvesting contractors, roasters, wholesalers, retailers and anyone else interested in the production and/or advancement of the Australian subtropical coffee industry.

A Strategic Plan for the Australian Subtropical Coffee Industry was developed in 2009/10 through industry consultation involving the entire supply chain and related educational and tourism organisations. Funding support for the Strategic Plan and for this Manual has been provided by the Rural Industries Research and Development Corporation (RIRDC) and ASTCA.

SECTION 1
Is coffee growing for you?

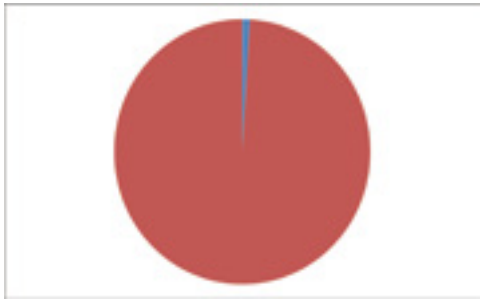
This section presents a consideration of many of the financial, horticultural, labour and logistical issues involved in the production of coffee. It provides facts and figures relating to viability.

The Australian coffee market

The pleasures of coffee were introduced to Australia by Italian immigrants during the first half of the 20th century. Our obsession gained momentum in the 1990s and has been growing ever since. Today coffee is firmly part of the Australian lifestyle. High streets and shopping malls have more coffee outlets than any other type of retail establishment and many homes now have machines and other means to make brewed – as opposed to instant – coffee. Australians have become connoisseurs of coffee and the market has become a sophisticated one where the origin and quality of the bean, the nature of the roast and the method and skill with which it is made are all relevant choice considerations.

According to the United States Department of Agriculture, Australia imported 87 million kilograms of coffee green in 2012. Quantities have been steadily rising at an average annual rate in excess of 6 per cent. Australia grows around 600,000 kilograms of coffee or less than 0.7 per cent of its total consumption.

Just a drop of the world's coffee is grown in Australia



87 million kg of coffee is imported to Australia

BIS Shrapnel's *Foodservice Coffee and Beverages Report 2012*, states that coffee is now the at-home beverage of choice for Australians, replacing tea for the first time. Australians are buying over two billion cups of coffee every year and coffee has become the number one hot beverage across all age and socio-economic groups. In the past two years the average price of an away-from home, espresso-based coffee has risen by 7 per cent. This market is expected to grow between 10 and 15 per cent within the next two years driven very much by the younger generation, while coffee consumed in the home is also expected to rise.

SOME FACTS ABOUT THE AUSTRALIAN COFFEE MARKET

- Coffee is now Australia's favourite hot beverage.
- We drink over two billion cups of coffee each year.
- The coffee market is one of the fastest growing industries in Australia.
- The price per cup and number of cups consumed continue to increase.

The growth and sophistication of the Australian coffee market, the willingness of consumers to pay well for a quality product, the concern over food miles and the economic attractiveness of home grown production are all favourable conditions for the continuing development of the Australian coffee growing industry.

Prudent economic and financial considerations

With the burgeoning coffee culture in Australia, there is an increasing romance associated with the prospect of growing your own coffee. The attractions of this dynamic market are clear, but before one takes the first step of acquiring the land or purchasing a coffee plantation, it is prudent to first consider the financial, horticultural, labour and logistical issues involved. The aim of this chapter is to introduce some of those considerations and provide some current facts and figures to assist in making the decision of whether coffee growing is for you.

The Australian coffee growing industry is established in northern Queensland and along the eastern seaboard of Australia's subtropics centred on northern NSW. This Manual relates to the latter region. The Australian Subtropical Coffee Industry is made up of a diverse group of growers on plantations of varying sizes. These range from a few fully commercial coffee plantations where the sole income is derived from growing and value-adding coffee, to part-commercial operations where there is an additional off-farm income to supplement that derived from growing coffee.

A range of what motivates and matters

Many growers entered the industry as a life-style choice with the feel-good factor of growing, processing and selling their own coffee. However, the prospect of increasing returns from value adding and the satisfaction of marketing the final roasted product, has seen some medium-sized plantations moving to vertically integrated operations by processing, roasting and selling their packaged product. This group makes up the bulk of the industry in terms of grower numbers. In addition, there are now a few large plantations operating as fully integrated businesses involved with the entire process from tree to cup.

Property size	SMALL <5,000 trees (1.5 ha)	MEDIUM 5,000–10,000 trees (1.5–4 ha)	LARGE >10,000 trees (+4 ha)
Property type	Hobby	Income yielding	Business venture
Motivation	Tree change Personal wellbeing Environmental amenity	Passion about coffee Business development Income potential	Market potential Investment returns Extension of enterprise
Principal consideration	Lifestyle	Practical ability, time and financial management	Profitability
Labour	Self	Self and casual employees	Employees
Management	Occasional and simple	Periodic and routine	Full time and complex
Support services	Largely reliant	Partly reliant	Self reliant
Establishment and operational costs	Minimal	Modest	Substantial
Returns	Returns are secondary to a feel good activity	Supports desired lifestyle or supplements income	Provides adequate return on investment

Establishment costs

One of the biggest challenges facing new entrants into the industry is to acquire land that is suitable for growing coffee at a reasonable price. The cost of a property is a major upfront outlay and subsequent sections of the Manual will assist in assessing the extent to which the asking price of land represents its value in terms of potential suitability for coffee growing.

Costs in establishing a coffee plantation can vary considerably depending on the existing vegetation, aspect of the land, the availability of contractors or the ability of landholders to carry out the necessary works themselves. The costs estimated in the following table are based on certain assumptions which are given for each item.

Item	Assumption(s)	Details	Unit cost	Cost per 10,000 trees or 4 ha NB economies of scale apply
Land preparation	A clean site suitable for growing coffee. This does not take into consideration the costs involved with removal of existing vegetation, drainage and major land works.	use of GPS navigation for accurate lay out of the plantation creation of mounded rows 3.84 metres apart v-drainage of the inter-row space planting of a cover crop to prevent soil erosion	Set up cost $1000 then $4000/ha with economies of scale	$15,000
Irrigation	A suitable water source exists with the necessary licences or harvestable water rights.	requirement is from 1–2 to 3–4 megalitres (ML) per ha depending on rainfall pressure-compensated dripper system includes pumps, laterals and sublaterals option to undertake fertigation	$2.50 per tree	$25,000
Seedlings	Seedlings purchased/supplied by a wholesale nursery or grower and planted by a contractor.	planting density 3,000 per ha in rows 3.84 metres apart spacing between plants is 90 cm for small batches less than a hectare watering-in costs are extra, if required	$2.50 per tree $3 per tree	$25,000
Equipment		tractor of 40–45 hp (second hand) ride-on-mower weed sprayer fertiliser spreader field bins x 12 (after year 4) shade cloth and black plastic for sun drying igloo for drying	$10,000 $15,000 $10,000 $1,000 $300 per bin $500 $3,000	$43,100
			Total establishment cost	**$108,100**

Maintenance and growing costs

The major regular inputs into coffee production are weed control (in young plantations in particular) and establishing and maintaining a sustainably fertile soil to optimise production.

Item	Assumption(s)	Details	Unit cost	Cost per 10,000 trees or 4 ha
Weed control	Cost of materials and maintenance of equipment; own time not costed.	mowing of inter row and control of weeds using herbicides in young plantations	$500 per ha	$2,000
Fertilising	Soil and leaf tests form basis of program.	annual program developed soil and leaf tests	$1,000 per ha $300	$4,300
			Total maintenance and growing cost	**$6,300**

Harvesting costs

Coffee was a well-established crop in the subtropics in the late 1800s but died out in the 1920s because of high labour costs. The industry rekindled during the 1980s and with the advent of machine harvesting in 1990, larger commercial plantations became established. While hand harvesting is still practised on smaller plantations, in today's labour market, it is a very expensive and impractical option on a plantation of 1,000 or more productive trees. While some of the larger plantations own their own harvester, most plantations are harvested by a contractor using a mechanical harvester. The costs involved are as follows:

Item	Assumption(s)	Details	Unit cost	Cost per 10,000 trees or 4 ha
Harvest	Mechanical harvest by contractor within 50 km radius of home base.	two harvests approximately 3 to 4 weeks apart includes freight of harvester to and from plantation and set up costs	$2,500 per harvest	$5,000

Processing

Processing is a critical step that can significantly affect the quality of the raw product. A centralised processing facility that specialises in processing for a number of growers is the ideal. The larger the volume to be processed, the greater the requirement to install (or utilise off-site) high-quality equipment to process, sort and grade product. The use of established processing centres not only avoids over-capitalisation on smaller plantations, but also enables a consistent quality product to be produced.

Item	Assumption(s)	Details	Unit cost	Cost per 10,000 trees or 4 ha NB economies of scale apply
Commercial processing facility	Facility offers processing to growers on a fee-for-service basis.	wet mill, dryers, dry mill, size and colour sorters, storage silos, elevators and associated equipment	$500,000+	
On-farm processing	Plantation is up to 20,000 trees – wet mill processing.	washer/separator 1500 kg per hour processor elevators	$9,000 $17,000 $10,000	
Outsourced processing	Cherry is harvested into field bins and wet processed, producing wet parchment/naturals.	water-separation/wet processing field bins and equipment required to transport/load harvested crop	$70 per 600 kg field bin (see equipment costs)	
Freight	Contractor to transport field bins of product to/from processing facility.	8 tonne payload	$80 per hour	
Drying	Sun drying – need to have an option in inclement weather to dry parchment.	2 cm deep 1 tonne requires 50 m^2 surface area plastic-covered igloo may be an option	Shade cloth (50 m x 2.4 m) Black plastic (50 m x 4 m)	$400 $100 $3,000
	Mechanical drying – by contractor using 3 compartment dryer. Each compartment takes 2 bins.	6 bins in (4 tonne wet parchment) yields 1 tonne dried parchment.	$0.75 per kg dried parchment	$1,200
Dry Milling	Contract dry milling of parchment – minimum 100 kg (yield of green bean from parchment is 80%).	hulled, size sorted and bagged in addition colour sorted	$1 per kg $0.50 per kg	$2,500 $1,250

Production

Production of the first commercial crop can be expected after four years from the time seedlings are planted in the ground. Some trees will flower in the spring two years after planting, giving their first, light crop in the spring at three years.

On average, a mature plantation that is 8–10 years old will yield 250 g to 500 g green bean per tree with mechanical harvesting. Hand picking can increase the yield per tree to between 400 g and 600 g per tree. Under optimum growing conditions, yields can be up to 700 g for machine harvesting and up to 1 kg green bean per tree for hand harvesting. Yield is greatest at 5 to 8 years after planting and slowly diminishes thereafter, depending on how well the plantation is maintained and the pruning regime employed. In the subtropics, the productive life of the K7 variety grown on volcanic red soils is considered to be 10 to 15 years, depending on maintenance and pruning.

Income

The biggest variable in estimating an income from growing coffee relates to the yield per tree. This is greatly influenced by the age of the trees, climatic conditions (rainfall in particular), fertility of the soil and agronomic management of the plantation. After yield, the next most important influence on income is the quality of the raw or roasted product. Of course, high yields mean little if the quality of the raw or roasted product is not consistently high.

Income can be derived from selling raw product (green bean and occasionally parchment or naturals) or by value adding and selling roasted bean either in the packet or in the cup. The table shows what value of production might be expected from small and larger plantations for a range of yields and prices for processed green bean.

Plantation		**5,000 trees**			**10,000 trees**			**20,000 trees**		
yield/tree		250 g	400 g	600 g	250 g	400 g	600 g	250 g	400 g	600 g
Value of green bean/ kg	$10	$12.5k	$20k	$30k	$25k	$40k	$60k	$50k	$80k	$120k
	$12	$15k	$24k	$36k	$30k	$48k	$72k	$60k	$96k	$144k
	$15	$18.75k	$30k	$45k	$37.5k	$60k	$90k	$75k	$120k	$180k

	Unviable But yields of 800 g+ per tree likely to be achieved through hand picking. Yield per ha can be increased with closer planting. Higher values less likely if inferior processing practices are employed.
	Provides supplementary income Good crop management and quality controls are important to maximise yields and achieved value
	Viable Higher labour and capital costs still require achievement of mid range yields and higher values

Value adding viability

Australian subtropical roasted coffee typically wholesales at around $20–$30 per kg and retails as a packaged product at around $30–$60 per kg. Further value adding occurs when sold as cups of coffee.

The following table enables a comparison to be made between incomes derived from the different products. The yield per tree has been assumed to be 400 g to enable comparisons to be made between the four products:

Product	Price per kg	Yield per trees	Yield per 100 trees	Income per 100 trees	Additional cost considerations
Parchment	$6 to $10	500 g	50 kg	$300 to $500	
Green bean	$10 to $15	400 g	40 kg	$400 to $600	dry mill processing
Roasted bean	$30 to $40	320 g	32 kg	$960 to $1,280	roasting and packaging
Coffee in the cup[1]	$350	320 g	32 kg	$11,200	overheads and other cupped components

[1] 1 kg roasted bean makes 100 cups of coffee at $3.50. Cost of coffee component/cup = about 3 cents.

The Australian subtropical region is an important international and domestic tourist destination and also a popular place to live. With an increasing demand for experiential travel, there are significant opportunities for agri-tourism in the coffee industry. There is the potential for visitors to have the full ‘coffee experience’ from the paddock to the cup in the pristine environment of the Australian subtropics where coffee is grown without the use of pesticides.

There is as yet unrecognised potential to gain value from processing waste products. Cherry skins are a potential source of high-value sugars or bio fuels and the fibre of parchment husk can be used in food products or converted to bio char.

Some conversion ratios, figures and facts

100 g of prime red cherry	=	0.5 m^3 of wet parchment
100 kg of prime red cherry	=	20 kg of dry parchment
Ratio of cherry to dry green bean	=	6:1
100 kg of tree dried naturals	=	33 kg dry green bean
100 kg of dry naturals	=	50 kg of dry green bean
100 kg of dry parchment	=	80 kg of dry green bean
100 kg of dry green bean	=	84 kg of roasted coffee

- Green bean should be dried to 12% moisture content prior to storage.
- Washed, wet parchment has 50–55% moisture content after drainage.
- Prime red cherry has 60–65% moisture content.
- Yield per mature tree of 1.5 to 4 kg of prime red cherry = 250 to 600 g of dry green bean.

Environmental considerations

The environmental factors to take into account when considering whether to grow coffee are varied. They include the following:

- The Australian subtropical region is one of the few coffee growing regions in the world that is free of the major diseases of coffee: coffee borer disease and coffee leaf rust. As a result of this, no insecticides and fungicides are sprayed on coffee in this region. The crop lends itself to a more sustainable farming approach and/or organic production.
- Processing plants need to establish good effluent management and control through the use of settling ponds to ensure run-off does not pollute adjacent waterways.
- Care needs to be taken to control seedlings in/near plantation perimeters and to channel drainage away from water courses.
- Unusually, rats and bats can cause problems in plantations when environmental conditions favour their predatory behaviour.
- In the increasingly urbanised environment of the Australian subtropics, coffee is a most compatible crop to grow at the urban/rural (peri-urban) interface. Its light environmental footprint fits in well with the high conservation value of this region.

What are the *Pros* of growing coffee in Australia's subtropics?
• demand far exceeds supply; 99% of coffee consumed in Australia is from imported beans
• Australian coffee is a high value niche product competing in a free commercial market
• coffee is increasingly an integral part of the social fabric; this coupled with the movement to 'buy local' has the potential to give Australian Subtropical coffee a marketing edge
• Australian subtropical coffee has approximately 10–25% less caffeine than imported coffee
• coffee growing is ideally suited to the subtropical environment with its fertile volcanic soils, abundant reliable rainfall and moderate temperatures
• none of the major coffee pests or diseases that affect coffee production in the rest of the world are present in Australia
• no insecticides or fungicides are used in its production
• it is an environmentally sustainable crop
• it is amenable to biological farming and organic production
• it is compatible with urban activities
• it is an attractive crop in appearance
• coffee growing can be a lifestyle choice with all aspects of production lending themselves to being contracted out; you can do as little or as much as you choose
• for a tree crop there is a relatively quick commercial return
• busy times are seasonal from September to January over the harvest period
• the technology for harvesting and processing has been developed and adapted for the Australian industry
• the region has an excellent supporting infrastructure of fabricators, engineers, contractors and freight services
• a vibrant industry association provides a forum for all who have an interest in Australian subtropical coffee to interact, learn from each other and grow the industry
• this is a challenging yet very rewarding industry that induces passion in people – from growers to consumers.

What are the *Cons* of growing coffee in Australia's subtropics?
• suitable land is expensive and there is competition from other agricultural industries for its utilisation
• there are constraints on the topography of suitable land
• competition from cheap imported coffee in general
• competition from imported coffees branded as 'Rainforest Alliance' or 'Fair Trade' with consumers having a poor understanding of what that branding means
• brand confusion in the marketplace
• no overarching regional brand in a fragmented market
• high input costs – fuel, fertiliser, electricity, labour, harvesting (multiple passes)
• lack of available casual labour for peak times
• unpredictability of rain fall in the spring can result in multiple flowerings which translate into multiple harvests the following year

The Industry's Strategic Plan, Contributors to this Manual and Where to Next

The subtropical coffee industry has been proactive in developing a Strategic Plan which establishes the groundwork for the industry to fulfil its potential and will guide the strategic development of the industry. A summary document of the Strategic Plan is available online at: http://www.astca.org/wp-content/uploads/2011/12/ASTCA-strategic-plan-summary-18.12.11.pdf.

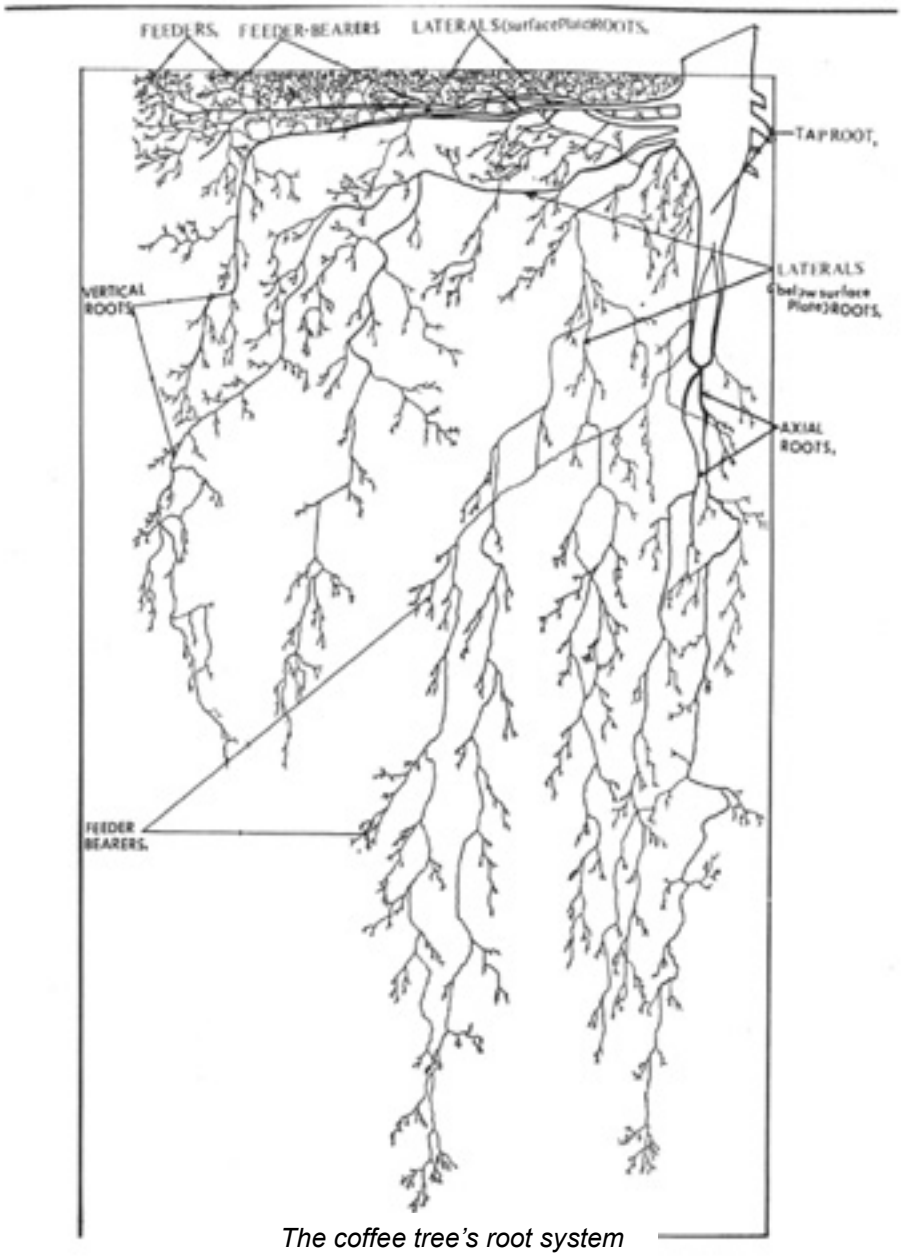
The following attended and contributed to a workshop held on 23 April 2013 that forms the basis of the information gathered together for this chapter: Steve Conrad, Jan Fadelli, Richard Gibson, Robert Grant, Craig Hayward, John Musgrave, David Peasley, Bernard Rooney, Peter Webb, Jos Webber, Ron Woods, June Zentveld.

If after reading this first section, your pulse has quickened, your interest is raised and you wish to know more about how to go about growing coffee, then the following sections of this Manual are designed to cover the basics of growing coffee in the Australian subtropics.

SECTION 2
The coffee tree

Understanding the unique features of the root system and growth habit of the coffee tree provides a sound basis for cultivation management decisions including irrigation timing, fertiliser application, harvesting and pruning operations.

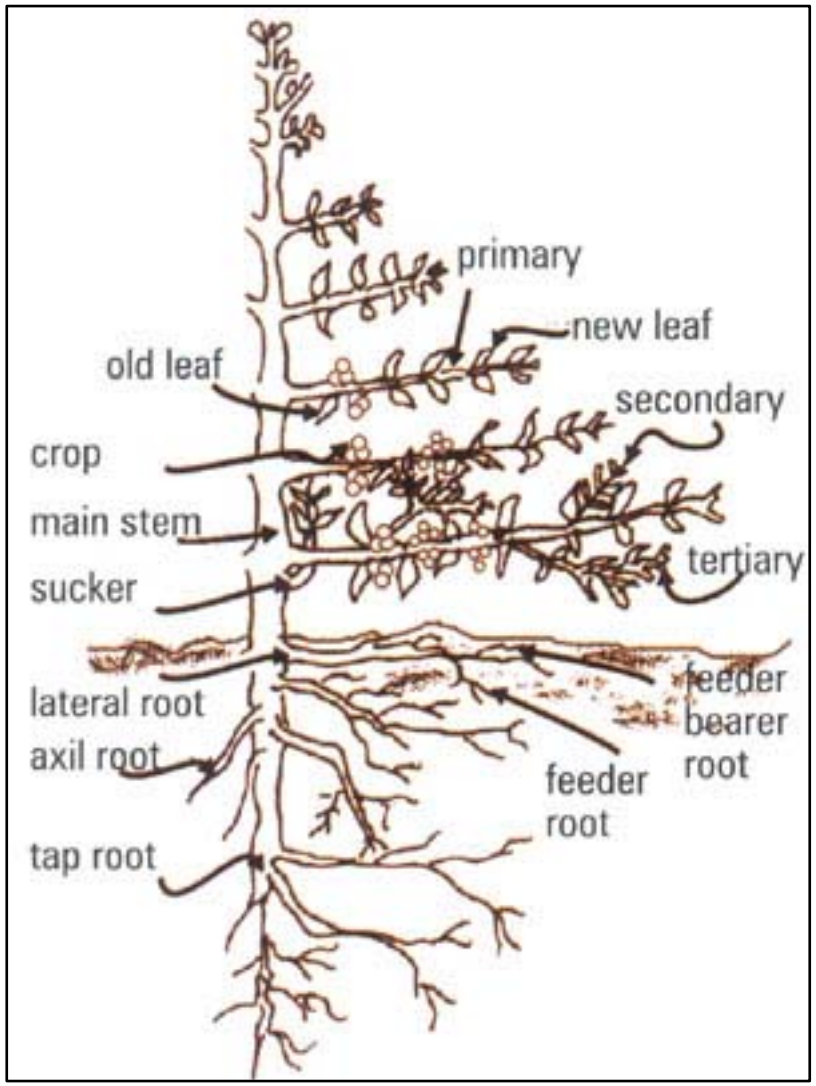
This section relates to the root system and above-ground parts of the tree. It describes how each part of the tree functions in the establishment, growth and fruiting phases of development and what might impact on the development of a mature productive tree. Advice is given as to how those impacts might be mitigated.



The coffee tree's root system

The root system has been restricted by a compacted clay layer

CONTEXT	PROBLEM	MANAGEMENT
The root system ***The tree's axial roots can extend down 3 to 4 metres in well drained soil.***	Poor drainage, a clay layer, soil compaction, rocks and rock shelf as well as transplanting constricted or damaged roots can cause a weak and unstable root system.	Check soil depth, deep rip the plant line and do not plant in poorly drained, shallow soils. Mound tree rows to improve drainage and harvester efficiency. Check the quality of plant stock.
The majority of lateral and feeder roots occur in the top 30 cm of soil. The tap root is short (30-40 cm).	Trees are easily blown over (lodged) by wind and heavy rain.	Remove/replace weak trees. Use grass cover to protect from exposure through erosion.
The deep, vertical (axial) roots and laterals provide the anchorage for stability.	Seedling root systems are easily bent during transplanting into pots and from pots to the field. Trees with weak root systems are more susceptible to die back (from overbearing) and do not recover. Premature ripening of cherry results in poor cupping quality.	Ensure the main and axial roots are not bent or distorted when transplanting seedlings. See Section 4.
	The normal growth, flowering and cropping cycle is interrupted when the root system is restricted.	Prevent water logging by providing good drainage and mounding, and do not plant in 'wet spots'.
	When trees are stressed by poor soil, nutrition and/or water, the roots are the first to suffer.	Maintain high organic matter (mulching) under the tree canopy. Test and adjust soils for compaction, water retention, organism activity, soil nutrition and pH balance. See Sections 7 and 8.



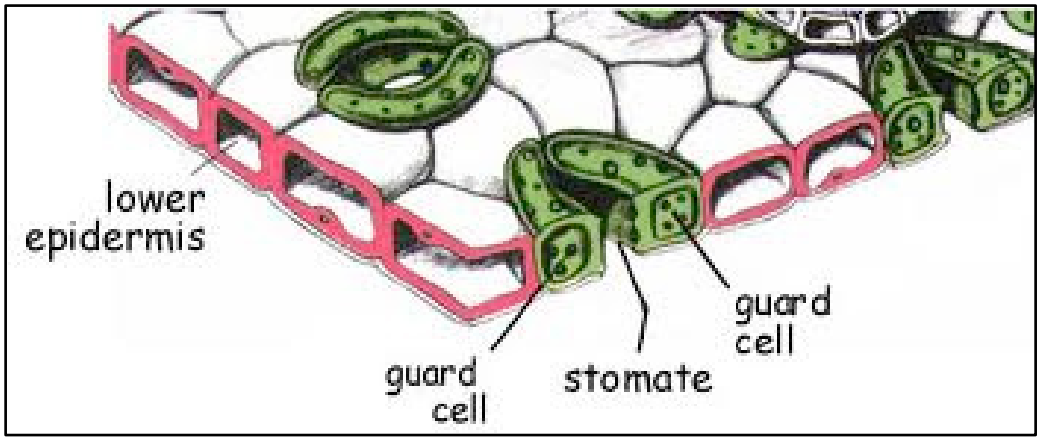
Branch hierarchy of the coffee tree

Main stem and primary branches of the coffee tree

CONTEXT	PROBLEM	MANAGEMENT
The root system *(continued)* ***Excessive irrigation of coffee during the establishment phase results in the production of superficial roots.***	Penetration depth of the main axial roots may be reduced resulting in poor anchorage. The trees are also less able to withstand dry conditions and be unable to access nutrients and water effectively.	Avoid frequent, light superficial irrigations after the establishment phase (the first year after planting). Ensure irrigation penetrates to below the root zone. See Sections 7 and 8.
Many of the plant hormones (auxins) that control flowering, fruit development and growth are produced in the roots.	A poor root system can result in overbearing, die back and irregular development of flowering and fruiting.	A healthy root system, good soil nutrition and water availability are essential for sustained yields and tree health. See Sections 7 and 8.
Coffee roots are the last to receive the plant foods (photosynthates) produced by the leaves.	Poor nutrition and root structure will cause rapid decline in tree health cherry productivity.	Ensure healthy leaf growth through foliant as well as ground fertilisation at critical times during periods of high nutrient take up. See Section 8.
Main stem and branches ***The main stem (trunk) is the central axis of the tree. At the tip of the main stem is the apical bud which controls the development of a main shoot from the main stem and all the buds below it.***	If the apical bud is damaged or removed when the tree is pruned, one or two of the lower buds in the leaf axil of the main stem will develop as suckers or secondary verticals to replace the last upright stem.	Avoid damaging the main shoot during the growth of the tree until at its desired height (300–500 mm). Remove suckers at the base of the tree and to a height of 600 mm to facilitate mechanical harvesting and focus tree growth. Other secondary verticals should be thinned out.
Trees such as K7s typically have four types of branches: • ***primary branches extend from the trunk*** • ***secondary, tertiary and quaternary branches, each extending from the preceding type.***	If a primary branch is cut at the main stem the branch will not be replaced by another as the lower buds in the leaf axils of the vertical shoots can only produce verticals or flowers. If the horizontal primary branches are cut they can produce more lateral branches as secondary and tertiaries or flowers but they cannot develop into vertical shoots.	Pruning releases lateral buds from dormancy to produce new shoots. See Section 8 relating to pruning.

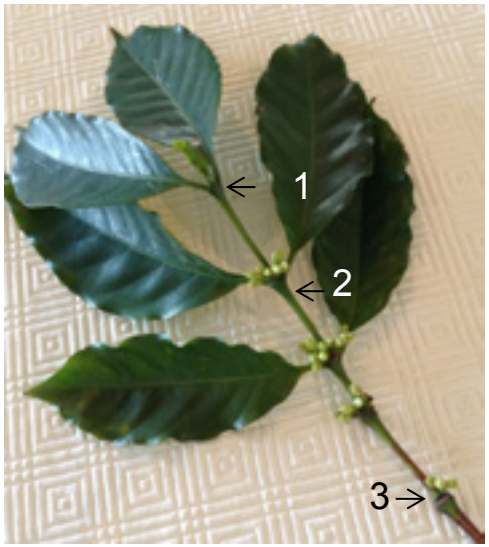
Mature green and immature bronze leaves of K7 variety trees

Diagram showing stomates in the leaf



CONTEXT	PROBLEM	MANAGEMENT
Leaves and stomates ***Leaves are produced throughout the year to replace old leaves.*** ***New leaves of Catuai and CRB tree varieties are light green while K7 leaves are bronze in colour. Mature leaves become dark green.***	Insufficient leaf development or leaf loss through stress reduces tree health. Beans within cherries will not properly form. Extended dry periods will cause leaf loss. Without leaf cover cherry is over exposed to the sun and prematurely ripens with immature beans.	The critical time to promote leaf development through fertilisation is after harvesting and post flowering. A sound fertiliser and irrigation regime will keep trees in full leaf.
The cooling ability of leaves through evaporation is lost at temperatures over 32°C.	Daytime temperatures particularly in more inland locations can exceed 32°C for periods of a week or so. If high temperatures occur too frequently and for extended periods, the tree's cooling mechanism (i.e. stomates) shuts down.	The subtropical climate is a benefit but temperature regimes are a factor when considering location. Little can be done to lessen the impact of temperature other than to grow under shade, however, this will reduce yield.
The surface of coffee leaves can record temperatures up to 10°C above air temperature if their stomata cooling system is shut down.	Exposed leaves become pale and are shed and the tree may go into decline and develop die back.	Spray irrigation will reduce leaf temperatures. Plantation layout should take into account the direction of prevailing drying winds.
Stomata are tiny pores on the underside of leaves. They enable gaseous exchange in photosynthesis and respiration, regulating moisture loss and carbon dioxide concentration.	Stomata are entry points for many fungal and other pathogens. Extreme conditions of high temperatures and hot dry winds can cause trees to shut down and shed their leaves.	Regularly check the undersides of leaves for signs of fungal growth. Aerial spraying will reduce the impact of extreme conditions.
Stomates open at sunrise and are fully open at a temperature of 25°C, the optimal temperature for photosynthesis and gas exchange.	Lack of adequate soil moisture combined with high temperatures cause the stomates to close and the tree shuts down its capacity to produce photosynthates (or plant carbohydrates) and transpire moisture.	Irrigate early in the day when high temperatures are predicted to minimise the impact.

Wavy leaf margins and drooping leaves indicate high temperatures, moisture stress and poor nutrition. This causes trees to 'shut down' and may result in leaf drop predisposing them to die back.



1 *Leaf axil*

2 *Lateral buds at the leaf axil at the point of flowering*

3 *Ring at the point where last year's growth commenced*

Wavy leaf margins and drooping leaves are a symptom of high temperatures as stomates shut down

CONTEXT	PROBLEM	MANAGEMENT
Leaves and stomates *(continued)* ***At temperatures below 15°C the stomates do not operate to their full capacity.***	Generally this is not a problem, other than where land profiles cause pockets of cold air to be trapped. The likelihood of frost is the principal consideration.	Avoid planting in cold air hollows and remove vegetation that could trap cold air. If perceived as a significant problem and other orientation considerations are not compromised, orient rows to allow cold air to pass down rather than through them.
Stomates play a major role in maintaining the water balance within the plant.	Internal water deficit (water stress) affects many physiological processes within the plant. Chlorosis (yellowing) of leaves, leaf fall, sunburn of fruit, premature ripening, decrease in bean size and die back can occur.	Maintain adequate soil moisture by monitoring soil moisture levels and irrigate according to crop load, weather conditions and stage of crop cycle. See Section 8.
Flowers and fruit growth ***Bud development occurs in the leaf axil and is controlled by hormones from a serial bud.***	Buds form in the spring but remain dormant until temperatures rise and dry conditions are broken by a good rainfall (usually above 8 mm) or by heavy irrigation.	Restrict irrigation to create an extended period of stress. Promote growth immediately after heavy and prolonged rain by fertilising.
A major flowering event occurs after a defined period of dry or cold stress and a significant rain event to break dormancy. The whole plantation is awash with flowers 8 to 12 days after the rain trigger. Temperature triggers the flowers to open. After two days the flowers wither and the floral parts, except the ovaries (developing fruit), drop away.	A single flowering is an ideal occurrence. However, the break of the dry subtropical winter is often by a series of intermittent showers which initiate multiple flowerings.	Flower production can be stimulated by heavy irrigation once the flower buds have reached the 'candle' or swollen stage.
Multiple flowering events happen if a series of spring rains occurs.	As many as six to eight flowering events can occur over a three month period. The early flowerings can coincide with the final harvest.	It is preferable to complete the harvest after a small flowering event to remove the crop and promote the later development of buds and flowers.

Synchronised flowering is triggered by rainfall after an extended dry stress period

Residual crop hinders the formation of new buds and flowers

Flower clusters occur at each node and can set up to 30 fruits (cherries)

CONTEXT	PROBLEM	MANAGEMENT
Flowers and fruit growth (continued) ***Harvesting after flowering.***	Matured cherry held on the tree will hinder the development of next year's buds. Harvesting flowering trees will hinder flowers from setting. If harvesting is delayed, the cherry will rapidly ripen and be shed as the tree focuses on next year.	Harvesting before flowering is the aim. If the opportunity is missed and a major flowering occurs, further harvesting should be delayed at least a week to allow flowers to set. Machine harvesting should be delicate or even abandoned, i.e. sacrificing the last of the crop.
From 6 to 9 weeks after flowering, pinheads slowly develop. The pinhead then swells and the endosperm (the starchy tissue of the seed) forms. Full size is reached at week 20.	Trees will shed those pinheads that it is unable to carry through to maturity.	Undertake a fertilisation regime to match the nutrient requirements of the tree in line with pinhead growth.
Seven months after flowering, the seed develops fully as dry matter is formed. Its structure and size are virtually complete. It then only needs to ripen.	During this period, the young green cherries are most susceptible to damage through fungal attack, leaf loss and die back.	Regularly check the wellbeing of trees. Maintain good nutrition and irrigation to avoid Cercospora spot.
A long ripening period over 3–4 months occurs in subtropical conditions. The timing and ripening period depend on factors such as altitude, topography, shading, tree health and distance from the sea.	Starting harvesting too early can be costly in crop loss of immature cherry. Cherries are also more difficult to remove early in the season.	Monitor cherry maturity before harvesting. See Section 9 for details. Attend to other tasks, check harvesting equipment and arrangements and be patient. Delay harvest until the critical maturity point is reached.
Early ripening cherry	Early selective machine harvesting is difficult as cherries are harder to remove. Harvesting costs are higher and unwanted immature green cherry is harvested.	Hand pick or allow early ripening cherry to mature to naturals as the remainder of the crop fully ripens.
In cooler areas of the hinterland, ripening occurs in late winter to the end of spring while in warmer coastal areas, ripening occurs up to 6 weeks earlier.	There is a greater chance of a harvesting/flowering conflict inland but more cherry will hold on the tree and gain full ripeness. Earlier ripening in coastal locations extends the harvesting period.	Keep a wary eye on weather predictions, particularly for strong winds in September, for inland plantations; while coastal locations have the challenge of identifying and dealing with a number of harvest passes.

Size variation of green cherry development from a multiple-flowering event

Different stages of ripening of coffee cherry resulting from a multiple-flowering event

Synchronised cherry maturity resulting from synchronised flowering

CONTEXT	PROBLEM	MANAGEMENT
The coffee tree is unable to shed excess fruits. The trees are committed to filling all the beans that are formed after the fruit expansion stage.	Where plant food is limited, seeds do not fully develop. They contaminate the quality of the harvest and have no value as coffee. Poor pollination, nutrition or water management can result in a high percentage of poorly developed seed. These are lighter in weight and need to be removed from the crop during processing.	Cherry with undeveloped seed need to be separated from viable seed. Separating from prime cherry is by floating them off from fully ripened cherry. Separating from fully ripened cherry is by hulling, with most being hollow or small and thus discarded. Those that remain need to be removed by size sorting.
Seeds have priority for nutrients drawing plant food away from the branches. With a heavy crop and particularly when nutrients are limited, growth of leaves and shoots is restricted.	Die back will be evident. Cherry ripens prematurely through die back. It will have poor liquoring quality and bean size. Yellowing (chlorosis) and leaf fall will occur at fruiting nodes heavily populated with cherry.	Ensure that adequate nutrition and water are provided according to crop load and climatic conditions. See Section 8. Use a holistic approach incorporating a balance of slow release natural mineral fertilisers to provide a more controlled release of nutrients rather than relying entirely on synthetic high analysis fertilisers which can promote troughs and spurts of growth.

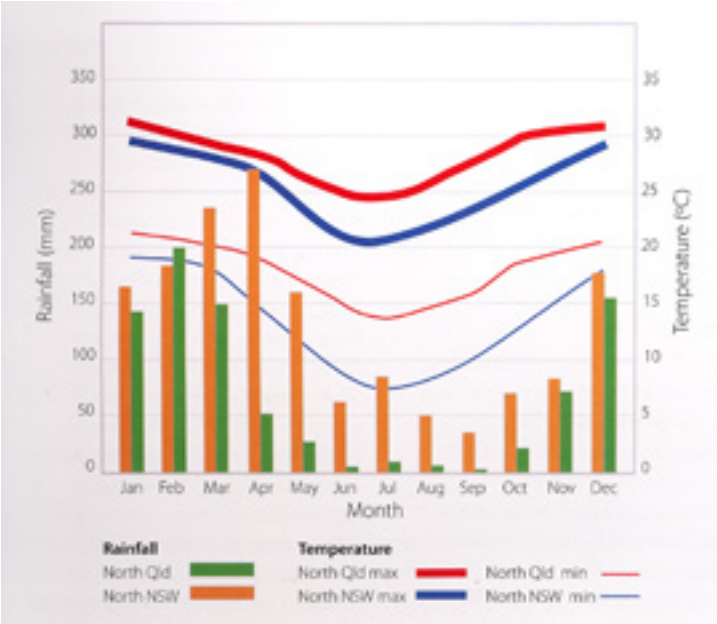
SECTION 3
Growing coffee in Australia's subtropics

The coffee tree originated in the tropics and it might be assumed that it is most suited to growing in tropical climates. However, the best-tasting coffees are grown at higher altitudes within the tropics where a cooler climate creates a longer maturing period for ripening.

The subtropical climate of Australia's eastern seaboard mimics the cooler higher altitudes of the tropics. It has a long, cool period during which the coffee cherries mature. In addition, the gentler winter sun and dry winters (promoting ripening through tree stress) make this region most suitable for producing quality coffee.

While Australia's subtropical eastern seaboard is suitable for growing coffee, it differs from the tropics in terms of temperature, soil, sunlight and water. Every location has a unique combination of these essential requirements for plant growth that influence the extent of its suitability. This section provides a description of the region's coffee-growing attributes, in terms of temperature, soils, sunlight and water.

"Altitude itself is less important than the interaction of altitude, latitude, aspect and slope and their combined effect on temperature and light". (M. St J. Clowes 1981)



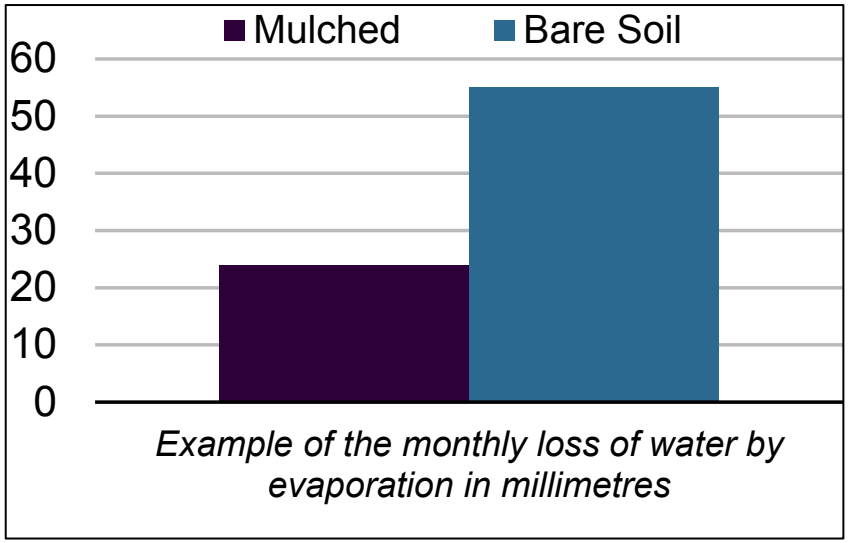
Rainfall and temperature profiles for subtropical northern NSW and tropical north Queensland Tablelands (Mareeba).

Cold air settles in lower areas and hollows, creating frost and killing the trees

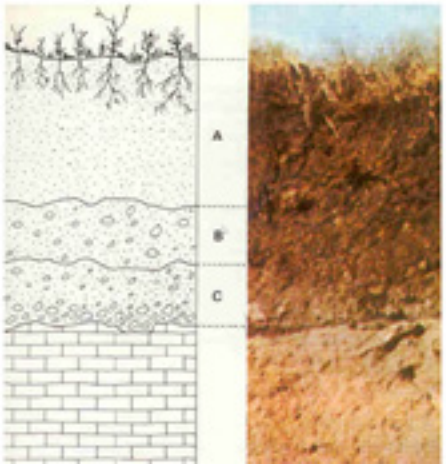
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years	
Temperature															
Mean maximum temperature (°C)	27.2	26.7	25.9	23.9	21.2	19.0	18.6	20.0	22.4	24.1	25.3	26.9	23.4	38	
Mean minimum temperature (°C)	19.5	19.4	18.3	15.9	13.3	10.9	9.9	10.6	12.8	14.8	16.6	18.5	15.0	38	
Rainfall															
Mean rainfall (mm)	177.8	224.9	260.6	196.7	182.4	164.6	94.3	74.8	55.6	109.2	132.7	153.3	1825.4	48	
Decile 5 (median) rainfall (mm)	145.9	168.3	225.0	158.0	148.6	121.8	74.1	47.6	34.2	83.0	111.3	118.6	1682.7	48	
Mean number of days of rain ≥ 1 mm	11.9	13.1	14.0	12.3	11.4	9.4	7.4	6.5	5.9	8.3	10.9	10.7	121.8	48	
Other daily elements															
Mean daily sunshine (hours)	7.4	6.9	6.7	6.7	6.1	6.1	6.9	7.7	8.1	7.8	7.6	7.6	7.1	28	

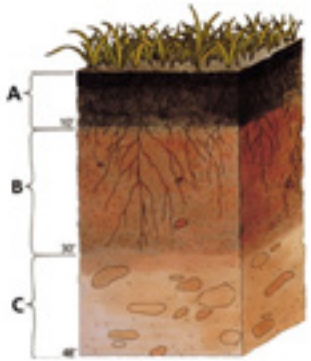
Monthly climate statistics for the Alstonville Plateau within the major coffee production area of the subtropics – source: Bureau of Meteorology

CONTEXT	PROBLEM	MANAGEMENT
Temperature, soil, light and water are the four essentials for vibrant plant growth. Locational characteristics that influence growth include latitude, altitude, aspect, slope and exposure to wind.	Every growing region has a unique combination of characteristics. Between the region's plantations and even within plantations there are subtle variations. How well coffee grows in each situation and how it is finally appreciated in the cup depends on how well the grower recognises and takes advantage of these characteristics.	Each of these aspects is considered generally here, however you are advised to refer in detail to the geological and climatic references and records, to seek out local knowledge and to extensively explore the character of the region.
Temperature ***Optimum temperatures for coffee range between15°–24°C. Continuous exposure to temperatures above 30°C can result in reduced photosynthesis, leaf damage and impede cherry development.***	The earlier table shows that mean maximum and minimum temperatures sit comfortably within the optimum range but there are exceptions particularly in relation to frosts.	The further away from the coast, the more critical consideration of temperature becomes. Local advice regarding frost likelihood on lower lying land and hollows will be particularly valuable. See also Section 5.
Low temperature is the major constraint to commercial coffee growing in the subtropics. Inland lower-lying land experiences temperature inversions.	Frosts kill coffee trees. Even short periods below 0°C will defoliate trees and destroy fruit. Growth is restricted below 7°C and young trees are injured below 3°C.	Check weather records to identify frost-prone areas and seek local advice to identify adverse micro-climate pockets of cold air. Remove or thin out vegetation on lower slopes to allow cold air to drain.
Wide ranges in temperature between night and day occur in this region, more particularly away from the coast. If combined with a southerly cold change, temperature change can be as much as 20°C.	Distorted yellow (chlorotic) new growth known as 'hot-cold' syndrome occurs when night temperatures suddenly drop. As a temperature rather than nutritional problem, trees will produce healthy growth when temperatures moderate.	Check daily weather records for typical day/night temperature variations and if they are prevalent be wary of south-west facing exposed slopes. Do not force growth by over fertilising.
Soil temperatures are coldest on the soil surface. About 50–100 mm below the surface the soil remains warmer.	Frost damage is greatest in dry soils.	Good soil moisture, a thick mulch cover and mounding planting rows are all methods of reducing opportunities for soils to get too cold for comfort.



Example of the monthly loss of water by evaporation in millimetres





Zone A: organic activity, nutrient feeding

Zone B: moisture and mineral absorption

Zone C: trace elements absorption

Take trial bores and analyse the soil profile in terms of structure, organic content and mineral composition to understand the medium you have to work with.

Northern Rivers Soil Healthcare Card
A specific card relating to coffee growing has been produced and is available at www.soilcare.org.au

For soil and leaf analyses see also:

- Northern Rivers Soil Best Management Practice Guide for Coffee
- Northern Rivers Soil Health Care Card "Best Management Practices for Soil Health"

Published by Landcare SoilCare Inc., Dept of Agriculture, Fisheries and Forestry and NSW Dept of Primary Industries 2008.

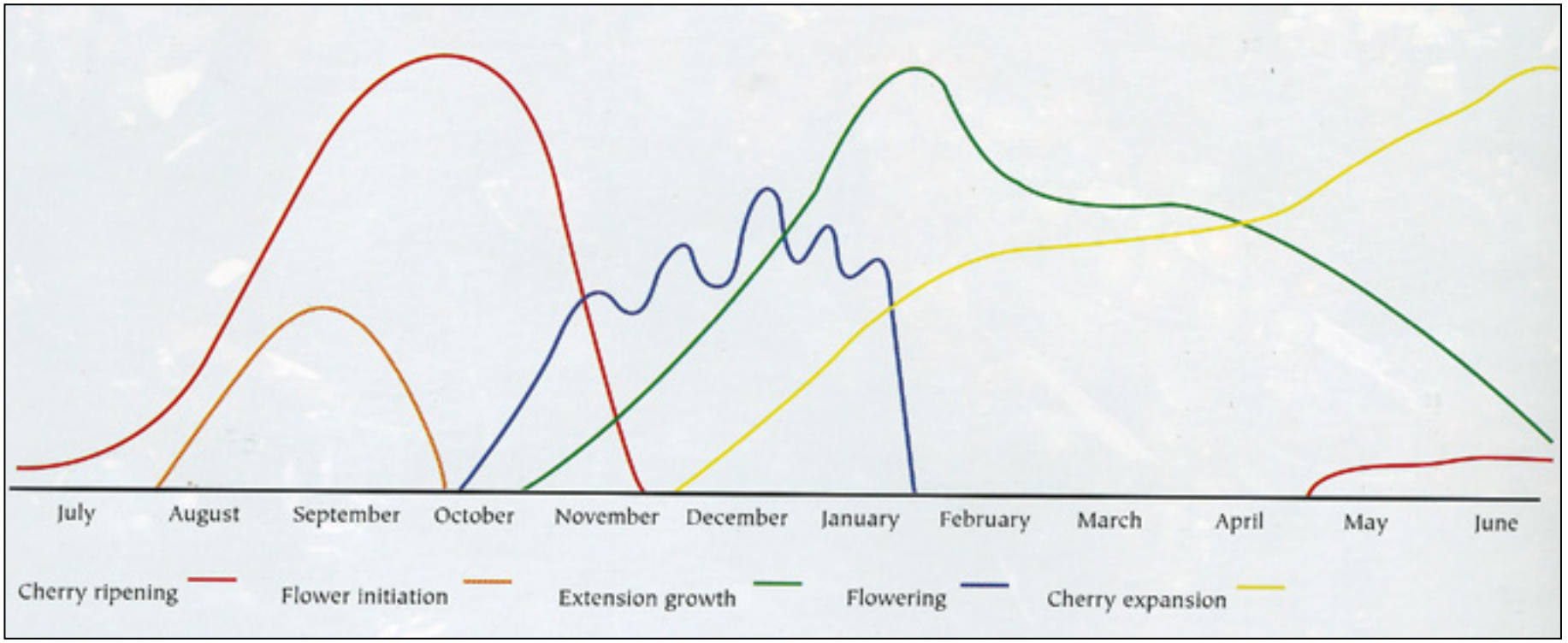
Prior to and at time of planting, coarse mulch needs to be produced and spread on exposed soil around newly planted trees and constantly built up to become a thick bed of under-canopy organic matter.

CONTEXT	PROBLEM	MANAGEMENT
Soils ***Coffee can be grown on many soil types, but the soil needs to be slightly acidic. A deep, fertile, permeable and porous volcanic red earth soil is ideal.***	Much of the subtropical region has the red volcanic soil that is regarded the most ideal for coffee. It extends to good depths but in places, acidity has increased through clearing, exposure and past agricultural practices. There are areas of rocky, sandy and 'pug' soils which should be avoided.	Take trial bores across the property to check soil profile and depth. Most soils will need applications of dolomite or lime and enhancement of minor elements to maintain perfect growing conditions. See also Section 5.
Research has shown that the cupping quality of coffee is influenced by the nutrient and mineral composition of the soil. The balance of phosphorous, nitrogen, magnesium and potassium together with trace elements is of primary importance.	Within the region, there are variations in the chemical soil composition from location to location and even within plantations. This may result in producing variations in the flavour profile. Research is currently being undertaken to better understand the factors contributing to the region's distinctive coffee flavour.	While quality can be influenced with applied nutrients, the contribution to flavour of trace elements is an important aspect of 'terroir'. The challenge is to present an overall consistency of the region's distinctiveness whilst maintaining the individuality of coffee from each plantation.
Soils with a high organic content are desirable as they assist assimilation of applied fertilisers, are less prone to erosion and offer better water and nutrient retention. Being once a subtropical rainforest, the region's soils in their natural state are relatively high in organic matter (18–20%)	Clearance of the original subtropical rainforest and exposure or subsequent agricultural practices could have reduced organic content to as low as 2–3%.	Building up a good cover of under-canopy mulch is important to enhance organic matter in the easily impoverished soils of the region.

An example of a young tree having suffered a combination of water stress and exposure to sunlight

Poor nutrition and water management predispose trees to die back, particularly when trees carry a heavy crop

CONTEXT	PROBLEM	MANAGEMENT
Sunlight ***Coffee is a shade-loving, mid-storey tropical rainforest plant. However, under-canopy production is not commercially realistic and management practices have been adapted to enable high productivity under full sun.*** ***In subtropical areas, the sun is less harsh and tracks across the sky at a lower angle than in the tropics, particularly in winter, resulting in lower light exposure/intensity on the western and southern sides of the tree.***	The lower angle of the sun particularly during the ripening period in winter increases the uneven ripening of cherry on each side of the trees running in an east-west direction. Uneven ripening increases harvesting costs as additional passes are required. The weaker winter sunlight discourages photosynthesis, stressing trees and halting the development of flowering – a distinct harvest advantage.	The less-harsh subtropical sun is a positive advantage that prolongs the ripening period with the only disadvantage being uneven ripening emphasising the need to avoid east-west plant rows. Wider spacing rows would allow greater light penetration to lower branches but at the cost of reducing the number of trees planted on the land available.
In full sun, evaporation and nutrient take-up are greater.	The trees are prone to overbearing and die back of laterals; branches and eventually the whole tree can die if nutrient stressed. A biennial bearing cycle can result if trees become significantly stressed because of nutrient depletion.	The cloud cover of this region compared to that of other tropical coffee growing regions is greater and the impact of full sun is less. However, during extended dry spells particularly during the ripening period, ensure that adequate nutrition and water is provided.
Shade is not required for high productivity or quality.	Low yields result from excessive shading.	Ignore advice relating to growing coffee under shade trees Avoid planting in close proximity to the canopies of adjacent trees. Yields are higher in full sun – provided nutrition and water requirements are met.



The coffee tree's cycle of growth, flower initiation, flowering, cherry expansion and ripening under subtropical conditions

CONTEXT	PROBLEM	MANAGEMENT
Water ***How rainfall is distributed throughout the year is more important than annual rainfall.***	The subtropical rainfall profile of the region differs from a typical tropical coffee growing region. The wet and dry seasons of the tropics are more defined than in the subtropics. And there is less definition of the transition from wet to dry at the critical stage of harvesting.	Higher rainfall during the wet growing period and a higher number of rain events during the bean maturing period are benefits. There is less need for irrigation but it is still useful for fertigation to restore nutrients, to maintain tree health and minimise the risks of overbearing die back and biennial bearing. Irrigation is also useful after harvesting to assist stressed trees to recover and to stimulate flowering.
The effects of the changes from wet to dry seasons and vice versa are vital for initiating flowering, breaking flower dormancy and inducing vegetative growth.	The lack of a defined 'dry' season in the subtropics and the prolonged maturity period for the coffee cherry results in multiple flowerings and poor breaking of dormancy of flower buds.	Withholding irrigation after harvesting in earlier coastal areas may improve the intensity of flowering by prolonging the stress period within the plant; however, this is difficult to achieve in later-maturing plantations where flowering overlaps with the end of the harvest period.
Steep sloping lands have poor moisture holding capabilities, and are conducive to soil moisture stress. Harvesting efficiency is also reduced on steeply sloping land.	Low yields, and poor harvesting efficiency are experienced on steep slopes above 15%.	Avoid planting on steep slopes. Orientate rows up and down the slope. If steeper slopes have to be planted, ensure adequate irrigation is supplied using pressure compensation.
Development of the cherry continues into the dry winter months when conditions for growth and photosynthesis are poor. ***The plant must meet the increasing demands for assimilates (plant food) of the developing crop.*** ***Cherry clusters draw nutrients from adjacent leaves during the bean sizing period.***	Lower rates of photosynthesis can result in die back of heavy-producing branches, exhaustion of plant foods and the commencement of a biennial bearing cycle. Yellowing of leaves and shedding of leaves will occur as the nutrients are drawn to the cherry clusters.	Maintain adequate nutrition levels using leaf and soil analysis particularly during the bean sizing period (January–April). Apply nutrients prior to the onset of cold weather (April–May) as the plant cannot utilise nutrients during winter months.
Sustained exposure to high winds increases soil moisture requirement, retards growth, reduces leaf coverage and damages branches, leaves and flowers.	Low yields, tree damage and reduced harvesting efficiency can arise from sustained high wind exposure.	Protection from southerly and westerly winds is essential in the subtropics. Use natural barriers (ridges), external and internal windbreaks to minimise damage. Avoid planting sites which are exposed to high winds.

SECTION 4
Selecting the right tree

Coffee is similar to wine in many ways and like wine; flavour (acidity, body, etc) is largely determined by the *terroir* (microclimate and soils) where it is grown rather than the variety.

Varietal characteristics such as tree height, shape, suitability for machine harvesting, ripening pattern, yield potential, resistance to pests and diseases and suitability to local climate and soil conditions must all be taken into account when choosing a tree variety.

This section outlines the process, pitfalls and management advice needed to produce that all-important 'right' tree once the variety is selected. The aim is to produce a healthy 'true to type' seedling with a well-structured root system.

The colour of new leaf growth is a good indicator of 'off-types'. The main variety K7 has bronze tips (left), while the green tips (right) indicate an off-type. These should be culled in the nursery before planting.

The middle tree is an off-type, being shorter, with different foliage and structure

CONTEXT	PROBLEM	MANAGEMENT
Arabica coffee varieties are highly self fertilised (up to 95%) and most pollination occurs before the flower opens.	Growing different varieties too close together increases the chance of cross pollination and the problem of producing seedlings which have different characteristics to the parent tree – 'off-types'.	If different varieties are planted in a single area, provide adequate separation. Cross pollination does not matter if all the trees in the area are of the same variety and are high producers. Seedlings will be identical to the parent tree and no grafting is required.
Most seedlings will be the same as the parent tree.	Off-types can have a different growth habit, tree height, yield, maturity period, bean size and liquoring qualities. Cherry may be held more or less tightly, reducing harvester efficiency and yield.	Purchase seedlings from a reputable nursery. Ensure seed for planting is taken from healthy 'true to type' trees where there are no off-types or other varieties nearby.
Selection and storage of viable seed ***Seed germination is usually 95–100% with sound fresh seed.***	Poor germination will occur if unviable seed is not 'floated' off and damaged seed removed. Drying seed in direct sunlight will reduce germination.	Seed can be planted immediately after pulping or fermented to remove mucilage. Only plant the larger sized, undamaged seed which sinks in water. Dry seed slowly in shade on mesh or racks. Drying in shade with good ventilation will take around 10–14 days to reach 35–40% moisture content suitable for storage.
Storing seed for planting	Over-drying and under-drying seed will reduce germination. Moulds will develop if seed is stored above 40% moisture.	Use a moisture meter to guide drying time if seed is to be stored for longer than a few days. Maintain seed at 40% moisture content in an airtight container.
Storage life for seed	Germination percentage drops from 95% when fresh to 75% after three months in airtight bags. It drops to 20–25% after nine months. After 15 months germination capacity is virtually zero.	Seeds stored at 40% moisture can retain full germination capacity for six months if stored at 15°C.

Testing the moisture content of coffee seed using a grain moisture meter. When storing seed, a moisture content of 40% will ensure maximum viability.

Germinating coffee seed with seed coat still attached

CONTEXT	PROBLEM	MANAGEMENT
Germination ***Germinating temperature is optimum at 28–30°C.***	Germination time ranges from approximately 32 days for fresh seed and up to 50 days for seed stored for 8 weeks, while older seeds can take up to 70 days to germinate at the optimum temperature range. Poor or slow germination will result when temperatures are too low, too high or too variable.	Use controlled bottom-heated germination trays to keep the germination mix in the 28–30°C range.
Germination mix and depth	Soil or water-borne pathogens can attack seeds and reduce germination rate. Bent or 'J'-root shape will result if mix is too shallow or compacted.	Use a soil-less mix which is free-draining and free from diseases. Vermiculite and washed river sand is suitable and vermiculite alone is ideal. Provide 15 cm depth in a germination bed or tray to allow roots to grow down unimpeded before they are transplanted.
Seed spacing in germination trays	Placing seeds too close together can cause damaged roots when transplanting.	Space seed approximately 1 cm apart in trays. Orientation of the seed does not matter as seeds will orientate themselves when germinating.
Direct seeding into pots or trays such as Hyko 150 trays	Can result in wasted pot space and potting mix if seed does not germinate. Difficult to sort seedlings for size until root system holds potting mix together (six leaf stage).	Ensure seed is fresh and clean to maximise germination percentage. Plant two seeds per cell to ensure a seedling is produced in each cell (remove the weakest one as soon as possible).

Hyko 150 cells are modular and robust for direct seeding, transplanting seedlings and for field planting

CONTEXT	PROBLEM	MANAGEMENT
Germination *(continued)* ***Growing bare-rooted seedlings sown in rows on raised soil beds under shadecloth***	The survival rate is low and there is a high risk of transplant shock. Trees take longer to establish. Replanting weak or dead plants is costly.	Cheap and less labour intensive than the container grown method – but not recommended under subtropical conditions.
Pre-germination by soaking seed for 24 hours	Unviable seeds can be identified and discarded.	This can accelerate germination by up to three weeks if using seed stored for long periods. All germinating seed should be planted out once the root tip appears directly into Hyko pots to avoid the need to transplant again at a later stage.
Nursery care and hygiene	Seedlings are fragile and easily damaged or their growth can be set back through poor care and hygiene. Roots growing outside the germination tray or out of the base of pots or cells will be damaged, favouring the development of disease.	Delineate a shaded and clean potting-up area within the nursery. Discard any damaged or stunted seedlings. Keep seedling trays elevated from the ground or benches to ensure good air flow under the tray. This facilitates 'air-pruning' of roots below the cell and tray.
Control of pathogens	Fungal diseases such as *Rhizoctonia* and damping off will cause major losses unless controlled in the nursery and when transplanting to the plantation.	Use a registered/permitted fungicide drench in the nursery and at planting.

Coffee seedlings at the 'butterfly' leaf stage are ready for transplanting. Note the gap beneath the tray to allow air movement and prevent water logging.

Modern day coffee growing involves producing a large number of consistently sized seedlings for field planting. There are practical limitations and cost efficiency considerations for the nursery, transport and for in-field handling.

The following table compares the performance of three common systems for producing seedlings for field planting; the conventional plastic bag (1 litre), the Space-Saver (5” x 2” x 2”) and the Hyko V150 cell.

Criteria for comparison	Conventional plastic bag (1 litre)	Space Saver (5” x 2” x 2”)	Hyko V150 cell
Cost of growing medium used	Very high	Low	Low
Transplanting	Excellent	Very good	Very good
Handling	Heavy and time consuming	Easy, needs support frame	Excellent, self-supporting, modular
Size sorting	Good	Excellent	Poor/fair in early stage, excellent in later stage
Nutrition management	Difficult to regulate nutrition due to volume	Very good	Very good
Root formation, development and structure control	Rooting medium far exceeds stem requirements, wastes potting mix	Very good until plant exceeds optimum size	Excellent – optimum size for ideal root and stem development Air pruning allows extended holding options
Transport handling costs	Costly – bulky and heavy	Good but needs additional support trays	Excellent – modular and self-contained
In-field handling	Poor – low productivity and root development issues Size of hole required for single unit Labour cost issues	Single unit – pot handling issues affect productivity	Excellent – 24 cell modular unit held on belt Planted directly from cell into ground

The applicator nozzle from a silicone tube makes an excellent 'dibble' stick to accommodate the root system to beyond its diameter and full depth of the plant cell.

The root should be straight. If root is too long, prune it by removing a small section from the end.

Gently add potting mix around the roots, ensuring the root is straight. Carefully pull upwards on the seedling, to bring the root collar in line with the level of the potting mix.

Seedlings should be transplanted into pots at the cotyledon or 'butterfly' leaf stage up to the emergence of the first true leaves. Ensure excess potting mix is removed from between cells, to avoid roots growing into that space.

CONTEXT	PROBLEM	MANAGEMENT
Developing a well-structured root system when moving seedlings to pots	Twisting or distortion of the delicate root system will occur if downward pressure is applied to the seedling roots during potting. Pressing down the mix after placing the seedling roots in the dibble hole may cause 'J'-rooting. Excess potting mix between the cells when topping up after transplanting into the Hyko trays will encourage roots to invade adjacent cells. If left to the field planting stage, root damage can occur, allowing the entry of soil-borne diseases.	Use a dibble stick to make a hole in the potting mix to allow the root system to extend fully downward into the pot/cell. Do not apply downward pressure on the potting mix after placing the seedling in the dibble hole. Do not over-fill the cells in Hyko trays and clear away potting mix between cells.
Direct seeding into Hyko trays avoids transplanting risks as roots are not disturbed	Planting a single seed per cell typically will result in 20% of cells without a seedling or in late germination, leading to uneven growth and inefficient use of nursery space.	Plant two seeds per cell, removing the weaker seedling as soon as possible in order not to disturb the root system of the dominant seedling. Highest germination rates occur by using fresh seed and controlling temperature and moisture.
Keeping plants 'disease free'	Fungus diseases such as damping off and collar rot will develop under high humidity and consistently moist conditions. *Cercospora* (leaf spot) will develop when plants are crowded or under nourished.	Maintain good air circulation. Monitor water needs using a moisture probe. Irrigate according to need – not by the clock. Keep potting-up benches and implements clean and apply copper-based fungicide to work areas.
Transplanting from trays to pots or cells	Roots will start to curl, bend and tangle if left in trays too long.	Transplant when the two seed leaves ('butterfly' leaves) have fully emerged and before the true leaves start to emerge. This will ensure roots are not over extended.

Shade is removed in the final four weeks before planting to 'sun-harden' the seedlings

These plants have been in their planting cells for too long and are root bound. Note the Cercospora *(leaf spot) on the leaves.*

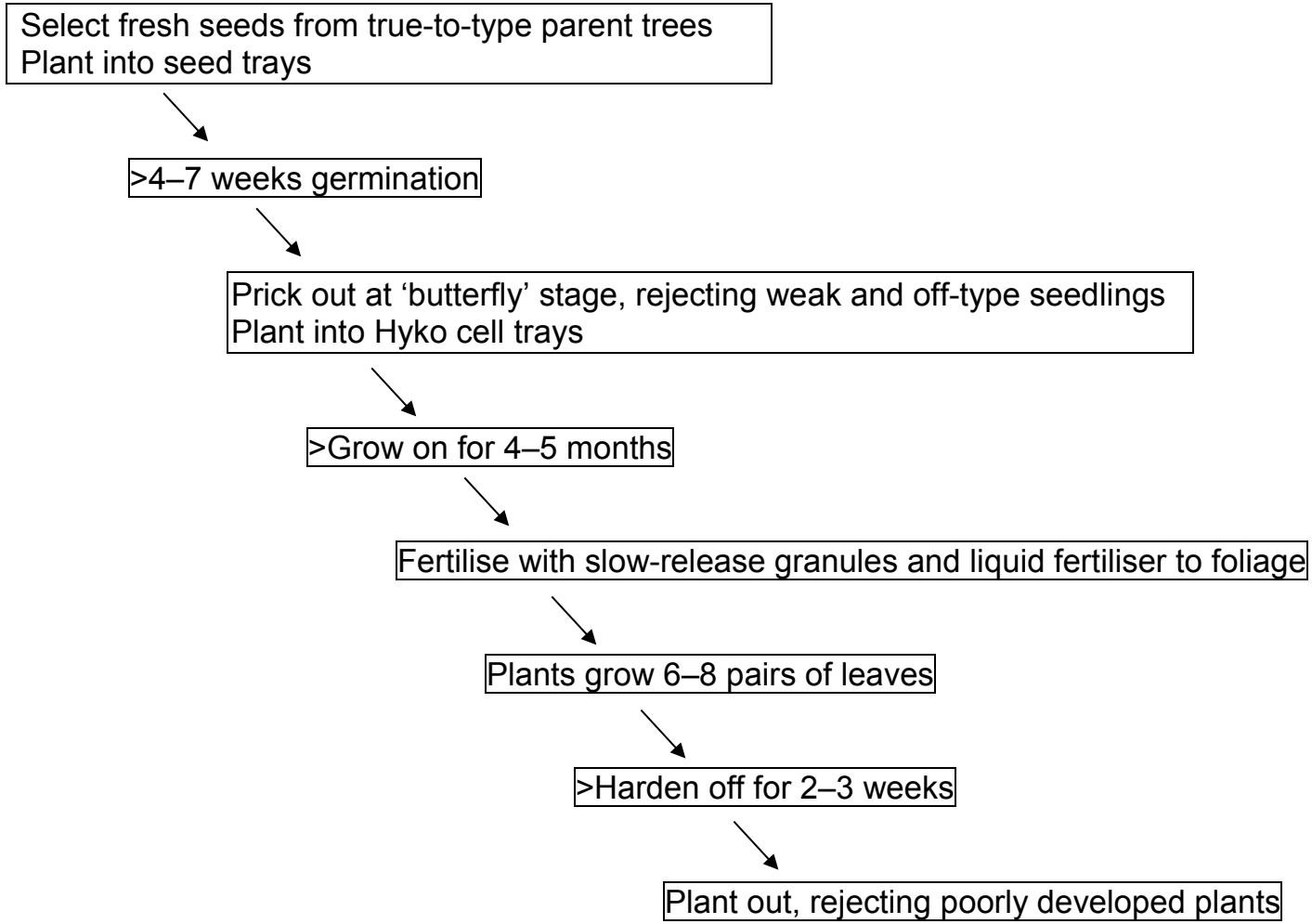
CONTEXT	PROBLEM	MANAGEMENT
Sorting seedlings according to size when transplanting	Mixing 'leggy' or oversized and undersized seedlings together will result in uneven growth, water penetration of cells and variable nutrient requirements.	Size sort seedlings and plant similar sized seedlings together in each tray. Discard 'off-types', plants with deformed leaves and 'J'-roots.
Shading is necessary in the nursery to encourage even, healthy growth	Excessive shade will produce 'leggy' tall plants with a weak stem. Planting seeds too close together will also cause excessive shading.	Start with 50% shade cloth to encourage vigorous growth. Remove shade during prolonged periods of cloudy weather then replace when full sun returns. As seedlings grow, gradually remove shade until seedlings have 3–5 pairs of leaves. Remove shade completely four weeks before planting in the field.
Irrigating seedlings to ensure even growth and freedom from disease	Overwatering, under-watering or uneven watering will cause stress in plants and uneven growth.	Look for signs of yellowing, *Cercospora* (leaf spot), wilting or reduced growth. Use a portable moisture probe to check for uneven watering in the nursery. If using overhead watering, ensure sprinklers have adequate overlap in their spray pattern.
Seedlings respond to regular applications of foliar fertiliser and slow-release granular fertiliser in the potting mix.	Exceeding the recommended mix or application rate will cause 'burning' of foliage, particularly under high temperature and sunlight conditions. *Cercospora* (leaf spot) will occur when nutrition is lacking.	Apply recommended rates only and apply in the early morning or late in the day to avoid burning. Ensure an even application of fertilisers to prevent *Cercospora* (leaf spot) from developing.

Portable soil moisture probes are available to check for uneven watering in the nursery

CONTEXT	PROBLEM	MANAGEMENT
Pest and disease control should not be required as seedlings are not attractive to insects.	Grasshoppers, caterpillars and scale may occasionally attack leaves. Coffee green scale (*Coccus viridis)* is the main pest of coffee in the subtropics. It is attracted to weaker seedlings/trees. *Cercospora* (leaf spot) will develop where nutrition is poor or when plants are stressed.	Scale is usually not a problem if plants are vigorous. Natural control agents such as the *Verticillium lecanii* fungus, and the *Cryptolaemus* beetle larvae are very effective. If weather conditions do not favour these natural control agents, application of a highly refined paraffinic oil such as Biopest oil is effective. Apply a copper-based fungicide if infection is heavy; then ensure adequate nutrition through foliar sprays and slow release fertiliser granules.

Cercospora (leaf spot) is a symptom of poor nutrition and/or poor air circulation. Note the copper fungicide on the leaves as a control measure after the infection has occurred.

Sequence for seedling establishment



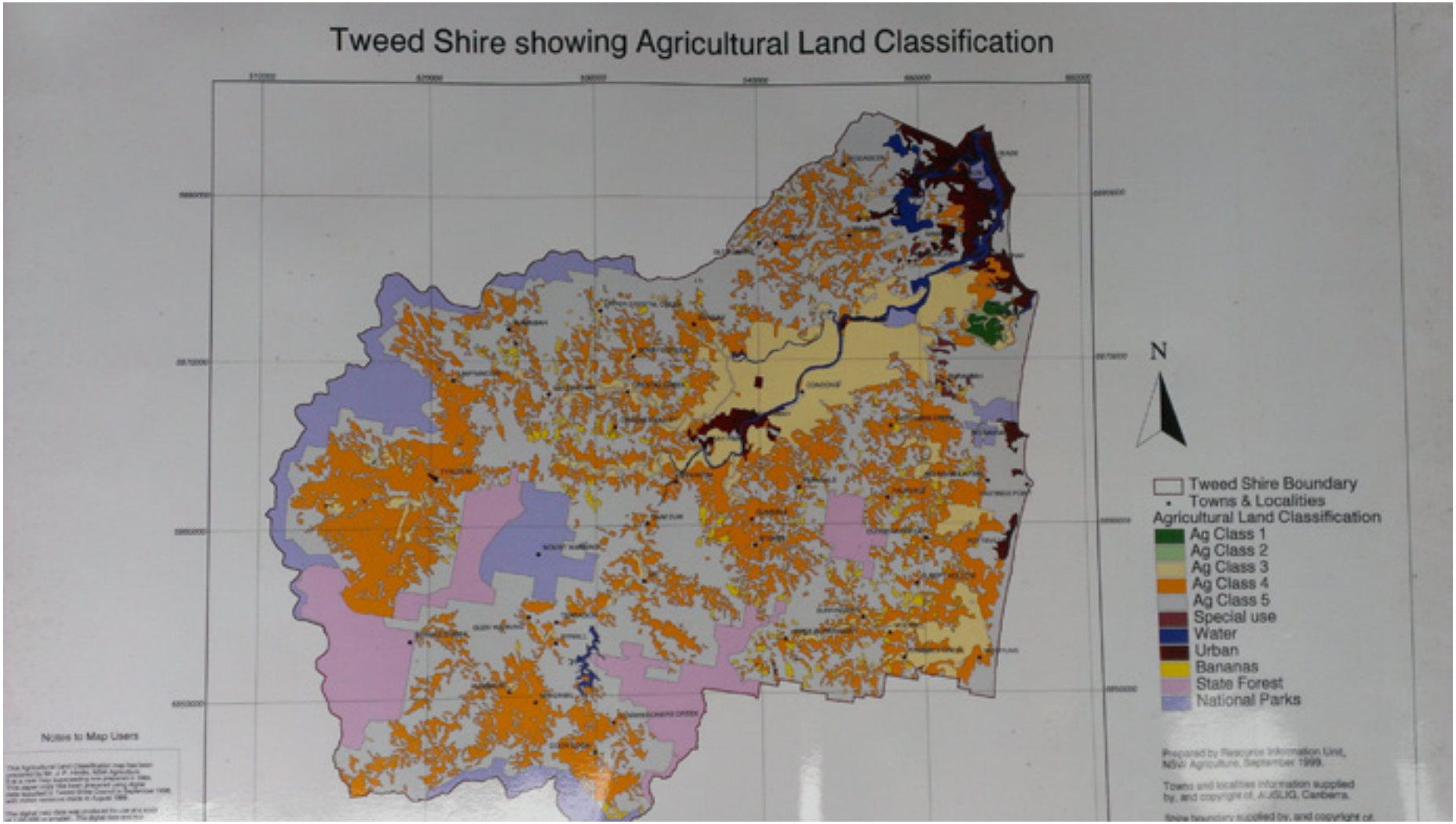
SECTION 5

Selecting a suitable site

The essential requirements for growing coffee are freedom from frost, protection from cold or persistent winds and access to water for irrigation. There are other requirements, some of which are unique to this subtropical region of Australia where the industry is based on machine harvesting and sloping land.

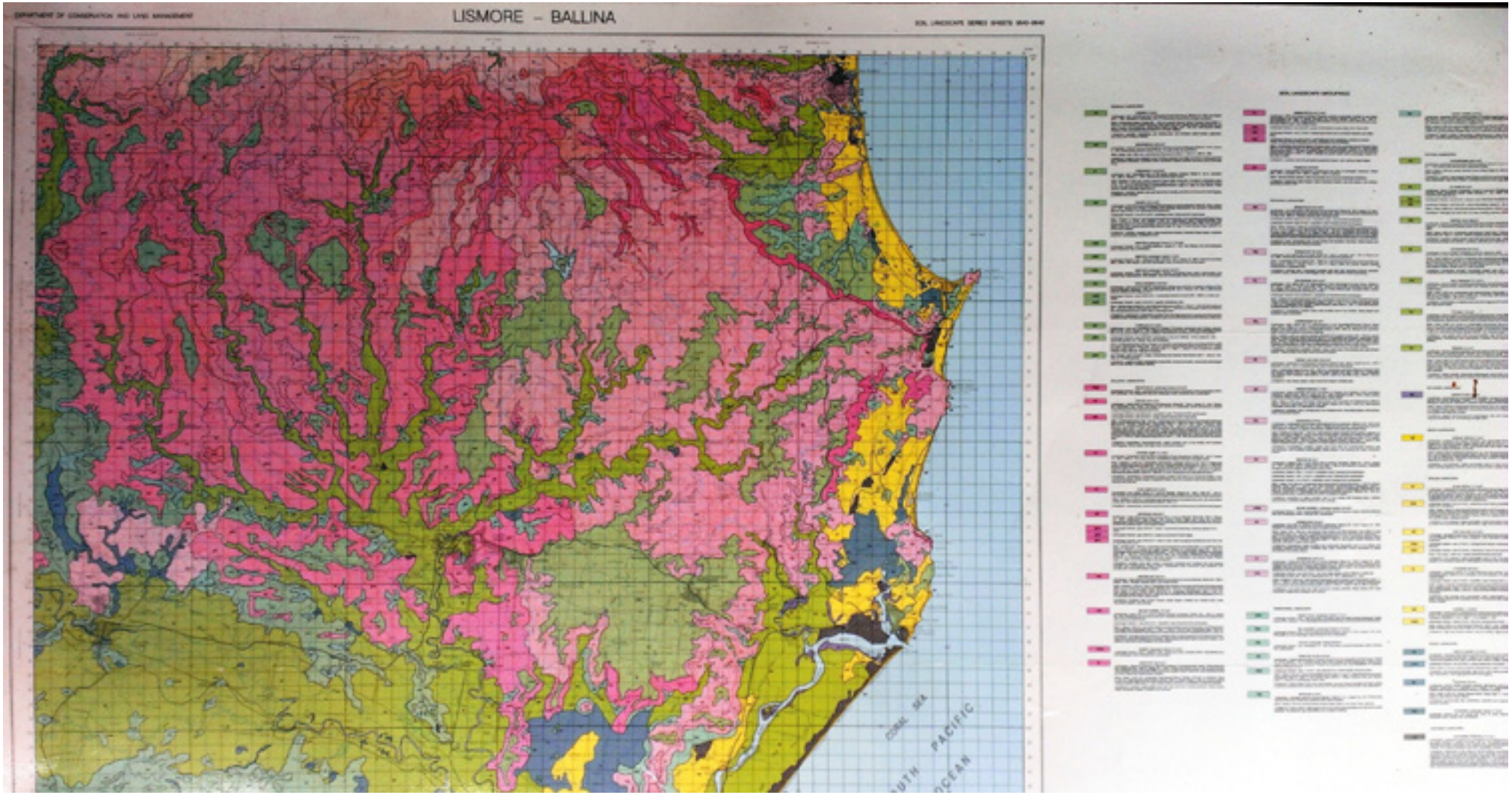
This section provides a ‘checklist’ of the requirements to consider when selecting a suitable site for commercial coffee production.

Useful maps relating to soils, rainfall and agricultural land classification for the local area are also presented to assist in selecting a suitable site.



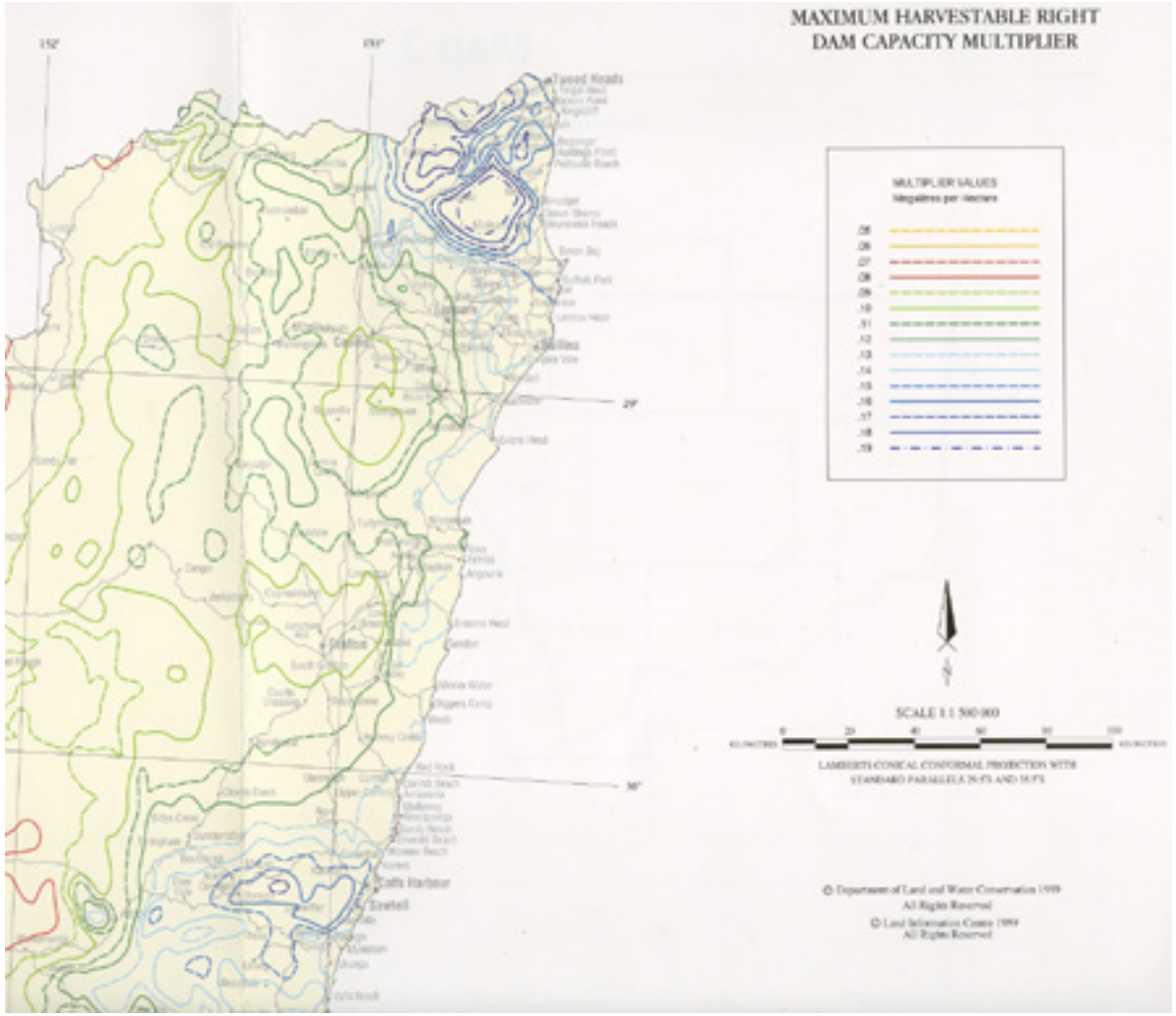
Agricultural land classification maps for each shire are available which show agricultural land quality. An agricultural land evaluation manual should be used to interpret the land classifications.

CONTEXT	PROBLEM	MANAGEMENT
A large enough area is required for cost effective harvesting and processing	Small areas are unable to take advantage of economies of scale and generate sufficient volume of production to justify the high capital costs of harvesting and processing.	A minimum of 30–40 ha of planted coffee is required to justify the purchase of a harvester and processing facilities. Alternatively, smaller areas can be viable if harvesting is contracted and processing is done through a shared or central facility.
Frost-free land	Coffee will not grow in frost-prone areas and is severely setback by extended periods of cold weather.	Check local maps and local knowledge on frost history of property and avoid frost-prone land. If frost risk is minimal, running rows down the slope and clearing breaks at the bottom of the slope through bushland will assist in draining cold air and prevent it from pooling and creating frost. Mounding of tree rows will also assist in draining cold air away from the trees.
Land should slope less than 15% down rows and have a side slope less than 5%	Harvesting efficiency decreases on slopes above 15% and damage to harvester shaker fingers increases on side slopes over 5%. Operator safety is at risk on steeper slopes, particularly in wet slippery conditions.	Select gently sloping land for locating tree rows. Avoid excessive side slope greater than 5–6% to minimise damage to trees and increase harvester efficiency.
Orientation of planting rows	There is potential conflict between selecting a slope to suit efficient machine harvesting and a north–south row orientation suitable for uniform ripening.	A compromise layout having regard to the ideal harvesting arrangement and optimum ripening will be required.
Protection from cold and persistent winds	Cold and persistent winds will damage trees and reduce yields significantly.	Avoid sites exposed to southerly and westerly winds. Utilise protection from natural barriers including ridges and bushland.

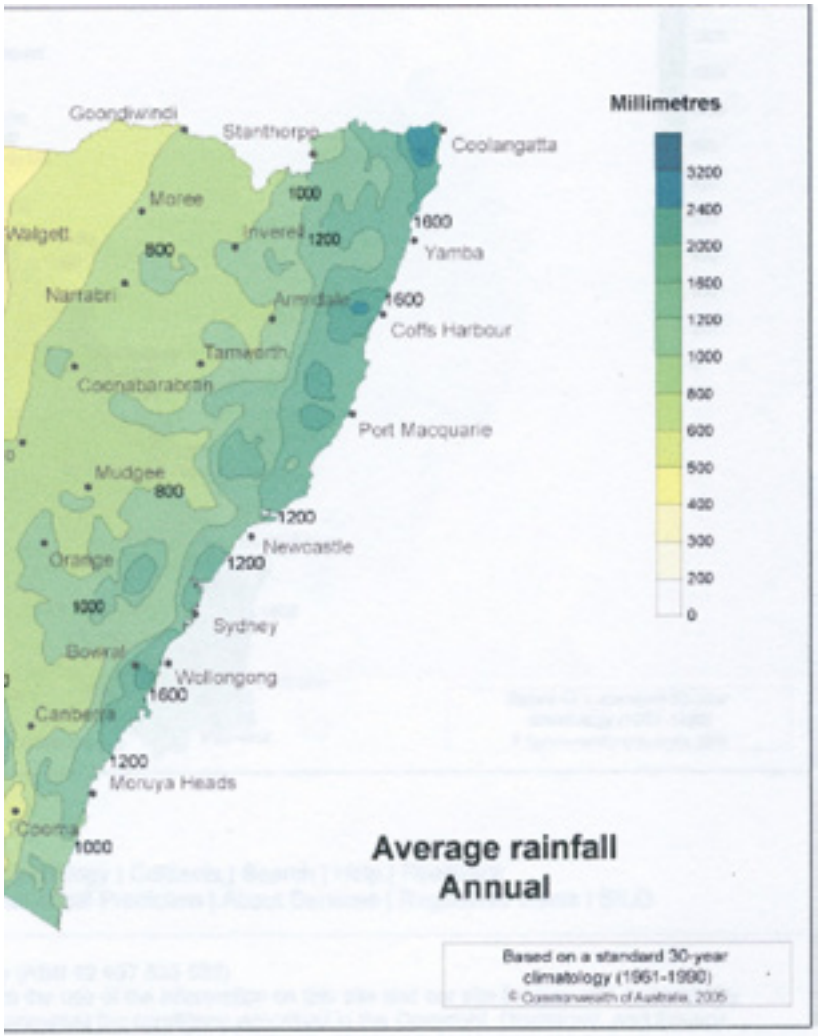


Soils landscape series maps are available for each shire showing the soil types. They describe characteristics of slope, soil depth, erosion risk and drainage limitations. These maps, in combination with the Agricultural Land Suitability Maps, provide a good starting point when looking for suitable land for coffee growing.

CONTEXT	PROBLEM	MANAGEMENT
Adequate reliable rainfall during the bean sizing period and/or adequate water storage for irrigation	Irregular or inadequate rainfall over the December to April period is likely to reduce bean size and stress the tree's ability to mobilise nutrients. Even in high rainfall areas close to the coast there will be extended dry periods at critical times which can initiate the onset of biennial bearing or die back if trees are carrying a heavy crop.	Supplementary irrigation is strongly recommended to meet the demand for moisture during critical times of growth and bean sizing. Check with local authorities on entitlements for on-farm storage, accessing water supplies and water trading. About 4 megalitres (ML) per hectare of irrigation water is required. See *Best Management Guidelines for Irrigation of Coffee in the Sub-tropics*, 2003.
Badly drained or heavy clay soils are unsuited for coffee growing. Soils should have good structure, high organic matter, cation exchange capacity and biological activity.	Heavy, shallow or compacted soils will restrict root development and the capacity of the tree to access adequate nutrients and soil moisture. Trees planted in these soils are prone to lodging (being blown over or carrying a heavy crop). Water logging will kill coffee trees.	Check soil maps for the area and understand the attributes and limitations described for the soil types present. Have a soil test for physical, chemical and biological components. Coffee soils should be free draining to a depth of at least 1.5 metres.
Environmental considerations	Disposal of waste from processing is of major concern in this region. The organic waste products have a high biological oxygen demand which can pollute waterways. Strict local and state regulations prevent disposal of waste into watercourses.	Consider using an existing processing facility with approved waste disposal capacity or investigate alternative processing systems which have low or nil water requirement. Holding ponds and reed filtration systems are used in some areas to reduce pollutants and prevent waste water from leaving the property. High tech bio digester systems are available.



A multiplier factor is used to calculate the maximum dam capacity allowed within this region



Rainfall maps and detailed long-term weather data are available from the Bureau of Meteorology for most localities

CONTEXT	PROBLEM	MANAGEMENT
Close proximity to processing facility	Transporting unprocessed cherry long distances is uneconomical and can lead to quality problems caused by uncontrolled fermentation and contamination.	Harvested cherry should be pulped or cool stored within a few hours to minimise quality problems if the fully washed or semi-washed processing systems are used. Proximity to processing is not as important with the natural or raisin-processing systems.
Access to reliable services	Mechanical harvesting and processing are highly technical operations requiring specific expertise and prompt response to breakdowns or problems. Mechanical, electrical, hydraulic, transport and spare-parts services are critical during the harvest and processing periods. Irrigation and agronomic services for trouble shooting and management support are required.	Locating the enterprise close to these services is necessary if the harvester and/or processing facility is to be located on the property. Using contractors for both harvesting and processing will reduce the need to locate close to services; however, Murphy's Law is alive and well on any farm.

A water storage facility provides adequate water for irrigation and processing

SECTION 6

Preparing the site for planting

The importance of spending time and effort in preparing the site for planting is often underestimated.

Time spent in planning and preparing the plantation layout well before planting time will produce dividends in later years by achieving yields of optimum quantity and quality. Operational costs are reduced through facilitating efficient farm operations, and reducing the potential for soil erosion and damage to farm machinery. Building a healthy soil environment in which the coffee root system can become established and be maintained, is essential for sustained tree health and productivity.

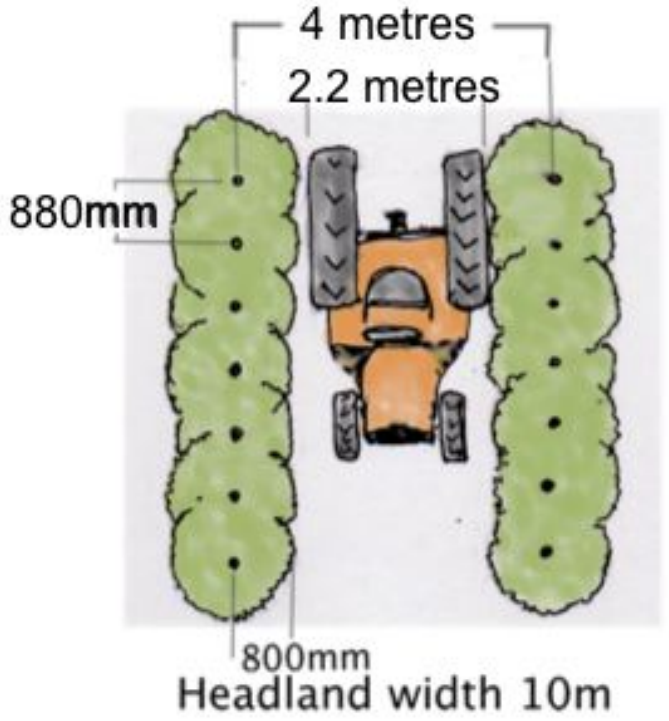
This section presents a step-by-step guide from planning through design to laying out the plantation.

It is important to ensure plants are 'sun hardened' for 4–6 weeks before planting in the spring. Spring planting is preferable, provided irrigation is available.

In cooler areas, late summer planting is not recommended as plants are not well established before the onset of cold temperatures resulting in yellowing (chlorosis) of the young leaves.

CONTEXT	PROBLEM	MANAGEMENT
When to plant ***Spring planting is the preferred planting time provided good rainfall is occurring or irrigation is available.***	Planting earlier (in August and September) is risky because of the possibility of cool and windy weather which can delay the start of field growth.	October and early November are preferred when soil and air temperatures are ideal for growth. Plants have the summer and autumn months to establish before the onset of cold weather. It is also a convenient time for nurseries to have plants sun hardened and ready at the ideal eight to 10 leaf stage. Sun harden plants for four to six weeks before planting in the spring as days are frequently cloudless with increasing temperatures.
Late summer planting (in February) usually provides ideal conditions for planting with regular rainfall, good soil temperatures and moisture. Frequent cloud cover provides 'shade-house' conditions for establishing young seedlings.	The approaching cooler weather in late autumn provides little time for establishing a sound root system and vigorous growth before the winter. Low temperatures cause growth to cease over winter.	Late summer planting is an option for warmer protected areas closer to the coast where cooler weather is delayed and is not as severe as inland or exposed areas. Late summer planting can be successful in warmer coastal areas particularly if irrigation is available. Nurseries using bottom heat are able to supply plants in a shorter time frame without the extended sun hardening period required for spring planting.
Clearing the land ***Land clearing should start at least 12 months before planting if tree clearing is required.***	Regulations apply to tree and land clearing within the buffer areas of watercourses. Pushing timber into gullies may interfere with natural drainage and runoff for watercourses. Old stumps, rocks, sticks and uneven terrain will reduce the efficiency of cultivation operations, mowing and harvesting, etc.	Check with local and state government agencies on regulations relating to tree clearing and protection of watercourses. Professional advice may be required on the location of headlands, surface drains, grassed waterways, access roads and dams, etc. Use existing tree belts and natural topography to provide protection from winds. Remove old stumps to reduce the risk of infecting coffee trees with *Fusarium* or *Armillaria* wood rots.

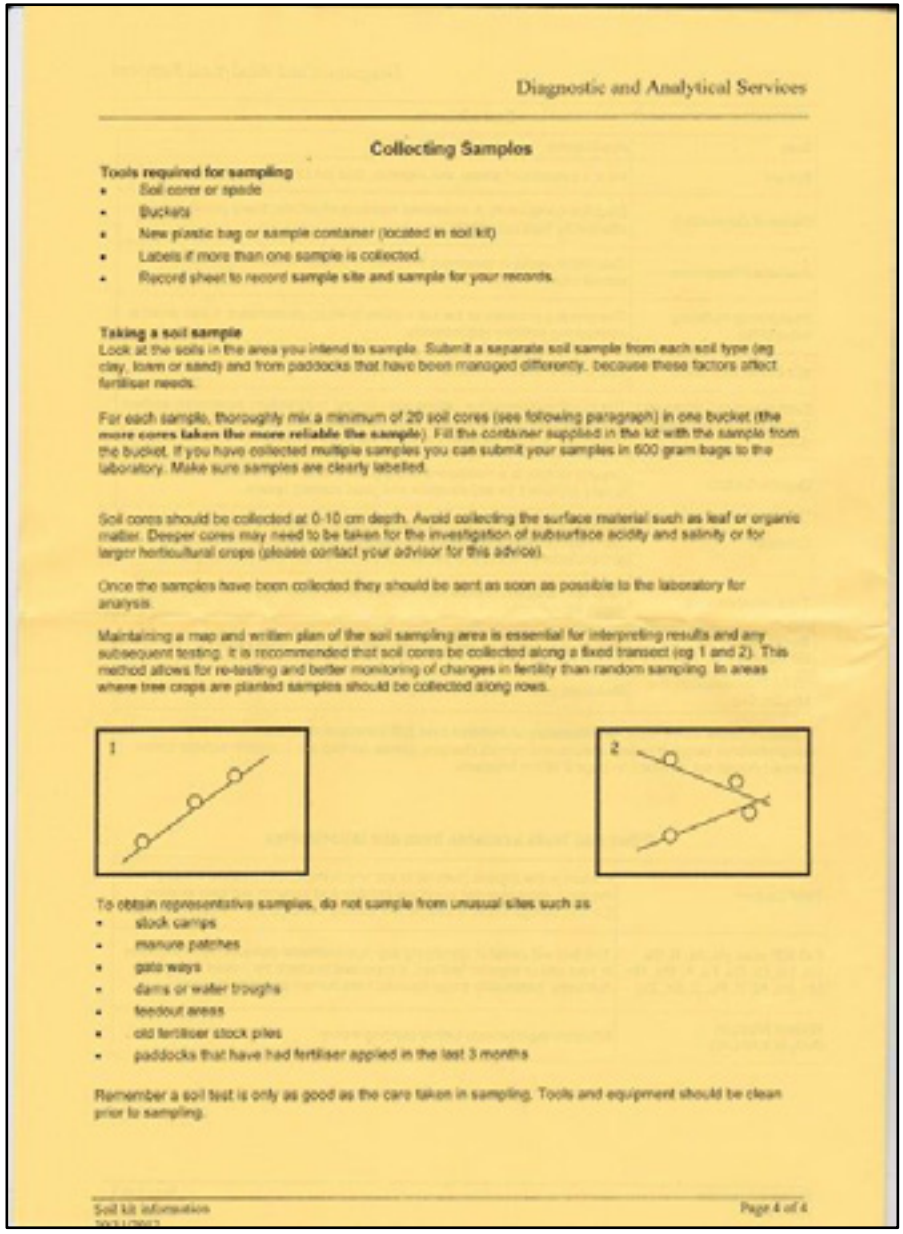
Planting trees on low profile mounds increases the effective depth of soil, improves harvester efficiency and minimises frost damage to the base of young trees. Stabilising the soil with a quick-growing ground cover minimises soil erosion.



Critical dimensions of planting rows and plant spacing

CONTEXT	PROBLEM	MANAGEMENT
Marking out the rows ***Locating the rows in the best direction to suit the topography is critical to the success of harvesting, irrigation efficiency and even ripening of the cherry.***	Locating rows to suit the slope alone may not be the optimal direction for sunlight penetration, or cherry ripening or irrigation efficiency.	Compromises will often have to be made because of the topography on most properties; however, maintaining a predominant north–south row orientation should be the major consideration when locating rows. Operational efficiencies can be gained by adjusting block designs to suit machine harvesting operations and pruning rotation programs.
Row spacing will vary according to the growth habit of a particular variety.	Tall vigorous varieties such as K7 will readily shade out the inter row and reduce light to adjoining rows if planted too close.	Semi-dwarf varieties such as Catuai can be planted closer (3.5–3.75 metres apart) than taller varieties such as K7 (3.8–4.0 metres apart).
Row spacing depends on the space required to operate inter-row machinery.	Adequate space needs to be created for machinery to pass through without damaging trees, crops and equipment.	The canopy of a healthy and mature K7 tree extends to approximately 1 metre from the main stem. Consider what machinery is to be used and what extra space is necessary for damage-free operation.
Providing an irrigation system enables a measured delivery of moisture and nutrients to plants. It needs to be designed and established when planning and laying out planting rows.	Irrigation is an expensive capital cost, is susceptible to damage and requires ongoing maintenance. It may not be required every year but it only takes one or two dry years at critical times to start die back and a biennial bearing cycle.	The costs and benefits of irrigation are complex considerations. Use qualified irrigation specialists at the planning stage to design an irrigation system to suit the particular features of microclimate, topography and planting layout.
It is at the establishment stage that the provision of moisture and nutrients is most critical and labour intensive.	If an irrigation system is not installed watering is a labour intensive activity. Irrigation is required immediately after planting to remove air pockets and provide direct contact of the soil with coffee roots.	Factoring in the costs and benefits of irrigation is essential (see the publication *Best Management Guidelines for irrigation of coffee in the subtropics,* NSW DPI 2003). Immediately after planting, each plant needs to be supplied with about two litres of water. Without rain it will require the same amount every four days.

CONTEXT	PROBLEM	MANAGEMENT
Preparing the soil ***Coffee requires deep well drained soils for good root structure, optimum growth and sustained productivity.***	Compacted clay pans, clay layers or impermeable rock shelf will impede root development.	Break up compacted cultivation pans or clay layers along the planting row using a single ripping tyne which efficiently loosens well-structured deep soils.
Soil within the plant line needs to be sufficiently broken up and have a friable nature for bedding in plants and to facilitate root development.	In heavily compacted soils, clay pans and clay layers a single tyne fails to provide the width of lateral disturbance or shatter required. A width of 150 mm and depth of 450 mm is desirable.	Double or triple offset ripping provides sufficient lateral disturbance of any restricted layers, however, extra time and costs are involved. Re-compaction of previously worked ground can occur.
Incorporating organic matter	Where fresh organic material is left in the soil surface the rippers tend to "ball up" or gather grass, making it difficult to retain an even surface and consistent depth of rip.	Prepare planting rows well in advance by hard slashing vegetation and if necessary applying a weedicide. Rip when soils are dry. Also, see below. Multi-gang rippers deal better in such situations but are difficult to operate.
A 'winged keel' implement designed by CSIRO, (see photo), when fitted to a single ripper, maximises lateral shatter and minimises disturbance of the natural soil horizons. It minimises the inversion or turning over of the soil profile.	The 'winged keel' overcomes problems of compacted soil and vegetation balling up.	The operation creates a basic friable soil to a depth of 360mm for root penetration. It creates a 'bow-wave' uplift effect behind the implement. Multiple workings of the planting bed reduce the size of clods and help to break up organic matter.
Once the soil is broken up, cultivating the plant line a second time will increase its friability.	Extra time and cost are involved but to plant in lumpy soils will reduce the percentage of the plants striking successfully.	It is better to spend a bit more time and money creating a good planting environment in the soil rather than having to replace dead plants.



Diagnostic and Analytical Services

Collecting Samples

Tools required for sampling

- Soil corer or spade
- Buckets
- New plastic bag or sample container (located in soil kit)
- Labels if more than one sample is collected.
- Record sheet to record sample site and sample for your records.

Taking a soil sample

Look at the soils in the area you intend to sample. Submit a separate soil sample from each soil type (eg clay, loam or sand) and from paddocks that have been managed differently, because these factors affect fertiliser needs.

For each sample, thoroughly mix a minimum of 20 soil cores (see following paragraph) in one bucket (**the more cores taken the more reliable the sample**). Fill the container supplied in the kit with the sample from the bucket. If you have collected multiple samples you can submit your samples in 600 gram bags to the laboratory. Make sure samples are clearly labelled.

Soil cores should be collected at 0-10 cm depth. Avoid collecting the surface material such as leaf or organic matter. Deeper cores may need to be taken for the investigation of subsurface acidity and salinity or for larger horticultural crops (please contact your advisor for this advice).

Once the samples have been collected they should be sent as soon as possible to the laboratory for analysis.

Maintaining a map and written plan of the soil sampling area is essential for interpreting results and any subsequent testing. It is recommended that soil cores be collected along a fixed transect (eg 1 and 2). This method allows for re-testing and better monitoring of changes in fertility than random sampling. In areas where tree crops are planted samples should be collected along rows.

To obtain representative samples, do not sample from unusual sites such as

- stock camps
- manure patches
- gate ways
- dams or water troughs
- feedout areas
- old fertiliser stock piles
- paddocks that have had fertiliser applied in the last 3 months

Remember a soil test is only as good as the care taken in sampling. Tools and equipment should be clean prior to sampling.

Soil kit information Page 4 of 4

Extract from the NSW Dept. of Primary Industries Soil Kit Information showing the procedure for taking soil samples

The wing-keel uplifts the soil, shattering compacted layers without disturbing the soil surface

Planting time line

winter	spring	summer	autumn	winter	spring		summer	autumn	winter
ripening	harvest/flowering	budding/ branch growth	cherry development	ripening	harvest/flowering		budding/ branch growth	cherry development	ripening
land clearing plan design	layout mounding	rip plant rows weed spray planting rows instal irrigation lay mulch	apply pre planting nutrients plant ground cover	control weeds mow inter rows	harden off plants weed spray re rip	planting water in add thick layer of mulch	water when needed, plant Smother Grass, control weeds apply nutrients build up mulch		
cool dry season		warm wet season		cool dry season			warm wet season		cool dry season
	September	December	March	June	September	December	March	June	

Using a soil sampling kit available from the NSW Department of Rural Industries

Newly planted seedlings on a mounded row and drip irrigation in position. A mulch cover has yet to be applied

The planting gel can be placed directly into the planting hole or incorporated into the backfill soil surrounding the root ball.

CONTEXT	PROBLEM	MANAGEMENT
Preparing the beds for planting ***The ideal planting bed for hand planting is a good friable mineral rich soil with high levels of well decomposed organic matter.***	Inadequate soil depth, low organic matter and poor soil structure will impede root development.	Forming low profile mounds increases the effective root depth, improves harvester efficiency and reduces the risk of frost to the base of young trees. On sloping land it mitigates against soil erosion.
Allowing the soil to 'settle' and remove large air pockets will help in establishing good root development.	Air pockets within the soil hinder root development. Broken soil that remains lumpy will need to be broken down (heeled in) around the seedling prolonging the process and increasing the potential to damage the plant.	Prepare the ground well ahead of planting. If time is constrained, additional mechanical cultivations will be required.
Applying nutrients before planting	The shock that seedlings experience when transplanted needs to be compensated by providing them with a new environment that promotes their establishment.	Incorporating mineral-based fertiliser containing rock phosphate and natural minerals with organic manures or biological soil activators is recommended at least 6 months before planting. These products provide an active biological root zone for the coffee seedling, improve the soil structure and provide a slow and longer lasting release of nutrients to the young plant.
The condition of the soil	Nutrient imbalances, leaching and burning of roots and foliage can occur through over fertilising, using the wrong fertiliser or not adjusting the pH.	The number of soil samples required will depend on the size of the property, the topography, range of soil types, depths and drainage. Soil sampling kits are available from all agricultural service stores and suppliers. Buy the kit and follow the instructions for sampling the soil to give a true reading of the property. Do a soil analysis and apply the required pre-plant nutrients and conditioners – such as gypsum, lime, minerals, organic matter, etc. Avoid highly soluble fertilisers in pre-planting.

African Sweet Smother Grass controls erosion and tolerates shady conditions

It is planted using the runners (above) or as potted plugs which can be contract planted

African Sweet Smother Grass (*Dactyloctenium australe*)

Highly effective in protecting the soil from erosion. It is best planted in the late spring or early summer with the onset of the summer rainy season

Inadequate weed control has taken nutrients from the trees and stunted their growth

Herbicide products registered for use on coffee plantations in

New South Wales and Queensland

Refer to the Australian Pesticides and Veterinary Medicines Authority for registered chemicals and current permits at:

www.apvma.gov.au

CONTEXT	PROBLEM	MANAGEMENT
Controlling weeds and preventing erosion ***Pre-emergent weedicides are permitted for use prior to planting coffee. The emphasis is to provide a planting bed free of weeds and weed seeds.***	Cultivating the soil to prepare the planting mounds, results in a proliferation of invasive and aggressive broad-leafed weeds such as Farmers Friends (*Bidens pilosa*), Blackberry Nightshade (*Solanum nigrum*). *Amaranthus* spp., Inkweed, Fleabane, etc.	Once these weeds germinate after cultivation, they should be sprayed **before they set seed** to deplete the 'weed seed bank' in the soil. Not allowing any seed to set once cultivation commences will enable young coffee seedlings to establish without severe competition. Glyphosate and a range of other weedicides are permitted on pasture before coffee seedlings are planted.
An application of a pre-emergent weedicide is desirable just prior to planting to give seedlings a good, uncompetitive start.	Weeds easily beat the young and shocked seedlings to moisture and nutrients. Weeds that establish in inter rows will quickly invade the plant rows on cultivated ground.	Spraying the weeds that emerge after the final cultivation will give plants and groundcover a chance to establish. It is easier to kill weeds prior to planting coffee seedlings. Once seedlings are planted, any weedicide spraying needs to be carefully controlled to avoid drift onto the seedlings.
Planting a suppressive groundcover in inter rows after mounds have been formed will help reduce weed infestation and minimise erosion.	Mounding creates the potential for erosion and open ground is a breeding ground for weeds. Inter rows need to be without ruts, well-levelled, weed-free, mulch-generating environments.	Inter-row groundcover should be quickly established and regularly cut to stop seeding and build up mulch around the new plants. Japanese millet germinates quickly and provides temporary stability of the soil in warmer weather. In cooler weather tall growing oats is preferable.
Mulching ***Mulching can assist in suppressing weed growth and building soil fertility prior to planting.***	Not recommended for mechanical planting. Undecomposed mulch will hinder planting and is a potential source of disease. Live weed seeds in mulch can be a problem.	A cover crop planted in the inter rows provides on-site mulch, is cost effective and avoids importing weeds. Provide a layer of well-shredded mulch, 300 mm wide along the planting rows. If importing mulch, use weed-free material such as sugar cane, silage or baled straw. Well-composted mulch is preferred. Apply well in advance of planting the seedlings.
Vigilance against weeds gaining a foothold is required for the next two years and until plants have established a lush leaf canopy. There is a restriction on which weedicides can be used.	Only permitted weedicides can be used once the seedlings are planted.	During the early months, selective hand spraying is recommended and then great skill is required when mechanically spraying.

SECTION 7

Establishing the plantation

Seedlings carried to the field in a planting rack

The coffee root system is slow to develop in the first year of growth and many problems occur such as poor anchorage, stunted growth and death of the plant if a poor planting technique is employed.

Hand planting by experienced contractors is now cost effective and is preferred to machine planting.

This section contains a photographic sequence of the most successful planting technique developed under local conditions. Irrigation and fertilising recommendations are also included to ensure the plantation gets off to a good start.

The soil within the planting row should be friable. Heavy, wet soils that remain lumpy need to be further broken down.

Fine feeder root tips are sensitive to moisture stress.

A simple hand-held moisture probe provides a quick check of soil moisture around the roots of young seedlings.

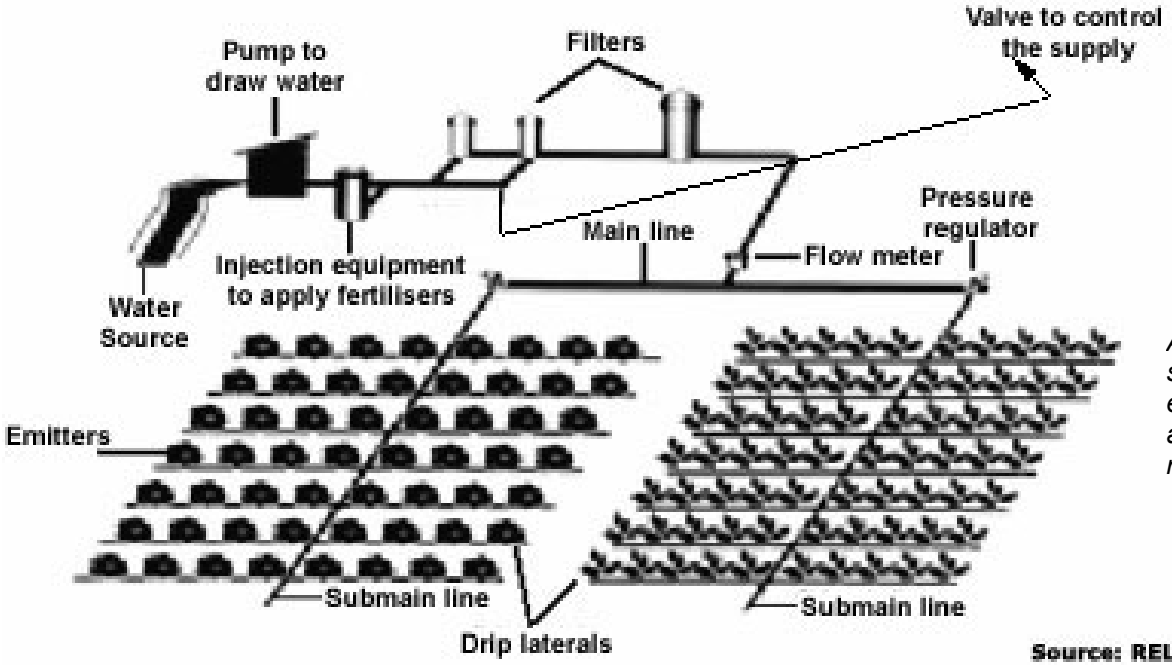
Irrigation by hand or a drip system immediately after planting is essential to remove air pockets and provide direct contact of the soil with the plant's roots.

CONTEXT	PROBLEM	MANAGEMENT
The zone within which seedlings are to be planted should be friable with no clods (large lumps of compacted soil) and with all organic matter fully decomposed.	Planting into freshly applied or sprayed off fresh organic matter is not recommended as it impedes the planting process and tends to dry out the root system of the young seedlings. There is the potential for decomposing organic matter to introduce pathogens (diseases) and create nutrient imbalances.	See Section 6 relating to the preparation of the site.
The soil along the planting row should be neither dry nor saturated but moist enough to retain friability.	Dry soils will not satisfactorily compact around the planted seedling while wet soils make planting difficult and will 'clag' to form a barrier between the seed-growing medium and the soil.	Avoid planting when the soil is saturated and if the soil is dry, irrigate the evening before planting.
Fully hydrate (wet) the seedlings prior to planting (allowing sufficient time for the plant cell structure to maximise its moisture content).	Just soaking the potting medium prior to planting will not be sufficient.	Ideally this entails heavy watering for the 24-hour period prior to planting to allow sufficient time for the cells to take up maximum water plus a final soaking of the potting medium just prior to planting.
Prior to planting the seedlings need to be 'unplugged' i.e. loosened from the cell.	Damage to the root collar is caused by having to use excessive force to pull the seedling from the tray. Damage to the soft bark or to the root system must be avoided as it can set the tree back substantially.	Apply pressure from the bottom of the tray using a purpose built tool.
Minimising transplanting shock is critical to successfully establishing early growth.	Transplant shock sets back the health of the plant which will remain in a weakened state until it re-establishes itself.	A liquor polymer coating such as *Envy*® (a foliar coating) and *Seasol*® planting granules when applied prior to planting will minimise transplant shock.
Plants should be placed in alignment into the centre of the planting row and at least 800 mm apart.	Misaligned trees upset the harvesting process. Yield is reduced from overcrowded trees. Spacing that is too wide is less than optimal and results in unproductive gaps.	Use a string line to achieve straight planting. Professional planters do this using sighting rods. The spacing will create a solid hedge with branches of adjacent trees interleaving into adjacent canopies as far as the main stem of neighbouring trees.

Grasses that more readily decompose and become organic matter in the soil profile create a good mulch cover when planting rows are being established.

After planting, a more durable mulch of wood chips should be spread along the planting row but with chips kept away from the main stem of the seedling.

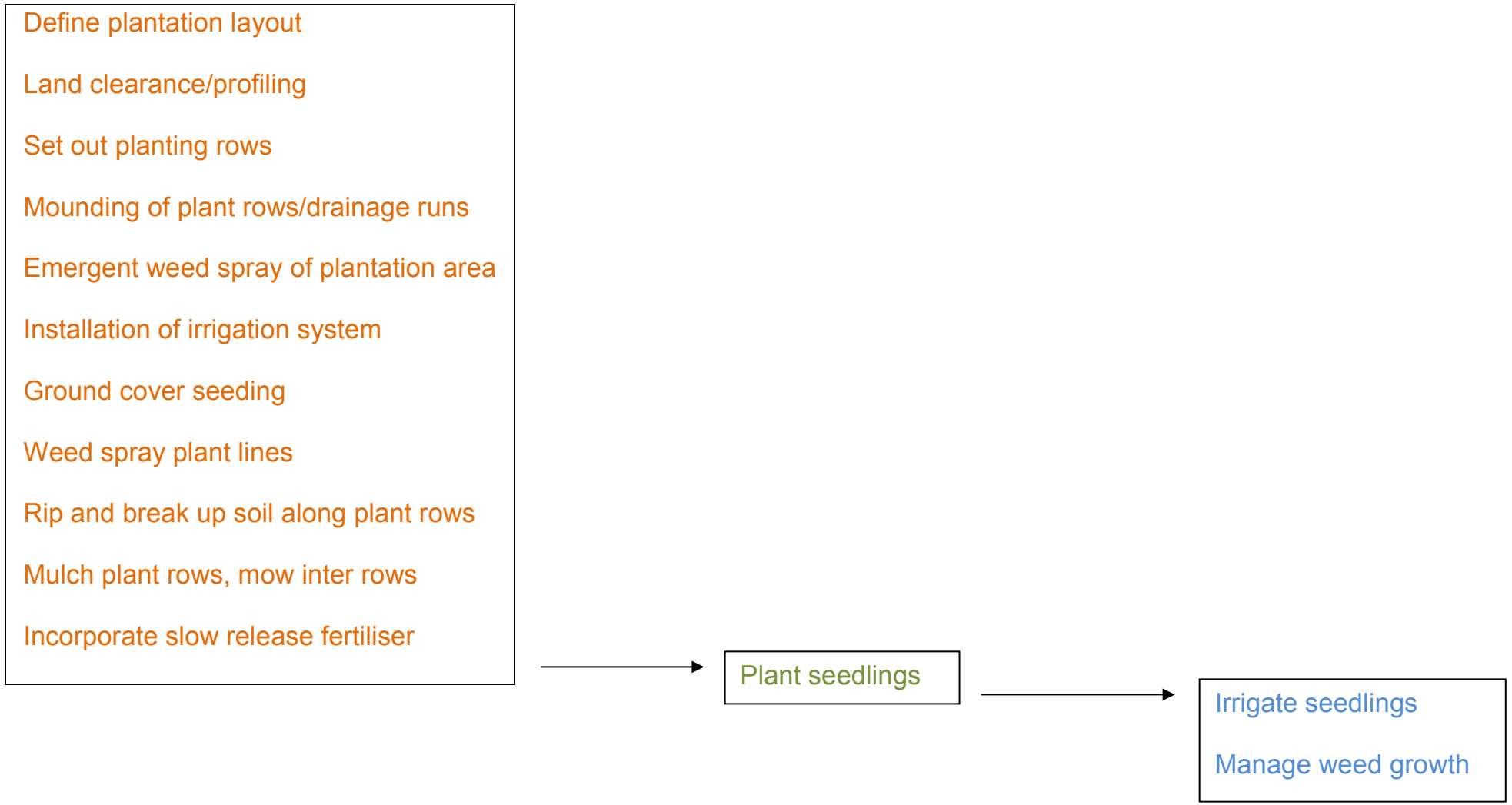
Drip irrigation is ideal to pre-soak the planting row before and immediately after planting to minimise transplanting shock.



Although a high capital cost, an irrigation system is an easy and efficient means of ensuring young plants have a continuous and adequate supply of moisture and nutrients.

CONTEXT	PROBLEM	MANAGEMENT
Plant the seedlings so that the soil covers the top of the planting mix.	Planting too shallow will cause the roots to be exposed, the plug to dry out and be less stable particularly on mounded rows. Planting too deep will cause bark damage and collar rot of the cambium layer (the green tissue under the bark).	Compact the soil around the young plant to ensure close contact of soil with the roots and remove air pockets. Be careful not to over compact the soil and bend or distort the root system.
Watering ***At this stage roots are confined within the top surface of the soil which even during the wet season can quickly dry out.***	Newly planted seedlings are highly susceptable to water stress until roots have extended deeper into the soil. Leaf wilt indicates inadequate moisture. Soils vary in their capacity to hold water.	Watering in after planting is essential. The best results are to maintain frequent applications until the roots have established. Then irrigate according to soil monitoring equipment. A moisture probe is a useful tool.
Irrigation ***Drip irrigation offers the best delivery of water to plants, providing moisture directly to the tree's roots.***	Young plants require a steady supply of moisture particularly for the first six weeks and thereafter for their first year of growth.	Modern irrigation systems allow automated watering according to plant need. Typically in the first six weeks irrigation is likely to be necessary every other day and beyond that twice a week.
Mulch ***The mulch previously provided will have been disturbed and will have become broken down through decomposition. A further application is now necessary.***	Weeds will take advantage of nutrients fed to the young plants and without mulch, the top layer of soil rapidly dries. Pathogens can be transferred from mulch to the plant's main stem.	Apply a thick, coarser layer of mulch that has a slower decomposition rate to cover the exposed soil of the planting row. Do not allow mulch to contact plant stems.
Weed control ***The biggest challenge to establishing trees is to control weeds.***	Young trees are sensitive to spray drift.	Use covered sprayers and low-drift nozzles to minimise drift. Inevitably there will be an unsprayed zone along the line of the main stems of the trees. This has to be dealt with by the careful hand application of herbicide.
Fertilising ***Commence fertilising of young trees six weeks after planting***	Trees need to overcome the stress of transplanting before stimulating growth. Young roots can be burnt if they come into contact with the fertiliser.	Evenly distribute fertiliser as a band within the planting zone, avoiding close contact with the plant. Apply in small quantities every six weeks.

Sequence for establishing a plantation



SECTION 8

Managing trees from establishment to maturity

Weed competition is the biggest problem when establishing young coffee trees. Freshly disturbed fertile soil, full sunlight and moist soil provide an ideal growing environment for a wide range of invasive broadleaf weeds and grasses. Weeds will out-compete young coffee trees which are slow to establish due to their poorly developed root system and slow growth rates in their first year.

Nutrition, irrigation and managing tree shape are essential operations from establishment to maturity.

This section also provides information and guidance on the control of pests and disorders that affect coffee in the subtropics.

*Pinto Peanut (*Arachis pintoi*) is effective in controlling erosion, is shade tolerant and fixes nitrogen*

Sweet Smother Grass is planted from runners in summer

Smother Grass suppresses weeds and other grasses, does not compete with coffee trees, controls erosion and tolerates shady conditions. Its low growing habit reduces mowing and weedicide costs significantly.

CONTEXT	PROBLEM	MANAGEMENT
Young seedlings are especially weak in competing with broadleaf weeds and grasses which invade the planting row.	Excessive competition with invasive weeds can severely retard growth of coffee seedlings, delay cropping by one or two years, result in poor tree stability and impair the structure of the root system.	Pre-emergent weedicides have been tried with limited success. Spray germinating weeds with a post-emergent weedicide such as Glyphosate or Basta, taking care to avoid drift onto coffee seedlings. (*Refer to the APVMA website for permitted weedicides.)* Apply a thick layer of mulch in a 50 cm wide band along the planting row.
Coffee trees have a shallow, poorly developed root system with 80% of the roots in the top 30 cm of soil.	Grasses such as Kikuyu, Rhodes Grass and Crowsfoot will rapidly invade the planting row and restrict the growth of young trees.	Maintain spraying as the young trees establish, building up under tree mulch with side mown material from the inter row.
In the region's favourable growing conditions, particularly in the spring and summer, active weed growth occurs amazingly quickly.	Weeds can rapidly overcome seedlings and young trees.	Waiting a few days for favourable weather conditions is unwise. Spray early morning as wind-free days are rare, particularly during the summer and autumn period of rapid weed growth – *so, get in while you can!*
Broad leaf invaders of freshly prepared ground are Blackberry nightshade (*Solanum nigrum*), Amaranth (*Amaranthus *spp), Farmers Friends (*Bidens pilosa*), Inkweed (*Phytolacca *spp), Wild Tobacco (*Solanum mauritianum*), Ragweed (*Ambrosia artemisiifolia*), Wandering Jew (*Tradescantia *spp) and Canadian Fleabane (*Conyza canadensis*)	Broad-leafed weeds are aggressive competitors for water, nutrients and light. Some weeds such as Fleabane are resistant to Glyphosate.	Spray when weeds are young. Allowing these weeds to become well established before spraying is a costly mistake. The risk of over-spray damage to seedlings is greatly increased. There are also costs in time and materials. Monitor results of spraying and manage accordingly.
Legume vine weeds are early invaders of freshly disturbed soil.	Tropical legumes such as Siratro, Glycene and Silverleaf Desmodium are all prevalent in the region. They quickly establish suffocating trees and will impede efficient harvesting if not removed.	If vine growth becomes established in the trees the stems need to be severed at the base and growth ripped out by hand.

Unless adequate nutrients are applied during the bean development period, overbearing and die back of branches will occur as nutrients are absorbed by the developing crop.

Overbearing die back results from poor management of nutrition and water under full sun.

Coffee trees will develop nitrogen induced chlorosis when exposed to full sun when soil nitrogen levels are low.

CONTEXT	PROBLEM	MANAGEMENT
Inter row ***A priority after planting is to establish an inte- row groundcover that provides mulch, suppresses weeds and does not invade the plant row to compete with the trees.***	Rapidly growing tall grasses are great for suppressing inter-row weed growth and as a source of mulch but will quickly invade the plant row and out-compete seedlings.	In the establishment phase, the generation of mulch is of great importance in order to retain a moist soil and suppress weeds in the plant row. Initially sowing non-invasive tall-growing grasses such as Japanese millet and oats is recommended.
Making the transition from tall mulch producing grasses to non-competitive groundcover that will provide long-term suppression of weeds.	Mowing and spraying are significant management costs.	Sweet Smother Grass (*Dactyloctenium australe)* is proving a very effective low-growing groundcover. Plant as runners in early to mid summer in moist soil. Smother Grass will rapidly spread and suppress most weeds and provides excellent erosion control. It does not compete with the coffee trees and grows well under shade.
Nutrition ***Newly planted trees have a high requirement for nutrients and water when grown in full sunlight.***	Inadequate nutrition stunts growth or even causes the plants to die, requiring replanting. An inconsistent pattern of growth results.	The pre-planting application of a mineral and organic-based fertiliser such as poultry manure, incorporated into the soil, will promote root development, tree growth and benefit the establishment of groundcovers.
Soil microbes release essential nutrients to the roots, in a slow, sustained form when required by the plant.	The need is to maintain a continuous nutrient supply cost effectively.	Natural mineral-based fertilisers are low cost and long lasting, requiring only an annual application of around 300 kg/ha.
There is a high demand particularly for nitrogen and potassium during the summer and autumn months, when tree and bean growth are at their peak.	Additional fertiliser applications in a more concentrated form will also be required.	See the table overleaf.

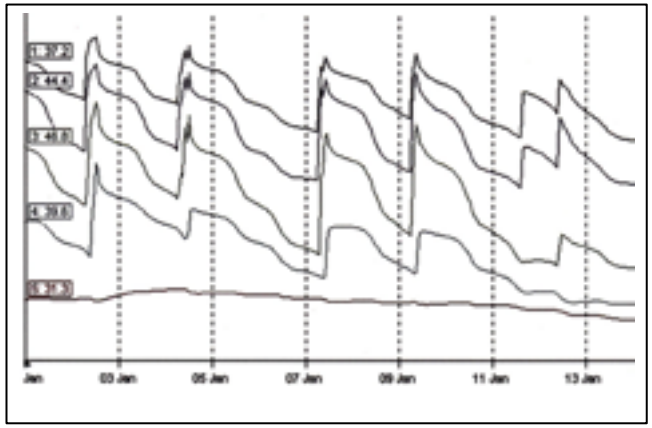
Leaf sampling procedure

1. Take the third or fourth pair of leaves from the tip of an actively growing main branch. Sample leaves from bearing or non-bearing branches but not a mixture of the two. Select from the mid-height of the tree. Only take leaves which are free from insect or physical damage and disease.
2. Take four pairs of leaves from each sample tree and sample at least 15 trees over the sample area or block. (There should be at least 60 leaf pairs in the sample.)
3. Place the sample leaves in a clean plastic bag and label the bag so the block or area is clearly identified.
4. Take sample bags to the local analytical laboratory. Do not keep the samples for more than 24 hours before they are analysed.

Left – The C-probe radio transmitter. The only cabling needed is from the sensor to the radio unit.
Right –The EnviroSCAN sensors are connected by cable to a central data logger and a controller with a solar panel which powers the probes. Installation technique is critical.

Connecting to a data logger and solar panel

Soil moisture readings from an EnviroSCAN sensor showing the increase in soil moisture at various depths after irrigation



The EnviroSCAN system consists of capacitance sensors installed at varying depths

Optimum leaf nutrient levels for coffee grown in full sun

NUTRIENT	OPTIMUM RANGE
Nitrogen	2.5–3.0%
Phosphorus	0.15–0.2%
Potassium	2.1–2.6%
Sulphur	0.02–0.1%
Calcium	0.7–1.5%
Magnesium	0.2–0.4%
Iron	70–200ppm
Manganese	50–100ppm
Copper	16–20ppm
Zinc	15–30ppm
Boron	40–100ppm

CONTEXT	PROBLEM	MANAGEMENT
Fertigation ***Applying soluble nutrients through the irrigation system is a cost-effective and efficient way of feeding the root zone of the tree and not the weeds.***	If unfavourable weather conditions such as heavy rain or a prolonged dry spell occur, ground-applied solid fertilisers can be expensive and wasteful.	A range of proprietary fertigation mixes are available to suit various growth and bean maturity stages. These should be applied according to leaf analysis recommendations.
Irrigation ***A pressure-compensated drip irrigation system is the most water-efficient method of applying water to the root system of coffee trees. It simplifies irrigation practices but requires competent management and monitoring.***	Applying water that only wets the surface will encourage the development of surface roots at the expense of deeper axial roots. While surfaces dry out quickly, at greater depths, soil remains moist even during dry periods. Guessing when to irrigate can result in overwatering, (water logging) or under watering.	Installing soil moisture probes at strategic locations through the plantation (upper, mid, lower slopes, changes in soil type, etc.) will take the guesswork out of deciding when to irrigate. A range of monitoring devices is available. Low-cost moisture probes which read soil moisture at a fixed depth (e.g. Decagon or Growpoint probes) can be incorporated into automatic irrigation systems. EnviroScan and C-Probe systems are more complex and provide continuous real-time readings at multiple depths. Sensors connect to a central data logger and irrigation controller using solar panels to power the probes. Further irrigation guidelines are in *Irrigation Guidelines for Coffee in the Subtropics*.

Pruning shoots to a single stem up to at least 45 cm above the ground improves harvester efficiency

Pruning the main stem to where the minimum stem diameter is 4 cm provides a strong base for new growth

Topping trees using rotating circular saws is efficient and best done by specialist contractors

Prune tall varieties at a height of between 1.3 to 1.8 metres. Trees in front show results one year after hedging and topping compared to unpruned trees in the background.

CONTEXT	PROBLEM	MANAGEMENT
Pruning mature trees ***Keeping trees in a manageable shape and size for machinery access between rows and for efficient machine harvesting***	Weak secondary verticals tend to hang into inter rows particularly when carrying a crop, obstructing access. Trees can grow to heights higher than can be properly machine harvested. Once trees reach 3.5 metres in height the harvester shaker mechanism is prevented from effectively removing ripe cherry and damage can occur to both coffee trees and shaker fingers.	Ensure secondary verticals and branches are cut close to the main stem to prevent regrowth and further suckering. This should be done three to four times in the first year after pruning. De-suckering is easier when suckers are small and soft. Rub or rip off rather than cutting to avoid regrowth from the wound.
Providing clear space for spray, fertiliser and harvesting equipment to pass under tree canopies and minimising damage and blockages	Multiple verticals from the stem of a tree and low branches obstruct equipment. When machine harvesting, cherry will be lost to the ground as the fish plate mechanism of the harvester is prevented from fully closing around the tree's stem.	Remove all secondary verticals and branches to a height of 400 mm or 300 mm if mounded.
Removal of dead or unproductive stems and branches	Dead stems and branches clog and damage harvesting and processing equipment. Small twigs and pieces can remain in the processed crop, reducing the quality and requiring further selective sorting.	Walk through the plantation pulling out dead stems and branches into the inter row pre and post harvesting for chipping/mulching.
Machine hedging and topping	Pruning by hand is not cost effective for commercial coffee production systems in Australia. Local contractors can undertake pruning using rotating circular saws similar to those used in macadamia growing/pruning. Topping is done in the first pass followed by side pruning. Pruning takes around 1 hour/ha.	Pruning should be carried out immediately following harvesting and at the onset of new growth, preferably after a heavy cropping year. Prunings are then mulched in the inter row using a flail mower or mulcher/mower.

A heavy crop occurs in the second year after pruning. Note the pruning cut mid picture.

Pruning height for topping tall varieties is from 1.3 to 1.8 metres

CONTEXT	PROBLEM	MANAGEMENT
Pruning stressed trees	Neglected or poorly managed trees may die if they are pruned too soon after a heavy crop when the tree is nutritionally exhausted, probably because the tree's carbohydrate reserves are severely depleted.	It is recommended to wait two months after a heavy crop before pruning to enable the tree to replenish its energy reserves.
Encouraging new growth of stems and branches to provide crop-bearing wood that will improve yields and fruit (bean) quality	The lower branches of tall trees become long, weak and unproductive as they become shaded. Bean size and quantity reduce as new growth focuses on upward growth towards sunlight.	The amount of hedging and topping required depends on the size and health of the trees. The standard height for topping ranges from 1.3 to 1.8 metres for tall varieties; however the pruning height should be determined by the diameter of the main stem (4 cm). This ensures there is sufficient strength in the main stem to support new growth after pruning. Hedge to the natural profile of the tree to remove all weak hanging secondary verticals and exhausted laterals.
Opening up the foliage canopy to light and air	Dense canopies encourage pests and diseases while heavy shading inhibits flower bud initiation. The profusion of branches and leaves prevents sunlight from penetrating the canopy, so fewer flowers develop, less cherry is set and ripening will be more uneven.	Multiple verticals will shoot from pruned stems producing dense canopies. After pruning, thin the shoots to four to six verticals by rubbing out any excess. Repeat three to four times during the year. This will increase efficiency of cherry removal and harvester selectivity in removing ripe cherry and leaving immature green cherries on the tree.
Reducing the crop in heavy bearing years	Trees overburdened with fruit risk die back and going into a biennial bearing cycle.	While it is hard to forgo the potential crop by cutting out cherry-laden branches, there is long-term benefit from selective pruning.
Yield loss through hedging and topping	In the first year after pruning, yield losses range from 25 to 75% depending on the severity of the pruning.	In the second year following pruning, yields are usually equal to or 150% greater than unpruned trees. Bean size is also larger and harvesting efficiency is improved dramatically compared to unpruned trees.

New shoots emerge 6 to 8 weeks after stumping. Trees must be in good health before stumping. They may die if trees are exhausted.

Regrowth 12 weeks after stump pruning at 45 cm

Multiple vertical stems at any height reduce harvester efficiency dramatically by preventing the catching fish-plates from enclosing the base of the tree. Shaker fingers are also broken and damaged with multiple stems.

CONTEXT	PROBLEM	MANAGEMENT
The need for a pruning strategy	Pruning the whole plantation in one year upsets the income stream but is cost effective and maintains consistency of plantation growth.	Block pruning involves dividing the plantation into roughly equal areas and pruning each block in sequential years. The influence of pruning on income streams is evened out and each block has consistency of growth. Pruning 20% of the plantation each year allows a five-year recovery and cropping cycle to be introduced. Eventually after multiple prunings, replanting will be required.
Pruning alternate rows	This system presents difficulties in the management of irrigation, nutrition and weed control; and is not cost effective.	Pruning alternate rows is not recommended.
Stumping involves cutting trees to approximately 30 to 45 cm above ground	This method of pruning has major disadvantages as uncontrolled suckering occurs, resulting in a profusion of growth. Trees are also out of production for at least two years.	A better option is to stump and kill the existing tree and to replant in the gaps between stumps. The new plants start producing heavy yields after three years.

The Good Guys

*The verticillium fungus (*Verticillium lecanii*) is a natural control agent for coffee green scale in the subtropics*

The Cryptolaenus *larvae actively seeks out and feeds on mealy bug and coffee green scale*

The Bad Guys

Coffee green scale and sooty mould

Poor nutrition and water stress favour the development of Cercospora *leaf spot*

Mealy bugs invade cherry clusters causing premature ripening. Overuse of broad-spectrum insecticides encourages mealy bugs by killing the natural predators.

Coffee leaf rust is the worst disease of coffee worldwide. Australia has so far remained free of this disease.

CONTEXT	PROBLEM	MANAGEMENT
Pest and disease control ***Fortunately the subtropical coffee growing region of Australia is free of major coffee pests such as the Antestia Bug***	A few pests such as Coffee Green Scale *(Coccus viridis)* and Mealy Bug *(Planococcus* spp.*)* may appear.	These pests are readily controlled by natural predators. Parasitic wasps and the *Verticillium* fungus provide effective control of Coffee Green Scale while the *Cryptolaemus* larvae control the Mealy Bug. These beneficial insects can be purchased from biological control suppliers such as Bugs for Bugs.
The region is free from Coffee Leaf Rust and Coffee Berry Disease – the two worst diseases of coffee. Cercospora Leaf Spot (*Cercospora coffeicola*) is the only potential disorder affecting coffee in the subtropics.	*Cercospora* Leaf Spot is common and can be found in every plantation.	It is generally a minor disease and is nearly always associated with trees in poor health or under stress. It is best controlled by providing good nutrition and irrigation management.
The rat in some situations has become a significant pest and difficult to control.	Rats are attracted to nutrients in the fresh bark of the branches of the upper canopy of mature trees where they chew through the bark and into the branch stem, weakening the branch or completely breaking it off.	Control is by baiting and removing potential rat-breeding environments.

Bats have chewed off the sweet cherry skins and spat out the beans

The depleted branch after a bat invasion

The top branches of trees have chewed through and broken off by rats

Rats have chewed through the branch

The broken off, chewed-through branches

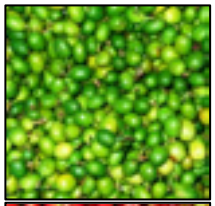
SECTION 9

Harvesting

Deciding when to harvest is particularly important in the subtropics where synchronised maturity of the cherry is difficult to achieve.

This section describes ways to assess the maturity of the cherry profile and yield in the plantation and the factors affecting harvester shaker performance.

The five maturity stages of coffee ripening



Green – immature, held tightly, not desirable in harvest. More than 1 per cent in the processed Dry Green Bean is unacceptable. These cherries should be left on the tree for the next harvester pass.

Coloured – mid colour and held less tightly than the green. The acceptable percentage of this stage in the sample is being researched.

Prime – full, shiny, red cherry is removed more easily than the immature green and coloured cherry. The ideal maturity stage for producing high quality plunger coffee with good acidity.

Past prime purple – darker, duller cherry, losing moisture. Its quality characteristics are showing good potential for the fuller bodied espresso coffee.

Naturals – purple/black, dehydrated, tree-dried cherry. Previously rejected as lower quality, however the fuller bodied taste is showing exciting potential for the espresso market and for blending.

The harvested crop showing an optimum stage of ripeness with most cherries prime and past prime. There are only a few immature green cherries, coloureds and naturals.

CONTEXT

Whatever harvesting method is used, the aim is to remove all fresh, ripe cherries, without damaging the tree and to leave unripe cherry on the tree for the next harvest round. Selective hand harvesting can achieve this; however, it is not a cost effective harvesting option in Australia where labour is scarce and expensive. Even at high coffee prices, the cost of hand harvesting alone exceeds the value of the crop. Field studies in Hawaii showed 568 man hours were required to hand harvest 1 acre of coffee (1420 man hours per hectare). One person can select hand harvest 10–20 trees in a day, and return up to 7 times to the same tree to complete the harvest.

Australia has made significant advances in the technology of machine harvesting of coffee. Technology such as preloading shaker fingers, layer harvesting, and adjustable selective vibration to allow 'on demand' variations in shaker harmonics of the shaker heads have improved the efficiency of ripe fruit removal. These controls can adjust the shaker pressure, amplitude and vibration frequency from side to side of the tree row and up and down the tree according to the crop load and ripening pattern of individual trees.

Also, techniques have been developed locally to measure the percentage of 'desirable' or 'ripe cherry' on trees compared to the 'unripe' cherry. A fruit removal force meter has been adapted to measure how much force is required to remove the cherry. These techniques are taking the guesswork out of deciding when is the best time to harvest a particular block to maximise the yield of 'desirable' cherry.

Sound, fresh, ripe cherries can be harvested by a variety of techniques from selective hand harvesting, hand-held vibrating shakers, hand-strip harvesting, selective machine or machine-strip harvesting. Choosing a technique will depend on the maturity profile of the trees, harvesting costs, and how well the processing system can separate the maturity stages of cherry to produce the best results in the final product.

The downside of machine harvesting is that not all of the cherry on the tree ends up in the final product. Not all of the ripe cherry is harvested and a percentage of immature cherry is picked and has to be removed during processing.

Depending on how well the machine is adjusted, and operated, there can be significant losses in harvesting through the collection and conveyor mechanism of the harvester. Some unripe cherry is removed by contact with the shaker's vibrating fingers and this can rise to an unacceptable level if the shaker mechanism is not adjusted correctly. It is common to lose 25–30% of the total crop on the tree in the harvesting and processing operations with some crop remaining on the tree at the end of the season. So, it is important to factor in these losses when estimating the final yield.

Remember that the harvesting method employed is not an indicator of coffee quality. How the coffee is removed from the tree is quite irrelevant. What is important is the freshness and ripeness of the cherries that are collected as the raw material for the ultimate production of coffees of the highest quality.

Trees at the end of the row tend to ripen earlier because of their exposure to full sun

Achieving less than 10% green in the harvested sample is the aim of selective harvesting. Less than 5% is ideal.

Our cooler ripening conditions allow unripe cherries to catch up to ripe cherries set in previous flowerings

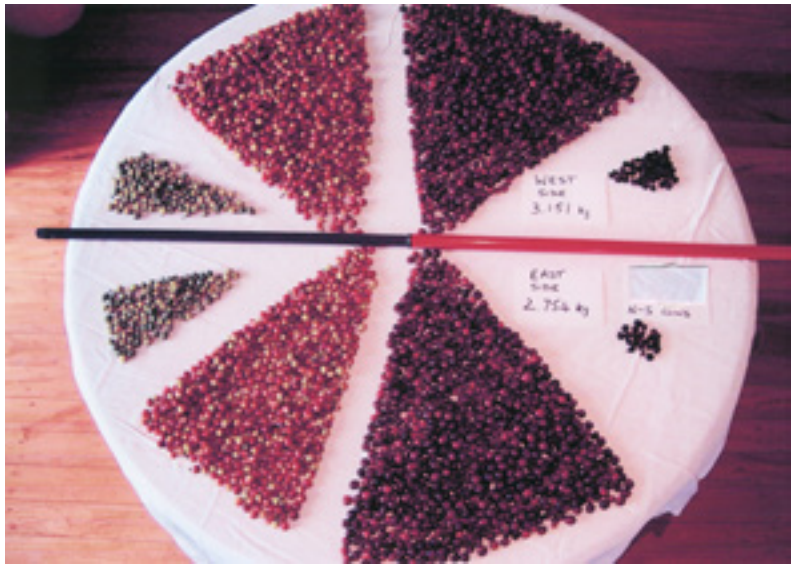
CONTEXT	PROBLEM	MANAGEMENT
A major advantage this region has is the long life cherry has on the tree under our cooler, drier winter. Under the hot, humid conditions of the tropics, cherry can progress from mature to over-mature and fruit drop can occur within 10 days. In our region, this process can take 10 weeks and allow later set fruit to 'catch up'.	The sight of a red flush of cherry promotes a desire to commence harvesting. Don't be deceived! The cherry that can be easily seen is on trees at the end of rows and on the tops of trees. They ripen earlier being fully exposed to the sun. The majority of 'hidden' cherry will still be unripe. Starting the first harvester pass too early, is costly.	Allow plenty of time before rushing to harvest. The climate is on your side. A closer inspection of the trees, within the block or plantation rather than from its edge will reveal most of the cherry is still green even in September. Strip pick one tree of all cherry (ripe and unripe) and separate into five maturity stages to see the true picture.
With multiple flowering events, the period during which cherry turns red and ripens can extend from June through to November.	In such situations it is even more important to allow time for late-developing cherries to catch up.	The key to efficient harvesting in the subtropics is to time the harvest according to the maturing of the coffee on the tree at the end of the season.
Cherry is tightly held on the tree until it is ripe and ready for picking.	Harvesting early requires excessive force and will result in damage to the tree and the removal of unripe cherry.	Err on the side of lateness. Beans from past prime cherries have an equal or even higher value than prime ripe cherries. Unripe cherries have no value and create a cost to remove them from the harvested cherry.
Deciding when to harvest is the most critical decision of the year. It is a question of percentages and judging the moment when most of the cherry across the block or plantation is in its prime state of ripeness. ***Two techniques have been developed in this region to take the guesswork out of deciding the optimum time to harvest.***	There will always be a percentage of the crop that is deep purple and is over ripe, and some that remains green and quite unripe.	1. Measure the Fruit Removal Force (FRF) of the various maturity stages of the cherry, with a pull-force meter modified to measure the force required to remove cherry. 2. Measure the maturity profile of the tree by strip picking a whole tree of all cherry and separating the five maturity stages into a 'Maturity Profile Wheel' where the actual percentage of each stage can be calculated. Using these two techniques in combination gives the harvester operator the best opportunity to achieve the highest yield of ripe (prime, past prime and naturals) cherry and the lowest percentage of unripe cherry in the harvester bin.

The SHIMPO MF, force gauge, Type MF-5LB with calibrations 5 lbs x 0.025 lbs

Modified claw for clasping the cherry stem

The fruit removal force of different maturity stages is measured using a pull-force meter

Measuring the maturity profile of the tree by strip picking a whole tree of all cherry and separate the five maturity stages into a 'Maturity Profile Wheel' where the actual percentage of each stage can be calculated.



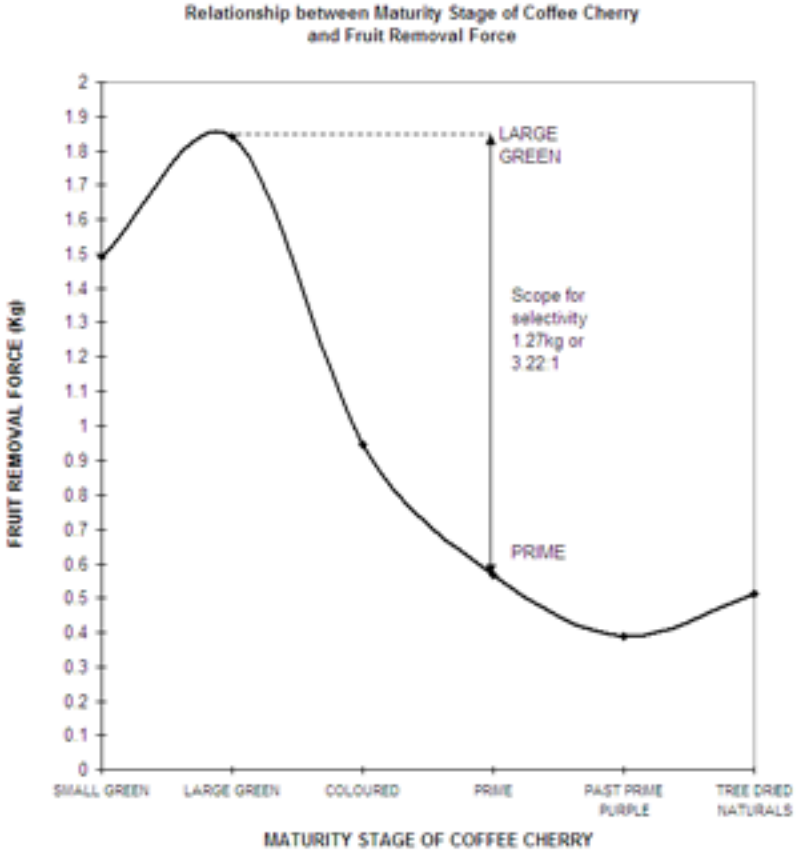
CONTEXT	PROBLEM	MANAGEMENT
The machine harvester can be set to give a harsh or light agitation or bean pull force	A harsh setting will optimise the volume harvested, increase the percentage of green cherry in the pick and lessen the need for subsequent passes. A light agitation will optimise the quality and consistency of ripeness of the pick but require subsequent passes.	For the first pass, a lighter agitation is preferable while the final pass should be the harshest so long as the trees have not reached the stage of producing flower buds in which case a light final pass is desirable.
Depending on the timing and completeness of the initial harvest, an assessment needs to be made as to the benefit of undertaking subsequent passes to remove residual and later ripening	As with timing the first pass, timing additional passes has to be assessed. A point is reached when there is insufficient value in the remaining crop to justify further passes.	A series of passes smoothes the flow of product through the processing plant. In addition to evaluating the costs of harvesting and returns from additional crop, there is also benefit in cleaning the tree of cherry as it promotes its readiness to begin the next productive cycle.
Using the Pull Force Meter ***As the coffee cherry matures from green to coloured (yellow-orange) to the red of prime cherry and then to purple and onto the tree-dried 'natural' stage, the force holding the cherry to the tree reduces.***	The key to achieving the maximum percentage of ripe (desirable) cherry and minimising the immature cherry (undesirable) in the harvester bin is to harvest when the ratio of the pull-forces between the ripe (desirable) and unripe (undesirable) is as wide as possible. The harvester operator then has greater scope for achieving selective harvesting and adjusting the controls on the harvester to maximise the recovery of ripe cherry.	The pull force required to remove cherry in the various stages of maturity is shown in the table below and shows large green cherry is the most stubborn and past prime purple the least. Excluding coloured cherry from the harvest presents the greatest challenge to selective harvesting. The quality characteristics of coloured cherry are of utmost importance in deciding what percentage of this maturity stage is acceptable in the final product.

	SMALL GREEN	LARGE GREEN	COLOURED	PRIME	PAST PRIME PURPLE	TREE DRIED NATURALS
Pull force (kg)	1.490	1.841	0.947	0.568	0.390	0.513
Ratio large green to:			1.94	3.24	4.72	3.59
Ratio coloured to:				1.67	2.43	1.85

The ratio between the unwanted large green cherry and the prime cherry is 3.24 to 1 or 3.25 times the force to remove the green than the prime cherry. This wide ratio provides the potential for a selective harvest.

Note: The ratio is even greater for past prime purples and the naturals.

More difficult is to select coloureds from prime with a ratio of only 1.67.



Collect all the cherry from the sample tree – this is the bulk sample. This sample shows it is too early to harvest.

Divide up the maturity stages into a maturity. wheel

CONTEXT	PROBLEM	MANAGEMENT
The Maturity Profile Wheel can be used to check the variation in maturity from each side of the tree row before harvesting commences.	The sample tree selected for analysis should be typical of most trees in the block North–south running rows have a more even ripening pattern on both sides of the tree row while east–west running rows tend to be riper on the north side of the row and immature on the south side.	Harvesting should not commence until there is at least 75–80% ripe cherry (prime, past prime purple and naturals). These are the desired maturity stages.
Factors affecting harvester performance ***Slope constraints*** ***Coffee harvesters were designed to operate on fairly flat land. However, the incorporation of self-levelling devices now enable operation on a side slope of 6–8%. Side-to-side slope adjustments keep the tree row centred and upright between the two shaker heads of the harvester.***	The slope limitation is determined by the need to keep the collection system of crop lifters, fish plates and conveyors above the ground as the machine is levelled. Modifications such as lowering the fish plates, shakers and crop lifters have improved the ability of the machine to harvest lower branches but tree damage occurs being off centre to shakers and more of the crop is left on the tree.	The limitation of side slope is more critical than the row slope. Slope rather than orientation should dictate the direction of rows with the lesser slope being across the rows rather than along it.
The harvester can operate travelling up rows which slope as much as 15%. For greater slopes the harvester has to operate downhill.	This increases harvesting time by 150% and the loss of cherry falling in front of the machine collection system increases. During wet weather, safe and efficient operation becomes difficult on slopes above 15%. As slope increases, there is less flexibility in adjusting the shaker pre-loading, and selective harvesting efficiency is reduced, however, some modifications have been made to improve selectivity on steeper slopes.	Plantation layout needs to appreciate the operating limitations of machine harvesting. Headlands on excessively sloping land need to be sized and profiled to facilitate safe manoeuvring of the harvester. A headland of 8–10 metres is the required dimension.

The Korvan harvester – note the fish plate arrangement and the importance of keeping the base of the tree free from branches and suckers

For ease of harvesting, the steepness of a slope should be along the row rather than across it

Offloading the harvested crop into field sacks for transportation to the processing plant

The inside of the harvester showing the shaker fingers, and fish plate base that catches the cherry. Side elevators carry the cherry into an on-board hopper.

The cherry laden branches intertwined with the shaker fingers. The cherry is shaken off and falls onto the fish plate floor of the harvester.

CONTEXT	PROBLEM	MANAGEMENT
Tree size and structure ***Tall varieties such as K7 are well suited to machine harvesting because of their open branching and long inter-node length between cherry clusters which allows more efficient transfer of vibration from shakers to the cherries. Provided trees are kept pruned to below the head of the shaker frame, the harvesting recovery can be as high as 90% on young trees, compared to 50% for semi dwarf types.***	Harvester efficiency is reduced and substantial damage to shaker rods and tree branches occurs if trees are allowed to grow above this height (2.8–3 metres). Semi-dwarf varieties are difficult to harvest initially because most of the crop is borne on lower branches which are too low for the harvester shakers. The cherry clusters too are tight and close together, making it more difficult to remove as they are less able to vibrate sufficiently to selectively remove cherry without causing significant tree damage and removing excessive unripe cherry.	Research is shortly to be undertaken into the suitability of varieties that are less vigorous than the K7 variety. Where hand picking is practised, the semi-dwarf varieties may be preferred as the crop is easier to reach and these varieties tend to be heavier crop bearers.
Maintaining a single stem at least to a height of 0.3–0.4 metres above the ground is essential for achieving high recovery of cherries.	Multiple leaders (or upright main branches) arising from below 0.3–0.4 metres cause significant problems for the collection systems and shaker fingers, keeping the catching fish plates open for a longer time and letting dislodged cherry fall to the ground. Vibration efficiency is also dampened by the thicker mass of older multiple vertical stems and damage to shaker fingers occurs more frequently.	Spray secondary vertical shoots at the base of the main vertical with a weedicide such as Basta (Glufosinate-ammonium) which will burn off new shoots without affecting the rest of the tree. On stumped trees, regularly rub out all but a single vertical then, once firmly established, maintain a single stem with direct weedicide spraying at the base of the stump.

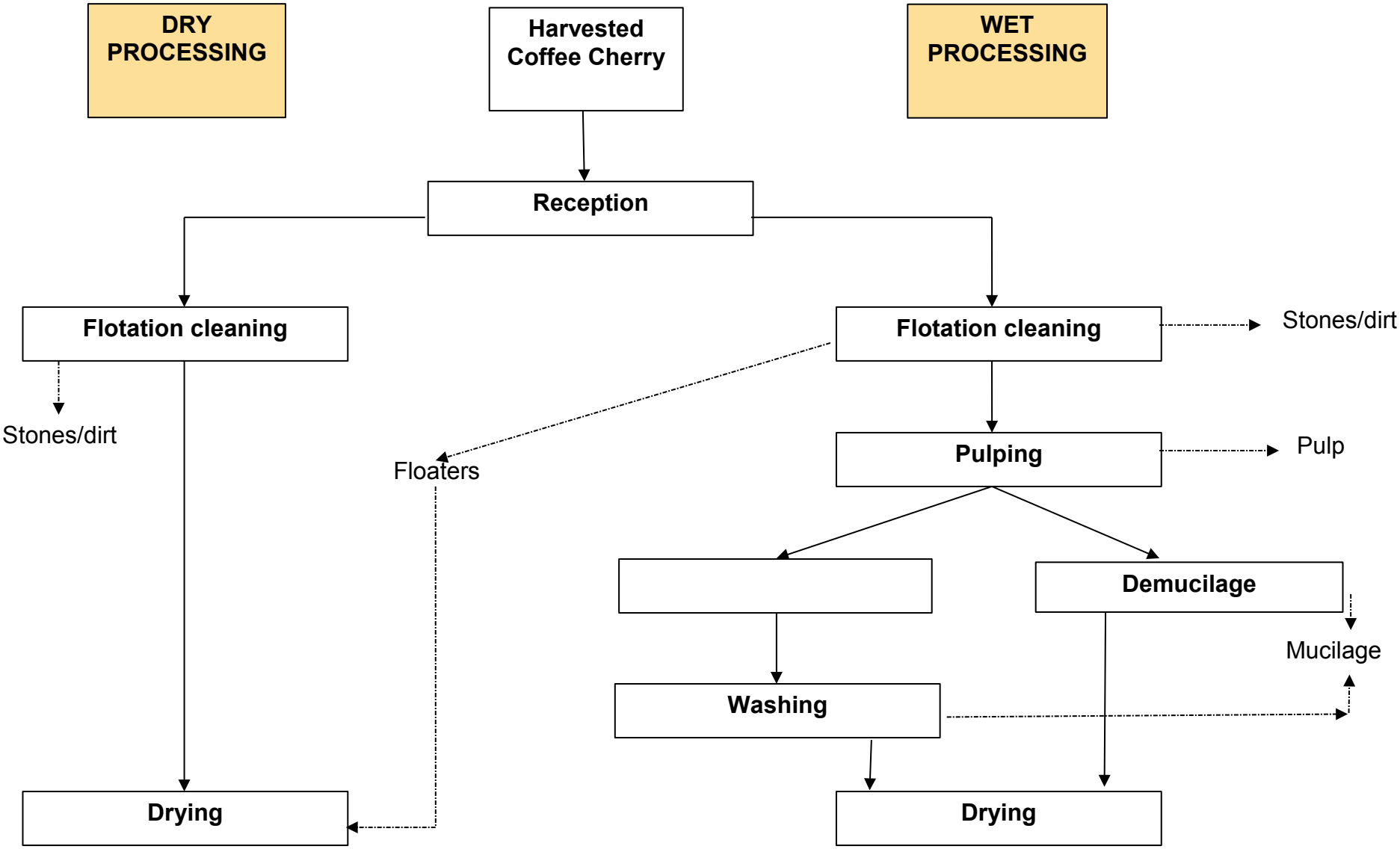
SECTION 10
Processing

A coffee's character is inherited from the terroir of a plantation. But, for its inherent character to be retained and enhanced, it is essential that the process of transforming the coffee cherry into a green coffee bean ready for roasting is handled skilfully and the processing methods used produce a bean of consistently high quality.

The wet processing method has dominated coffee processing in the subtropics. However, a range of processing methods has been tried to create different products with the aim of enhancing the positive attributes of the region's coffee.

This section describes various processing methods available in today's market and factors that can either positively or negatively affect the quality and consistency of the coffee's flavour and aroma.

PROCESSING THE COFFEE CROP



CONTEXT	PROBLEM	MANAGEMENT
Cherry begins to deteriorate the moment it leaves the tree. A build up of heat occurs through fermentation.	Fermentation will cause decomposition of cherry skins and beans will absorb off flavours seriously reducing the quality of the coffee.	Harvest in cool conditions. Cherry held on the plantation should be stored in the shade then delivered for processing within four hours of harvesting. Deterioration of cherry can be slowed if stored in a cool, airy environment.
Transporting cherry from the plantation to the processing plant needs to be well managed.	Poor preparation and implementation of transport will reduce time efficiency, increasing cost and possibly affecting the quality of the product. A steady flow of supply to the plant needs to be achieved.	Prepare and practice a plan of attack. Have the equipment needed to move product serviced and ready. Have sufficient containers and space to store the volume of the expected harvest. Identify collection and delivery points and the routes between them. Have a back-up plan for critical operations.
Scale and design of processing plants range from complex factories to on-plantation plants and stand-alone machines with improvised equipment.	Processing plant is a significant capital expenditure, requires operator expertise, has high maintenance costs and stands unused for most of the time. Plant and equipment needs to be of adequate size to cope with expected volumes.	Assess the scale (capacity) and the sort of equipment required to efficiently handle crop volumes. Consider the extent to which processes are to be undertaken (see diagram). Compare with the costs/benefits of off-site, factory processing.
Processing is divided into wet and dry methods with separate plant for each part. Product that has a moisture content of less than 20% is in a stable and transportable condition.	There are operational advantages in having the convenience of an on-plantation wet processing plant. Dry processing is less critical.	Assess the disadvantages of cost, transportation and third-party dependency of off-site processing against the advantages of saving on capital equipment. Consistency and quality of product is easier to achieve in fully equipped factory-scale dry processing mills.
Processing plants need to be housed, have adequate water supply, waste disposal provision and three-phase electricity.	Unless these are available, the cost of making provision is considerable.	If on-plantation processing is desired, the availability of these aspects needs to be considered at the plantation feasibility assessment stage. Alternatively, assess the availability and convenience of using existing processing plants.
The efficiency of processing is dependent on the smooth and steady flow of product through it.	Without a continuous supply of product, processing will be inefficient. A delay in processing will adversely affect the quality of the product.	Delay commencement of processing until adequate supply is held to ensure smooth and continuous throughput. Ensure reception areas have capacity and capability to ensure continuous feed.

	GREEN	COLOURED	PRIME RED	PAST PRIME RED	TREE DRIED
Skins	Solid light and dark green skin	Yellow, orange and light red skins	Bright red turgid skins with fresh lustre	Soft skins sweet sticky mucilage beginning to dehydrate	Wrinkled dark brown/black tight skins fully dehydrated & fermented
Skin/bean separation	Substantially impossible	Mainly possible to separate skins from beans	Easily separated	Easily separated if dehydration is not too far progressed	By hulling when dry to remove skin and parchment (husk) or repassing while wet after initial processing.
Mucilage	Undeveloped	Partly developed, bitter taste	Juicy and sweet taste	Sticky and intense sweetness	Leathery with molasses/caramel aroma
Beans	Immature	Developed	Fully mature	Fully mature	Fully mature
Quality	May have some blending quality	Low oil content, second grade product reducing flavour quality	High grade product if green cherry removed	High grade product if processed carefully	Quality product requiring special processing
Processing methods	Generally discarded	Can only be discarded by hand sorting Fully washed Semi washed	Fully washed Semi washed Honey	Fully washed Semi washed Honey, Winey, raisin potential	Naturals Raisin Repass

FULLY WASHED WET PROCESSING	COMMENT
Unripe cherry, leaves, twigs, and other unwanted material are removed from the crop by hand passing down a conveyor belt or mechanically using a shaker table which removes unwanted material other than full-sized green cherry and small twigs. ***Over ripened and fully ripened cherries float in water and are separated in floatation tanks from unripe, coloured, prime red and past prime cherry which sink. Floated product (known as naturals) is collected and spread out to dry while cherry that sinks is conveyed to a pulping machine.*** ***Some fully washed processes incorporate a green separator at this stage (see the semi washed process below). The pulper separates the skin from the parchment (coffee bean enclosed in its endocarp or 'parchment'), with skins collected as waste product and the parchment passing into fermentation tanks.*** ***Pulped parchment is soaked for up to 72 hours until it has lost its slimy feel and is rough to the touch. The parchment is either dried in an unwashed state or washed clean of the fermented water and then dried. Drying is done either mechanically or on drying beds by the sun.***  *Parchment entering a fermentation tank*	This has been the typical processing method employed in the region and is most suited to small-scale operations. Relatively cheap and unsophisticated equipment is involved. A moderate supply of clean fresh water is required for float tanks, to promote a flow of product through the pulper, for fermentation and for washing. The water used for fermentation becomes highly acidic and should be discharged into holding ponds to break down before being released into water courses. Fermentation is the most critical stage of the process. Over-fermentation can result in 'stinker beans' which cause off flavours and are a serious defect. If under-fermented, the parchment retains a coating that will continue to react when laid out to dry and can develop moulds that infuse adverse flavours into the beans. Fermentation is carried out in batches and the size of the tanks used is a constraint on volumes that can be dealt with at any one time. The rate at which the mucilage breaks down (through fermenting) varies depending on the amount of sugar in the mucilage, the ambient temperature and the humidity. Maintaining consistency of product between each tank and batch is more difficult than with product that flows through a semi washed process. During fermentation, the parchment needs to be regularly stirred and felt for sliminess. As soon as the parchment feels like river sand, fermentation is complete and beans should be removed from the fermentation soup and thoroughly washed until the water is clean. Expert tasters favour coffee produced by this method. If practised correctly, the resultant beans will have a uniform dark green colour and produce coffees with good acidity and sweetness, particularly suited to milk-based plunger-made coffees.

SEMI WASHED WET PROCESSING	COMMENT
This process is the same as the fully washed method described above but eliminates the fermentation stage. ***After floatation, the product passes through a green bean separator which forces the desired cherry with bean through a size grid which restrains the hard green-skinned cherry within a revolving drum that ejects green bean from the process.*** ***The wanted product then proceeds to a pulper, which removes residual skin and flesh from the bean seed (leaving it as parchment coffee). The wet and slimy parchment is conveyed to a demucilaging machine which washes and scrubs off the sticky mucilage. When washed and scrubbed, the clean parchment is sent for drying.***  *Parchment drying on shadecloth*	This semi-washed process has become a 'standard' production method in major coffee growing regions where water supply is limited. It has also become the normal method of production within the Australian subtropical region for medium and large-scale plantations where machine harvesting produces large volumes of product that have to be speedily processed. There is a high capital cost in purchasing and housing the equipment required. Machinery is likely to require a three-phase electricity supply. A steady throughput of product is required for machinery to function efficiently and satisfactorily. The rate of conveying product from one stage to the next needs to be continuously monitored. Continuous supervision of processing equipment is essential to ensure trouble-free performance and optimum quality of product. A skilled machinery operator is required to supervise the operation of the processing plant, respond to malfunctions and adjust machinery performance. This process produces a clean consistent product with beans having a good uniform green colour. Whether removing the mucilage using aqua pulpers instead of fermentation affects the quality of the coffee is debatable.

HONEY PARCHMENT	COMMENT
Prime and past prime cherry that sinks in the floatation tank is used for this process. Ideally any green or coloured cherry that remains in the product leaving the floatation tank is removed by hand sorting. ***Cherries pass to a pulping machine to remove the skins but the fermentation or demucilage processes are not carried out. The mucilage is left on the parchment or is only partly washed off.*** ***The sticky parchment is then spread out in a very thin layer on raised drying beds to allow greater airflow. Frequent agitation to separate the parchment is required during the early stages of drying until the mucilage is dry. Once touch dry, dryers can be used to achieve a moisture content no greater than 12% before storing.***	This process is only suited to small batches and is an interesting alternative production method for smaller plantations wanting to create a specialist product. The greatest challenge is to achieve even drying and stop the parchment congealing into stuck-together lumps. This is best done by sun drying in the open air rather than in mechanical dryers. The drying process is labour intensive. Honey parchment must be covered at night and in the event of rain. If the touch-dry parchment becomes damp through rain or dew the stickiness will return. Mucilage left on the bean provides the opportunity for spoiling if the drying process is prolonged and uneven. In tests this process has consistently produced the best quality coffee. The result is a honey-coated parchment infused with the natural sugars of the cherry. Some residue of skin is thought to enhance flavours by adding molasses and tannins to produce full-bodied, sweeter coffee flavours with less acidity.

WINEY PROCESSED	COMMENT
This is a novel method being trialled in the region. It should not be confused with the natural processing method (see below). ***Impurities are removed from the harvested cherry which is then either sorted to remove green cherry and/or floaters or the entire crop is laid out on drying beds for the cherries to continue to ripen and fully dehydrate to become raisins.***	This is a simple method that is not labour intensive, requires little skilled input and no expensive wet-processing equipment The time taken to achieve full dehydration can be many weeks and is prolonged in humid conditions. The greatest challenge is to maintain a moisture-free environment during the long dehydration period. Cherry will readily rehydrate and is highly susceptible to moulds developing. Taste profiles resulting from winey beans are very different to coffee produced from naturals. The result is a fruitier, wine-like taste profile, hence the term 'winey' being used to describe this processing method.

NATURAL PROCESSING	COMMENT
Sometimes referred to as raisin processing, this process involves those cherries that are separated from prime cherry as floaters at the floatation stage. Initially considered waste, this product is now regarded worthy of processing. ***The floaters are immediately taken from floatation tanks and spread out on drying mats or loaded into dryers before they rehydrate.*** ***The beans in their skin must be turned at least twice a day until touch dry and kept dry until fully dried to at least 12% moisture content before storing.***	As the product is primarily cherry that has completed ripening on the tree, the content is fully fermented and mucilage fully infused. If harvested when dry and separated by size (the dehydrated cherry being smaller) the moisture content may be low enough for immediate storage. The most critical stage of this easy processing method is achieving a touch-dry condition and maintaining it so until ready for storage. Because up to 50% of the total harvest may be naturals, a considerable area is required to spread them out if they are to be sun dried. The coffee produced is not of a style favoured by expert tasters but has more intensive flavours, is full bodied with low acidity and is more suited for espresso coffees or for blending with wet processed coffee to increase complexity.

REPASSING	COMMENT
Floaters are soaked in clean water until they rehydrate and skins soften sufficiently for pulping using a specially adapted pulping machine. No fermentation is required. The pulped parchment can be immediately dried in the sun or by machine.	The period of time allowed for rehydration is critical. Over soaking results in an infusion of tannins while under soaking results in imperfect skin removal and inconsistent drying. A greater number of imperfect beans result, producing a second-grade green but an extremely full-bodied coffee with a plum-like fruit taste.

Mechanical drying equipment

The dry mill with the densometric table in the centre of the picture

DRY MILL PROCESSING	COMMENT
The first process is to remove the parchment husk of wet-processed beans or the skin and husk of dry-processed beans. This is called hulling, done by a machine which rasps the covering away from the bean. ***The second process is to remove any remaining parchment (endocarp) and the thin silverskin using a polisher or by re-hulling.*** ***The beans are then size and density sorted using a fluid bed densometric table This separates shells, broken and defective beans and other imperfections and sorts beans into quality graded categories.*** ***The last process is to remove discoloured beans using a colour-sorting machine or by hand.***	Dry mills are an expensive capital cost and unlikely to be cost effective for any but the largest of operations. Their operation requires skilled operators. With inputted product being in a stable condition and able to be stored, supply and operation can continue throughout the year which increases capacity and improves viability. Dry mills are established in the region and have the capacity to handle product from the region's plantations. The cost of dry mill processing depends on the volume and quality of product supplied to the factory, and the extent to which processing and grading is required. Economies of scale apply. As a rule of thumb, the cost of full processing and grading is in the order of $1.00 per kg. The market requires beans to be sorted to certain internationally recognised sizes such as 14s (14/64ths of an inch), 16s, and 18s etc. Peaberries (a single bean formed in the cherry) is a separate marketable category. For there to be confidence in the quality, consistency and availability of supply of Australian subtropical coffee, growers are encouraged to market product that has well processed and graded.

STORAGE	COMMENT
Coffee is best stored as either parchment or naturals. Storage can be in bulk containers or in more manageable sacks. The environment must be dry and not subject to wide variations in temperature. ***Coffee is not of interest to pests but pest control is required in stores as vermin tend to build nests in sacking.*** ***To prevent coffee taking on taints and flavours from the environment, the store should be secure, clean, well aired and not house any volatile products.*** ***Once the green bean is exposed, it is more susceptible to adverse environmental influences.***	Handling requirements and storage space will determine the type and size of storage. Storing parchment and naturals in sealed plastic sacks provides greater protection from environmental influences but there is debate as to whether restricting interaction with the environment is desirable. Coffee can be stored without physical deterioration for many years. Storing coffee is a cost and delays cash flow. It extends the risk of spoiling. On the other hand, as a commodity in a rising market, stored coffee is an investment and a diminishing resource. Whether or not the cupping quality of coffee improves or deteriorates over time is debatable. If parallels with the wine industry are drawn, then age is beneficial. Tastings undertaken by ASTCA members comparing their young and aged green bean suggest there is an enhancement of flavour. However, there is clearly a deterioration in the appearance of the green bean which takes on a paler straw-like hue. Once parchment or naturals are hulled, the green bean is normally stored and marketed in 40 kg hessian sacks. However, without the protective husk, the green bean is directly exposed to the atmosphere and is better protected in sealed plastic sacks. There is little to be gained and much potentially to be lost in storing green bean for extended periods before roasting.

Glossary of coffee terms

Terms related to coffee production

Active ingredients (a.i.)	The biologically active portion of a pesticide formulation.
Alternate host	A plant (or animal) that is host to pests or diseases which affect cultivated crops (or farm livestock).
Apical dominance	Dominance exerted by an apical bud which prevents the development of lower buds.
Auxin	Growth hormones that promote the elongation of shoots and roots in all plants.
Available water	Amount of water that plants can extract from the soil as long as moisture tension remains below the permanent wilting point (about 4.2 = 15 atm.). Coffee trees are adversely affect by moisture stress at lower moisture tension than 15 atm.
Beneficial insects	Insects that feed on or destroy pest species.
Berry	Common name for the coffee fruit. The correct botanical name is a ‘cherry’ or a ‘drupe’.
Biocontrol, biological control	The control of crop pests by the introduction of natural predators, parasites or other living organisms without harmful side-effects on the crop plants.
Biodiversity	Refers to the numbers of species, variety and variability of living populations of organisms within specific environments.
Carbon:nitrogen ratio, C:N	The ratio of the weight of organic carbon (C) to the weight to total nitrogen (N) in a soil or in organic material.
Cation exchange capacity (CEC)	The sum total of exchangeable cations that a soil can absorb. Also called ‘total exchange capacity’ or ‘cation adsorption capacity’. Like the anion-exchange capacity it is expressed in milliequivalents per 100 g of soil.
Chlorosis	Yellowing of the foliage of a plant.
Cotyledon	The first leaf, or leaves of the embryo in seed plants.

Cover crop or living mulch	Crop grown as groundcover to protect the soil and reduce erosion, provide additional soil nitrogen, and improve soil structure by adding organic matter.
Cultural control	The use of cultural practices (mulching, pruning, tilling etc.) to provide conditions which are unfavorable to insect pests and which improve crop resistance to disease.
Die back	Describes symptoms which begin with the appearance of necrotic tissues in the young shoots or branches of a plant, spreading to older tissues, ultimately affecting the main stem and finally causing the death of the plant.
Dormancy	A period during which the plant or a seed is inactive, generally due to physiological and environmental reasons.
Endemic	Restricted or peculiar to a site or region.
Endocarp	The outer covering of the coffee bean, otherwise known as ‘parchment’.
Estate, plantation	The land on which the coffee is grown and all the infrastructures which surround the coffee growing and processing business. Ownership can be individual, corporate or cooperative.
Evapotranspiration	Refers to total loss of water from a cropped area including transpiration loss through the stomata of the leaves of the plants and evaporation loss from the soil.
Field capacity	The amount of water the soil retains after free drainage from a saturated soil.
Foliar application	Spraying leaves and the canopy with agrochemicals to control pests or diseases, or to feed plants.
Fungicide	A natural or chemical substance which has the property of killing fungi.
Genome	The complete set of genes on the chromosomes carried by an organism or virus.
Herbicide	A chemical compound for eliminating undesirable plants which can either be applied to the plants or to the soil.
High grown	Arabica coffees grown at high altitudes, over 1000 m (approximately). These coffees are usually superior to those grown at low altitudes. The term ‘high grown’ also figures in many grade descriptions.

Host plant	A plant on which a particular insect, disease or fungus feeds, develops and reproduces during part of its life.
Humid tropics	Regions where the mean annual biotemperature in the lowlands is over 24°C and where the annual rainfall exceeds or equals the potential evaporative return of water to the atmosphere. They include all lowland areas where the annual rainfall is over 1500 mm.
Immature	Unripe
Infection	The penetration of an undesirable organism into a host plant.
Infiltration rate	The rate at which water enters the soil under controlled conditions.
Inputs	Items purchased to carry out farming operations. Inputs include fertilisers, pesticides, herbicides, seeds, fuel etc.
Integrated pest management, IPM	An integrated approach to the control of pests or diseases in which chemical, cultural, biological and any other methods of control are combined.
Intensive cultivation practices	Involves the use of high levels of inputs of agrochemicals, irrigation, mechanisation and other modern technologies. Costs are high so profitability depends on high yields.
Intercropping	The growing of different crops in mixed stands (as opposed to mono-culture).
Internode	Portion of a plant stem or branch between two successive nodes.
Interveinal	Refers to spaces between the veins of leaves.
Leaching	The removal of soluble constituents of the soil, including plant nutrients, by water moving downwards through the soil by percolation.
Leguminous	Refers to species which belong to the Family Leguminosae, including herbs, shrubs and trees, all of which bear nitrogen-fixing nodules on their roots.
Mealy bugs	Sucking insects with sedentary habit, and body usually covered with a mealy white wax.

Microclimate	The climate in a very small area or in a particular habitat.
Monocropping	Cultivation practice which consists of growing a single crop in a specific area.
Mulching	The practice of spreading fresh or decayed plant material on the surface of the soil with a view to decreasing weed growth, reducing evaporation losses from the soil surface and ultimately increasing soil organic matter levels.
Multiple stem	Coffee tree with more than one stem developed through selective pruning. Not desirable for machine harvesting.
Nitrogen fixation	The conversion of atmospheric nitrogen gas to ammonia, nitrates and other compounds which contain nitrogen by means of nitrogen-fixing bacteria, photosynthetic bacteria and algae.
Nutrient recycling	Nutrients are recycled in the natural world – a living plant takes nutrients from the soil, dies and decays, and nutrients are recycled through the next generation of plants.
Organic matter	Often refers to carbohydrate materials originally produced as a result of photosynthesis and the combination of gaseous carbon dioxide with water. Examples are plant litter (roots, stubble, leaves, mulch) and animal manures.
Pathogen	An undesirable organism which penetrates a host plant and causes a disease.
Peri-urban	Agricultural land abutting onto residential areas on the outskirts of towns.
Pest	Any organism which attacks a plant or an animal. This includes fungi, viruses, bacteria, insects, nematodes, ants, mammals, and all other micro flora and fauna.
pH	Indicates the degree of acidity or alkalinity. A neutral pH = 7, below 7 is acid and above 7 is alkaline.
Phenotype	The outward appearance of an organism.
Phloem	Soft tissues of the plant through which nutrients and sap are conducted.

Photosynthesis	Synthesis by plants and some bacteria of sugars from atmospheric carbon dioxide and water vapour. Photosynthesis takes place in chlorophyll-containing cells when they are exposed to sunlight.
Phytotoxic	Toxic to plants.
Plagiotropic growth	Tendency to grow horizontally or obliquely from the trunk or the tap root (branches or lateral roots).
Predator insect	Insect which feeds on other insects. Unlike parasites, its movements are autonomous so predators do not depend solely on an individual host.
Provenance	Place of origin.
Primary branch	A lateral branch arising directly from a vertical stem.
Pruning	Cultivation practice which consists of removing wood from a plant in order to increase the fruit-bearing branches or to shape it.
Relative humidity, RH	The ratio (%) of the water vapor in the atmosphere to the amount required to saturate it at the same temperature.
Resistance	The power of an organism to overcome the effects of a pathogen or any other specific damaging factor.
Scale insects	A group of sedentary bugs which feed on plants.
Screen	Frame with a perforated metal plate or wire mesh with openings of different sizes, used to grade coffee beans by size.
Secondary branch	A branch arising directly from a primary branch.
Seedling	Plant grown from a seed.
Selective harvesting	Consists of hand-picking or mechanical separation of ripe cherries only.
Shoot	Young orthopedic stem formation. New above-ground plant growth.

Single stem	Coffee tree maintained on one stem only.
Soil texture	Defined by the proportion of particle sizes – sand, silt and clay – in the soil.
Species	A group of interbreeding individuals having some common characteristics not normally able to interbreed with other such groups. Species are subdivided into subspecies, races and varieties.
Stem	The upright branch of a tree which bears leaves and flowers.
Stoma	Minute orifice in the epidermis of plant tissues, mainly located underneath the leaves, through which gaseous interchange takes place, particularly water vapor and carbon dioxide. Plural = stomata.
Stripping	Consists of removing all the coffee cherries present on the branch irrespective of their degree of ripeness.
Stumping	Cutting a tree back, leaving only the stump.
Sucker	Orthopedic shoot arising from the stem, the root, the axil or from a branch.
Susceptibility	Vulnerable to a given disease (sensitivity).
Sustainable agriculture	Agricultural production system which enables the farmer to maintain productivity at levels that are economically viable, ecologically sound and culturally acceptable in the long term. Under such a system, resources are managed efficiently with minimal damage to the environment and human health.
Systemic pesticide	Pesticide which enters the plant tissues before being fatally ingested by the pest.
Tap root	Main root which grows downwards from the radical and generates lateral roots.
Tensiometer	A device for measuring the suction force required to extract water from the soil.
Terroir	Originally a French term used in wine, coffee and tea to denote special characteristics that geography bestowed upon particular varieties.
Tipping	Pruning the ends of primary branches or stems.

Topping, capping	Cutting off the terminal end of an upright stem.
Trimming	To reduce a tree or a plant to a neat, orderly shape by pruning or clipping.
Understory	Vegetation which grows under the shade of taller plants.
Wilting point	Point at which plants are unable to absorb any more soil moisture.
Xylem	The lignified part of the water conducting tissue of plants.

Terms related to green and roasted coffee

Aged coffee	Coffee from previous crops stored in special warehouses for long periods. Ageing reduces acidity and increases body.
Arabica coffee	Coffee of the botanical species *Coffea arabica.*
Arabusta coffee	Hybrid interspecific of *Coffea arabica* and *Coffea canephora*.
Bean	Endosperm or seed of the coffee fruit.
Bean in parchment	Coffee bean enclosed in its parchment.
Bean sizes: flat beans	Screened through round holes of different sizes, ranged from size 13 to 20: very large (size 20), extra large (size 19), large (size 18), bold (size 17), good (size 16), medium (size 15), small (size 14–13).
Blend	A mixture of two or more coffee varieties producing a recognisable and reproducible quality of coffee liquor.
Bold	A large to very large well formed and even coffee bean.
Caffeine	An alkaloidal compound present in coffee tissues but more concentrated in the bean (average 1.5%).
Caffeol, coffee oil	The volatile, oily substance developed in the coffee bean during roasting.

Centre cut	Cleft or groove on the flat side of the bean.
Clean coffee	A well graded coffee, free of defects.
Cleaning	Removal of foreign matter, fragments of coffee and defective beans from green coffee.
Coffee bean	Commercial term used for the dried seed of the coffee tree.
Coffee cherry	The fresh fruit of the coffee tree.
Colour	From blue-green to yellow-green and brown depending on origin, species, age, method of processing, fruit maturity, harvesting and conditions of storage and transport.
Defect	Any impairment of the coffee bean that could cause deterioration in quality.
DGB	Dry green bean
Dried coffee cherry	Also known as coffee in pod or husk coffee.
Dry fermenting	After pulping, the coffee is fermented without water.
Drying of coffee cherry	Drying coffee cherries to reduce their moisture content in order to remove their husks and to condition them for storage.
Drying of parchment coffee	Drying parchment coffee to reduce its moisture content in order to condition it for storage and further hulling.
Dry-processing	Treatment of coffee cherries whereby they are dried under the sun or mechanically. This process produces husk coffee. Drying is usually followed by the mechanical removal of the husk. The result is ‘natural’ or ‘unwashed’ green coffee.
Fermentation	Biological treatment which consists of degrading the mucilage which still adheres to pulped coffee.
Foreign matter	Any mineral, animal or vegetable matter which does not come from the coffee cherry (stones, sticks, clods, metallic residues etc.).

Grinding	Mechanical operation which fragments roasted coffee beans and produces ground coffee.
Ground coffee	Roasted coffee which has undergone grinding.
Hull	Dried parchment (endocarp) of the coffee fruit.
Hulling or dehulling	The mechanical removal of the dried endocarp (parchment) from parchment coffee to produce green coffee.
Husk	Assembled external envelopes of the dried coffee fruit.
Husking or dehusking	The mechanical removal of the husks from dry coffee cherries.
Pales	A term used to describe discolored beans. They can come from old stocks, from immature beans or from coffee afflicted by drought. Amber beans often cause pales in the roast.
Peaberry coffees	Beans are graded through oval shaped screens, sizes 9–13.
Polishing	The mechanical removal of the silverskin from green coffee.
Pulp	Part of the coffee cherry which is eliminated during pulping and fermentation. It is composed of the skin and part of the mucilage.
Pulping	Operation which consists of removing the pulp and part of the mucilage by mechanical means. Part of the mucilage generally remains adhering to the parchment.
Roasting	The use of heat to generate fundamental chemical and physical modifications in the structure and composition of green coffee beans in order to darken the bean and develop its characteristic flavor.
Robusta coffee	Coffee of the botanical species *Coffea eanephora* var. Robusta.
Silverskin	Dried seed coat of the coffee bean. It is usually silver or copper colored.
Washed-and-cleaned coffee	Dry-processed green coffee from which the silverskin has been removed by mechanical means and using water.

Washing	The use of water to remove the degraded mucilage from the parchment.
Wet-processed coffee	Green coffee that is wet processed is known as washed or semi-washed coffee. Washed coffee is green coffee from which the mucilage has been totally removed and semi-washed is green coffee where most of the mucilage still adheres to the parchment.

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Australian subtropical coffee grower's manual

By David Peasley

Pub. No. 14/029

This manual is intended to assist growers, both new and experienced, so that they are aware of the good practice and possible pitfalls of growing coffee in subtropical Australia.

The manual contains a collection of information largely based on the expert knowledge of the author and the practical experiences of the contributors.

The information and advice is presented in a practical, easy to follow format. For this reason the manual has been designed as a 'dynamic' document readily able to be amended, updated and added to.

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