

Tropical banana information kit

Reprint – information current in 1998



REPRINT INFORMATION – PLEASE READ!

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This publication has been reprinted as a digital book without any changes to the content published in 1998. We advise readers to take particular note of the areas most likely to be out-of-date and so requiring further research:

- Chemical recommendations—check with an agronomist or Infopest www.infopest.qld.gov.au
- Financial information—costs and returns listed in this publication are out of date. Please contact an adviser or industry body to assist with identifying more current figures.
- Varieties—new varieties are likely to be available and some older varieties may no longer be recommended. Check with an agronomist, call the Business Information Centre on 13 25 23, visit our website www.deedi.qld.gov.au or contact the industry body.
- Contacts—many of the contact details may have changed and there could be several new contacts available. The industry organisation may be able to assist you to find the information or services you require.
- Organisation names—most government agencies referred to in this publication have had name changes. Contact the Business Information Centre on 13 25 23 or the industry organisation to find out the current name and contact details for these agencies.
- Additional information—many other sources of information are now available for each crop. Contact an agronomist, Business Information Centre on 13 25 23 or the industry organisation for other suggested reading.

Even with these limitations we believe this information kit provides important and valuable information for intending and existing growers.

This publication was last revised in 1998. The information is not current and the accuracy of the information cannot be guaranteed by the State of Queensland.

This information has been made available to assist users to identify issues involved in the production of tropical banana. This information is not to be used or relied upon by users for any purpose which may expose the user or any other person to loss or damage. Users should conduct their own inquiries and rely on their own independent professional advice.

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Queensland Government



Key ISSUES

This section contains more detailed information on some of the important decision-making areas and information needs for growing bananas in the wet tropics. The information supplements our growing and marketing recipe in Section 3 and should be used in conjunction with it. The information provided on each issue is not designed to be a complete coverage of the issue but instead the key points that need to be known and understood.

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Understanding the banana plant

The aim of banana production is to produce high yielding plants while maintaining plantation health. To achieve this, it is essential to have a basic knowledge of what governs fruit production and quality. Here are the important things you need to know.

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About the plant

The banana plant is a tree-like perennial herb. It is composed of a flattened, modified stem called the corm and a false stem (pseudostem) with a crown of large leaves (Figure 1).



Figure 1. A banana plant showing a bunch and a following sucker

The pseudostem

The pseudostem is not a real stem as it is made up of bundles of leaf sheaths and is about 90% water. Water pressure in the stem tissues enables the plant to stand upright. New leaves emerge one at a time from the centre of the top of the pseudostem.

The corm

The roots of the plant grow from the corm (Figure 2) and are the pathways for nutrients and water for the plant. The main bud or growing point is positioned at the centre of the top of the corm, in the middle of the pseudostem. This bud produces leaves initially before changing from vegetative to reproductive and producing the inflorescence (the structure which eventually becomes the bunch).

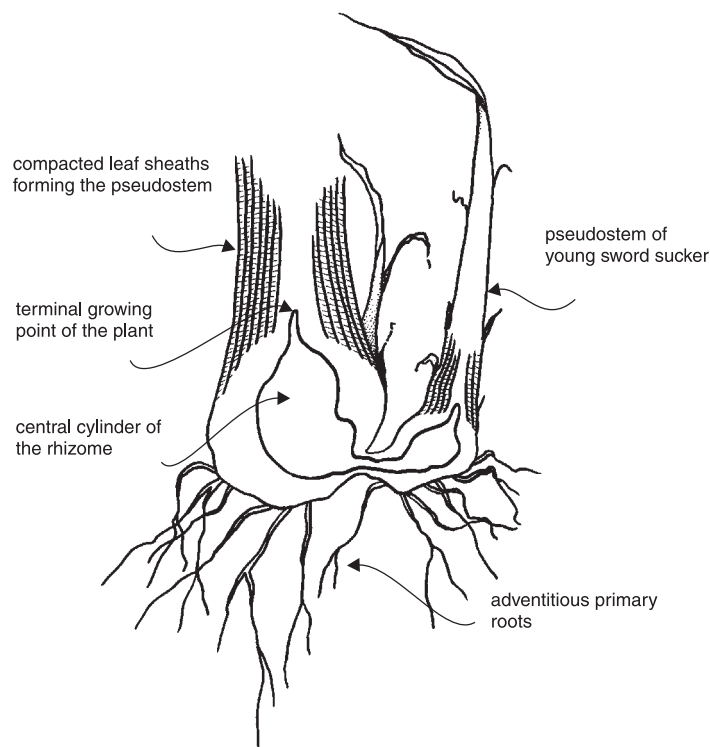


Figure 2. Vertical section through the base of a banana plant

The suckers

Secondary buds on the outside of the corm are referred to as 'eyes'. These buds produce new plants called suckers that draw nutrients and water from the corm of the parent plant when they are young. Later in their growth the suckers develop an effective root system and become independent of the mother corm, eventually developing their own suckers. This is how the clump of bananas (called the stool or mat) perpetuates itself.

The inflorescence (or bell)

The main bud produces no more leaves after it has changed to a reproductive cycle. The inflorescence (bell) grows up the centre of the pseudostem and emerges from the centre of the crown of leaves. At this stage the inflorescence is greenish-red, bullet-shaped and pointing vertically up. It quickly turns over to a pendulous position.

The inflorescence consists of male and female flowers attached to a central stem and arranged in grouped double rows, called hands (Figure 3). A reddish-purple, fleshy bract protects each hand. As the bunch develops, the bracts begin to lift and fall off, revealing the developing fruit. The female flowers are the first hands to be revealed and are recognisably bigger than the male flowers (Figure 4). In commercial cultivars only the female flowers will develop into fruit and the hands of male flowers fall off soon after their bracts do.

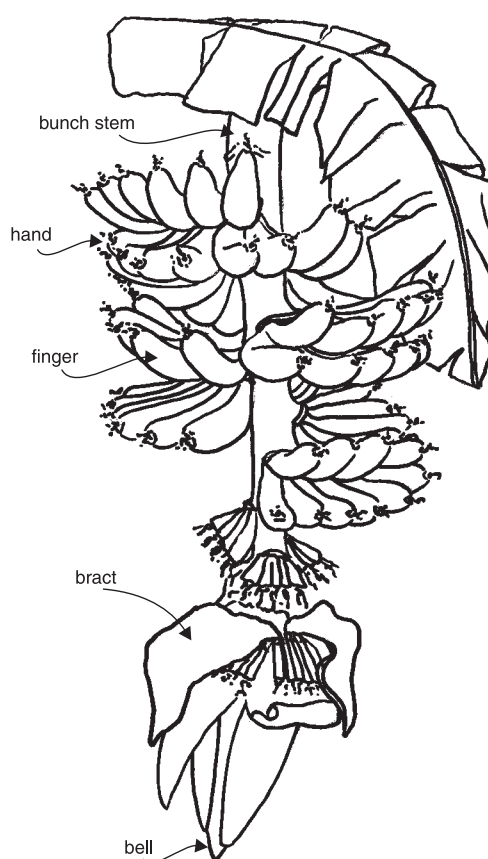


Figure 3. A developing bunch of bananas

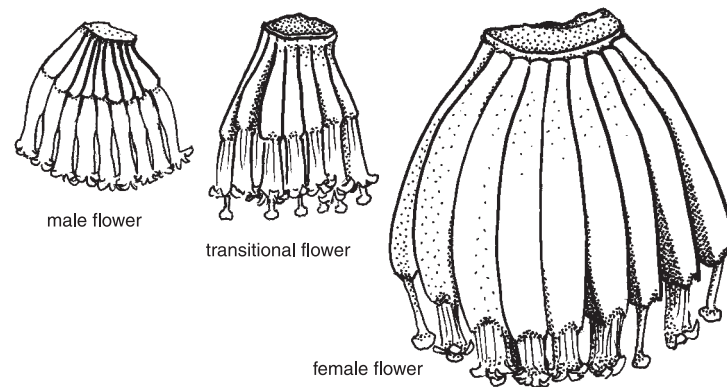
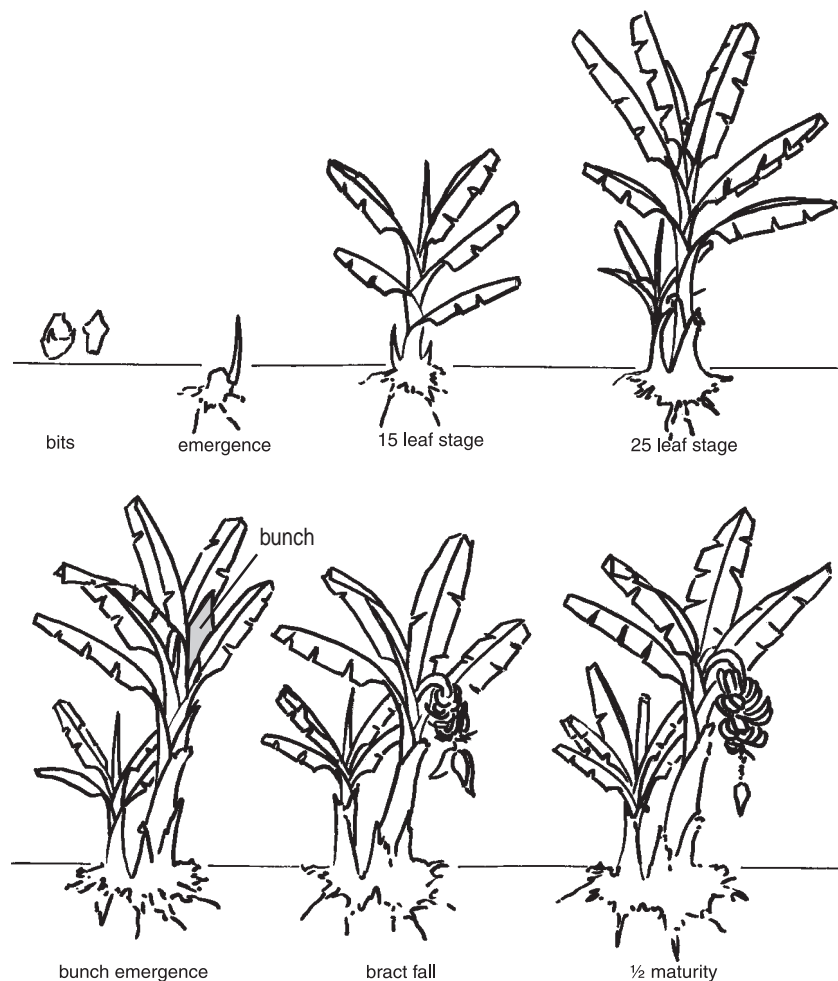


Figure 4. Flowers types on the banana bunch

The growth cycle of the plant

Bananas plants tend to clump, with the main stem called the mother plant and subsequent suckers called daughter plants. Once the bunch has ripened or is removed by harvest, the mother stem dies and the suckers develop into mature plants that then continue the cycle. The cycle can be described as a series of stages (Figure 5).



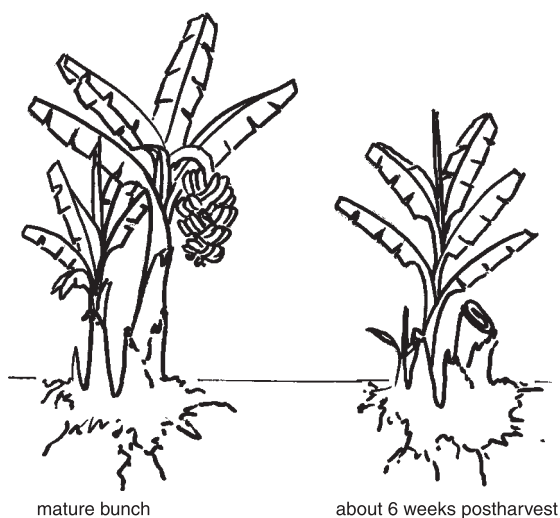


Figure 5. *The nine growth stages of the banana plant*

Plantation managers use knowledge of these stages to implement farm practices and manage productivity. This includes matching fertiliser and irrigation requirements to plant growth, and identifying when key pest and disease management practices must be applied.



Legislation in banana growing

Banana growing is a highly regulated industry. Unlike other horticultural industries anyone who plants or grows bananas needs to be aware of and comply with a range of legislative requirements. Various pieces of legislation will affect you in the course of growing bananas.

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The Queensland banana industry produces \$200 million of fruit each year. State Government legislation aims to protect the Queensland banana industry from the spread of pests and diseases that can severely damage this production.

Legislation and codes of practice also exist to protect workers, owners/managers and consumers, govern employment of staff, marketing of fruit and the use of chemicals and dangerous equipment.

Department of Primary Industries' inspectors have responsibilities under state legislation relating mainly to:

- pest and disease control
- chemical use, residues and spray drift.

DPI plant health inspectors (banana inspectors) carry out activities under the *Plant Protection Act 1989* that include:

- monitoring plant movements
- ensuring control is regained over unacceptable levels of banana leaf spot
- monitoring and treating outbreaks of serious diseases.

Levies

A range of levies is deducted from banana sales. One of these is a compulsory levy (4 cents per carton) under the *Plant Protection Act 1989*, with the Banana Industry Protection Board (BIPB) administering the collected funds. This levy is matched dollar for dollar by the State Government to fund the activities of the BIPB. The purpose of the BIPB is to protect the Queensland banana industry against the



BIPB
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introduction, spread and proliferation of any serious disease, insect or other pest. It does this by funding extension, inspections and research projects. More information on the activities of the BIPB is available in its annual report, *Banana Protection*.

Quarantine

Regulation of the production and movement of banana planting material is used in Queensland to manage the spread of serious pests and diseases such as Panama disease and banana bunchy top virus. Under the banana industry planting policy the state is divided into six quarantine areas (Figure 6). Most of the Queensland industry is located in the Northern Banana Quarantine Area (3 on the map) that extends from just north of Cape Tribulation to just south of Carmila.

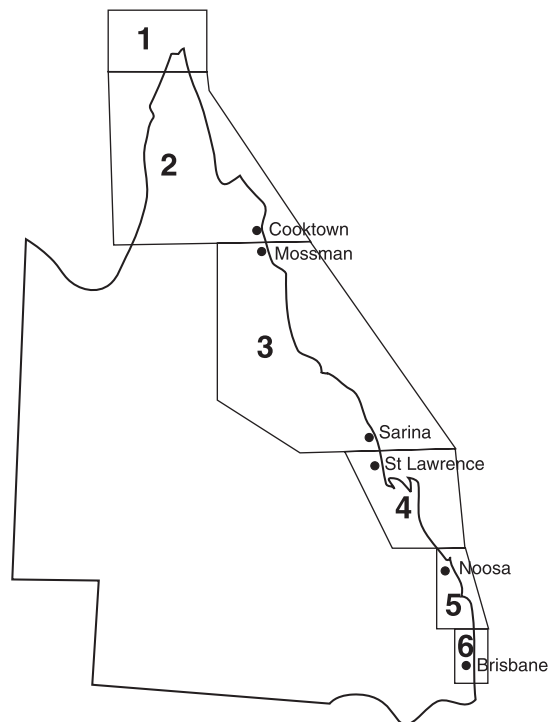


Figure 6. The six banana quarantine areas

Each area has specific requirements with regards to the planting policy. In the Northern Banana Quarantine Area, there is:

- no restriction on the time of the year for planting;
- no restriction on varieties which may be grown commercially;
- a restriction on the total number of stools that can be grown on holdings smaller than 1000 sq. m; (The restriction is a maximum of five stools, each stool comprising one stem with up to two suckers attached.)
- a total ban on the movement into this area of banana plants from any other quarantine area;
- no movement of tissue-cultured plants without an inspector's approval (an official document).

Within the Northern Banana Quarantine Area all movement and planting of any banana plants must comply with a current permit to plant banana plants. Currently all non-Cavendish planting material must come from a DPI-approved Quality Banana Approved Nursery (QBAN). By December 1998 this requirement will also include Cavendish planting material.

Notifiable and gazetted pests

A range of insects, diseases and other pests is gazetted as pests under the Act. Some of these pests are so serious that they are deemed notifiable. If growers suspect a notifiable pest is present on their plantation, they **must** notify an inspector within 24 hours. The three current notifiable pests are:

- banana bunchy top
- Panama disease (Fusarium wilt, race 4)
- black Sigatoka leaf spot.

For other gazetted pests growers must make every effort to maintain infestations below acceptable levels. Inspectors can direct growers to take action to regain control of any of these pests if their infestation exceeds the acceptable levels. Most of the economic pests of bananas in north Queensland are gazetted pests.

A range of exotic seeded banana plants is gazetted as pest banana plants. These can only be grown if the grower is the holder of a pest banana permit. These permits are usually only available to botanical gardens that meet the conditions of the permit.

Working under the *Plant Protection Act 1989*, inspectors may enter farms to inspect and take samples for pest identification. Weed growth must be controlled so as not to impede inspection.

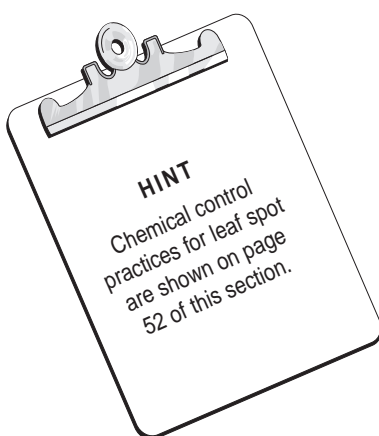
Leaf spot

Banana leaf spot inspectors have a responsibility to ensure that growers who have lost control of leaf spot, to the point that the pest can spread to another planting, regain control of the disease. Adequate control of the pest is determined by meeting infestation levels that have been determined through consultation with the banana industry.

Growers who lose control of a pest may be issued directions under the Act. These directions usually take the form of:

- an advice that will **recommend** an action to be taken within a set time
- an order that will **direct** the grower to take action within a set time.

If an advice is not carried out, an order will be issued. If an order is not fully carried out, the inspector may employ a contractor to do the work. The costs of the contractor and departmental administration costs will be charged to the grower/land owner.





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Requirements for produce movement

Some restrictions apply to the movement of banana fruit interstate, and sometimes within Queensland. Contact DPI plant health inspectors for the current restrictions.



Economics of banana production

Banana production is a complex business and should be approached with a business philosophy. You need to realise that operating a banana farm requires a high level of personnel, financial, production and information management skills. Not everyone is suited to the banana business.

Before you start you should develop a business plan which identifies what you wish to achieve (not just financially) and what is the current position of your business. From this information you will be able to identify the aspects of your business that you need to develop.

This section provides a gross margin for growing bananas on Queensland's wet tropical coast.

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Gross margin for north Queensland (wet tropical coast)

The profitability of banana growing varies with competency of management and market returns. The following gross margins for Cavendish bananas grown in north Queensland (wet tropical coast) will provide a guide to production costs.

This gross margin calculation is based on the following assumptions:

- the crop is grown under good management by a family unit
- an average yield of 2200 and 3800 cartons per hectare for plant and first ratoon crops respectively
- fruit is packed and marketed in 13 kg cartons
- plant density is 1800 plants per hectare for plant and ratoon crops
- the crop is planted as staggered double rows
- an average price of \$11.70 per carton is achieved across the season
- labour requirement is two permanent employees (one employee per four hectares over and above the first four hectares).



more info



Personnel management
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Preharvest costs

Item	Total cost (\$/ha)	
	Plant	Ratoon
Plant crop		
Land preparation and planting	2 419.04	
Fertiliser	2 755.20	
Weed management	210.16	
Pest and disease control	1 748.25	
Plantation management	4 166.70	
Electricity (irrigation)	127.50	
Ratoon crop		
Fertiliser		3 233.40
Weed management		76.99
Pest and disease control		5 270.37
Plantation management		4 166.70
Electricity (irrigation)		150.00
Total preharvest costs	11 426.85	12 897.46

Harvesting and marketing costs

(Assumed yields: plant crop – 2200 cartons per hectare; ratoon crop – 3800 cartons per hectare)

Item	Cost per unit (\$)	Cost/ha (plant crop)	Cost/ha (ratoon crop)
Cartons	2.20	4 840.00	8 360.00
Liners/taping	0.12	264.00	456.00
Fuel / oil	0.14	308.00	532.00
Packing labour	0.40	880.00	1 520.00
Levies	0.28	616.00	1 064.00
Commission	1.46	3 212.00	5 548.00
Freight (Sydney)	2.63	5 786.00	9 494.00
Total	7.23	15 906.00	26 974.00

Gross margin sensitivity analysis

Gross margin when price or yield changes.

Yield (ctns/ha)	Plant crop/ha		Price per carton (\$)		
	9.00	10.00	11.00	12.00	13.00
1 800	-5 970	-4 396	-2 821	-1 246	329
2 160	-5 213	-3 323	-1 433	457	2 347
2 700	-4 076	-1 714	699	3 011	5 374
3 240	-2 940	- 105	2 730	5 565	8 400

At a yield of 2200 cartons per hectare, variable cost of production per carton is \$11.33.

Yield (ctns/ha)	Ratoon crop		Price per carton (\$)		
	9.00	10.00	11.00	12.00	13.00
2 700	-7 214	-4 851	-2 489	-126	2 236
3 800	-4 898	-1 573	1 752	5 077	8 402
4 500	-3 425	513	4 450	8 388	12 325
5 400	-1 530	3 195	7 920	12 695	17 370

At a yield of 3800 cartons per hectare, variable cost of production per carton is \$10.29.

The next step

Remember that gross margins do not take into account fixed costs (rates, depreciation, administration, registration) or capital costs (land, machinery, buildings). It also does not include the labour supplied by the grower or the grower's family. These need to be included in a whole enterprise budget. This is essential to determine whether you are providing yourself with reasonable a wage and return on your investment.



Crop scheduling

Crop scheduling in bananas aims to increase the uniformity of cropping and reduce the spread of harvest. You can use crop scheduling to coincide your peak harvest time with periods of low production and higher prices, or to avoid producing a crop at a certain time of year. This section will help you understand the techniques you can use to influence your cropping schedule.

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Why schedule your crop

Producers may want to schedule production to:

- avoid an expected period of oversupply and glutting of the markets
- schedule more production for expected periods of higher prices
- achieve efficiencies in the production system.

Reasonable uniformity of cropping is achieved in plant crops and can be continued into the first ratoon crop if there is little variation in the age of following suckers selected.

However, subsequent ratoon crops show increasing variation between plants in age and cropping cycle. This results in an increased spread in the harvest period for any particular planting. While this eventual spread of harvest is natural, it can sometimes be preferable to achieve a more condensed harvest period.

How do I schedule my crop?

There are several methods growers can use to schedule their crop. Choosing tissue-cultured plantlets at planting time, early or late desuckering and water stress before bunch initiation all help with bringing more uniformity to a crop. The two main techniques growers should know about, however, are time of planting and nurse suckering.

Time of planting

Variation in the age of plants in the plantation produces the variation in time to harvest for bananas (Figure 7). A planting of the same sized plants growing at the same rate will produce a very even crop. This is most easily achieved in the first crop or 'plant' crop because all the plants are planted at the same time. Different sized pieces of planting material, different types of planting material and natural variation in soil types are the main causes of variation in plant growth in the 'plant' crop.

If management is good and variation in the 'plant' crop is minimised, producers can schedule their cropping period by planting at various times of the year.

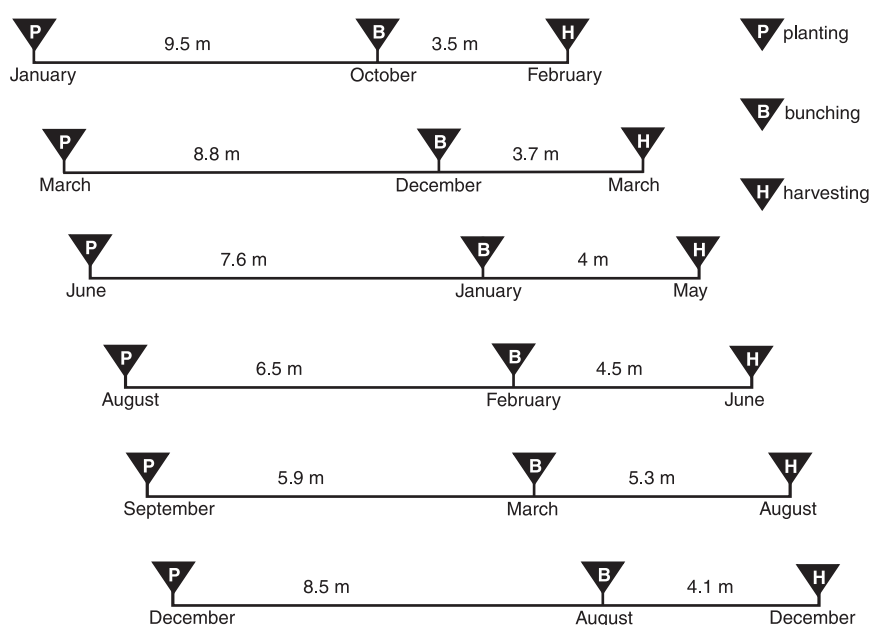


Figure 7. Effect of date of planting on duration (m=month) of crop cycle at South Johnstone

In north Queensland, the most common planting time is from late June through to late October. Planting in this period schedules harvest from May to September the following year, when prices are traditionally higher. Some growers will also plant small areas from December to March as insurance against devastation by cyclonic weather.

Nurse suckering

Nurse suckering is a system of sucker management that helps confine fruit production to a particular period of the year. It has been used in north Queensland to allow producers to schedule fruit production for the winter/spring period when prices are traditionally highest. It is also useful to bring a plantation back into uniform production.

How to nurse sucker

The nurse suckering method is shown in Figure 8. Select a sucker positioned in the row. This sucker becomes the nurse sucker. When the bunch on the mother plant has been harvested and the nurse is at least 1.5 m tall to the throat, cut it down and gouge out the growing point. A flush of suckers will develop from the nurse sucker. About one month later, select one sucker which has developed from the nurse sucker. This technique, by skipping a ratoon cycle, is able to delay production of the next crop by about three months.

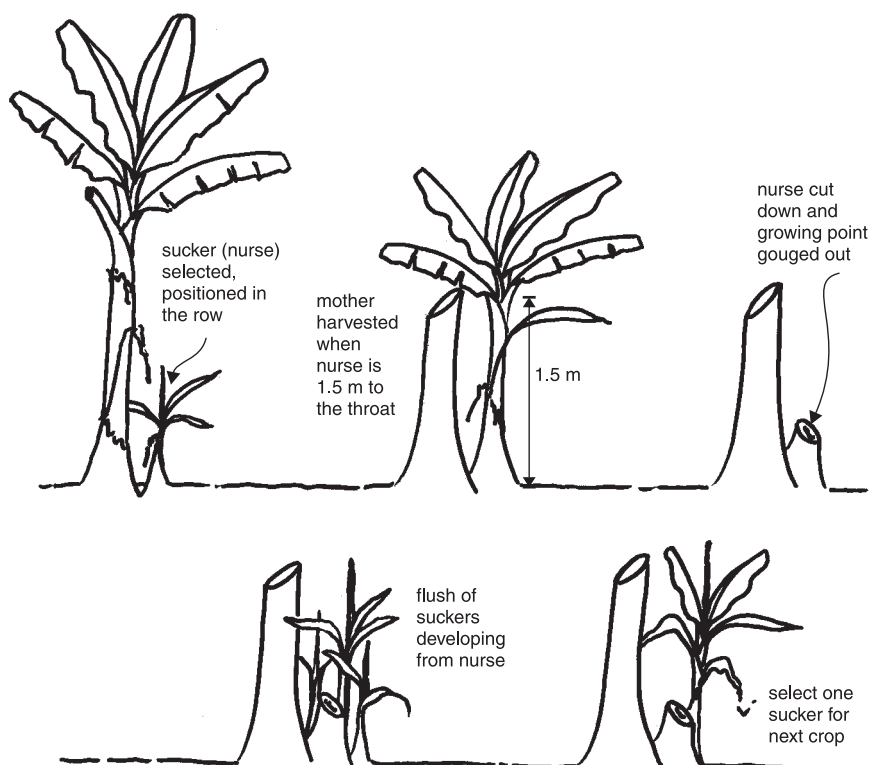


Figure 8. A nurse suckering technique

There are variations on how to deal with the growing point of the nurse sucker. Cutting a wedge on the nurse at knee-high and bending the plant over will produce a flush of suckers. This is easier work than cutting and gouging. Another method is to leave the stem of the nurse sucker standing and take out the growing point from the side with a desuckering gouge.

When to nurse sucker?

The decision on when to nurse sucker depends on when production is desired, the farm environment and crop management procedures. Production times at South Johnstone for three nurse suckering times are shown in Table 1.

Experience helps to determine how much to vary these times to suit the district and crop management practices. For example, slightly lower temperatures at Cardwell require cutting the nurse down earlier to achieve harvest at the same time as warmer areas.

Higher plant densities and water/nutrient stresses are examples of crop management that would delay development. There will also be variation in timing of harvest from year to year, depending on the weather, particularly if a winter is cold.

Table 1. *Production times at South Johnstone for three nurse suckering times*

Nurse cut down	Sucker set on nurse	Bunching	Harvest
December	January	April/May	September/October
June	July	January	April/May
August	September	March/April	July/August

The bottom line

Successful use of nurse suckering depends on its cost:benefit ratio. Yield is forfeited with the technique because of lower bunch weight and extra time between successive crops. More uniform crops, however, can reduce cost of production, and returns per carton can be higher if production is scheduled for periods of higher prices.



Sucker selection

A very important aspect of management in bananas is choosing the correct following sucker to produce the next crop. Choosing the right sucker will lead to higher yields of better quality fruit. Sucker selection can also be used for scheduling production to times of higher prices and increasing the evenness of the crop. Choosing uniform healthy followers and maintaining row alignment can extend the life of the plantation.

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Selection of the following sucker

Selection criteria

The choice of the 'correct' follower depends on the relative importance of the following criteria.

Evenness of the crop (especially time of harvest). Selecting even-sized (height) followers will slow down the rate of development of variability. More uniform crops (Figure 9) reduce production costs because fewer passes are necessary for bunch covering, dusting and harvest. Plantation life can be extended if crops are kept more uniform.

Early compared with late suckers. Early (largest) suckers will produce the next crop sooner (about 8 to 10 months in north Queensland). They will usually produce larger bunches, so that yield in cartons per hectare per year is greater.

However, later suckers, which will produce a lower overall yield, can be kept more closely to a 12-month cycle, so ensuring several consecutive crops are produced during winter/spring, when market prices are usually better. The selection of late suckers may require the removal of all suckers at various intervals before bunching. Suckers that emerge later usually arise from buds higher on the parent corm and, being shallower in the soil, are liable to be less stable.



Figure 9. Uniform plant size in a block planted with tissue-cultured plantlets

Position of the follower in relation to the row direction. Selecting followers on the same side of each plant and in the direction of the row will prolong the potential life of the plantation. This ensures continued machinery access and maintains the desired plant spacing arrangement for high yields of good quality fruit.

Position of the follower in relation to the bunch on the parent plant. It is desirable that the follower is not growing up underneath the bunch. This could lead to rub damage to the fruit.

Where bananas are grown on steep slopes, following suckers should be chosen on the uphill side to ensure the stool remains deep in the soil, and so minimising falling over from various causes.

Time of follower selection

If unwanted suckers are left to grow more than 30 cm high, bunch weight in the parent crop can be reduced by up to 18%. Controlling the sucker regrowth from these large pruned suckers increases desuckering costs.

When selecting early suckers, follower selections are usually required earlier (one to two months before bunching) to reduce competition with the parent bunch. However, this can lead to leaving a sucker in a position where it will grow up underneath the bunch. In this situation the bunch orientation can be predicted before bunching because the plant usually bunches in the direction it is leaning.

Types of suckers

Suckers are usually of two types: sword leaf suckers and water suckers (Figure 10).

Sword suckers are tapered with a large base and small narrow leaves.

Water suckers have broad leaves at an early age and also lack the

distinctive stem taper of sword suckers (Figure 10). Water suckers usually develop from the corm of previously harvested plants. They are unsuitable as followers because they lack a strong attachment to the corm and may suffer an early nutritional deficiency, causing production of small uneconomical bunches. Water suckers also take longer to bunch and are more prone to topple.

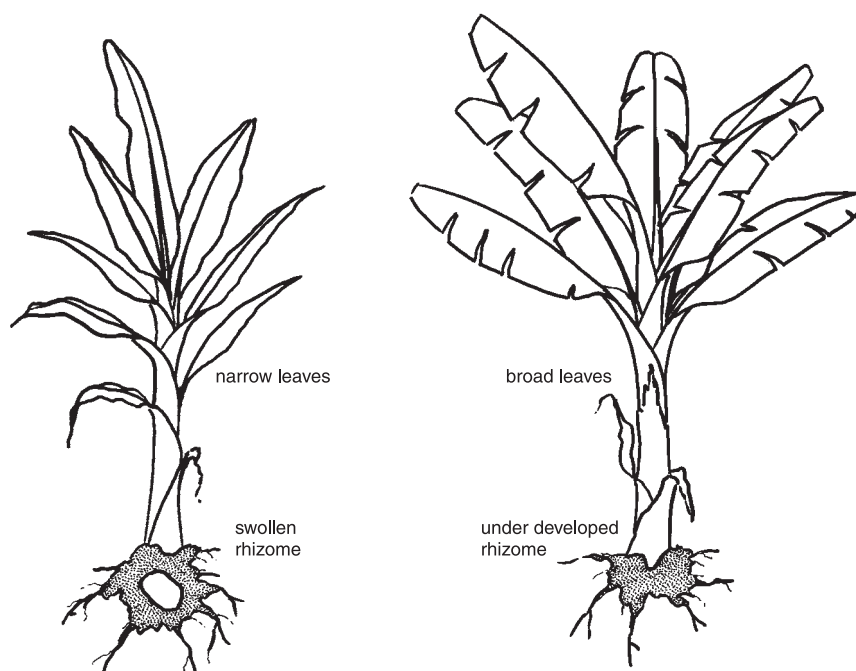


Figure 10. A sword sucker (left) and a water sucker

The following sucker should be one which has developed directly from the parent plant. Choose vigorous sword suckers that originate from deep-seated buds. Vigour is essential because it indicates the place of origin. Deep-seated suckers are less prone to blowing over. They usually develop well out (about 10 to 15 cm) from the parent plant.

When large suckers are pruned (desuckered) some regrowth suckers will develop. These are also unsuitable as following suckers.

Other considerations

Setting of the following sucker on the plant crop is most important as the stool will tend to develop in this same direction in subsequent ratoon crops.

The single row/double follower system requires two followers to be selected on the plant crop. These followers are best positioned on opposite sides of the parent plant and facing towards the interrow spaces. This will facilitate bunch support with twine in ratoon crops. In subsequent ratoon crops following suckers are 'marched' or selected in the direction of the row.

It is preferable to use special planting material nurseries to provide planting material for new plantings rather than digging suckers from young ratoon crops. Digging of large suckers for this purpose leads to reduced yields of the parent plant because of damage to the root system. Competition between the sucker and the parent leads to a greater incidence of wind damage because of weakening of the root system.

Beware of very early suckers which form on plants derived from medium (0.5 to 1.0 kg) and large (1.0 to 1.5 kg) suckers. These suckers have developed from buds on the side of the medium/large suckers and produce the next crop much earlier than is usual for normal sucker development. Medium/large suckers should preferably be graded and planted separately to maintain evenness of production times. Otherwise they should be split in half and planted as bits.

Sucker development is retarded at higher densities. At high densities it is more difficult to select following suckers of consistent size in the desired position. Lower densities mean more flexibility in follower selection.

It is usually preferable to set more than one follower on plants next to misses in plantings, such as

○• ○• miss •○• ○•

where ○ is the mother plant and • is the sucker.

For small gaps this gives a better result than replanting.

A different approach to follower selection is required for crops established from tissue-cultured plantlets.

Desuckering

Once the following sucker has been selected, the remaining suckers are removed. The main removal methods are:

- hormone desuckering; (Use an automatic vaccinator to place 0.5 mL of 2,4-D amine (5% active ingredient) in the throat of suckers. This is the quickest and cheapest method of desuckering. There is a high risk to the stool, however, if unskilled operators are used.)
- kerosene injection; (Use a Velpar spot gun and lance attachment (Figure 11). Take care in its use to minimise damage to the stool.)
- gouges, bars and desuckering shovels. (These tools are also used but are more labour intensive. This method is only suitable in ratoon crops.)



Figure 11. Kerosene injection using a spot gun with a lance attachment

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Selection of tissue-culture followers

Poor growth of following suckers

Poor growth of following suckers on plants established from tissue-culture is sometimes a problem. This occurs when the growth of the selected follower stops and later suckers grow instead, resulting in a poor first ratoon crop.

The early suckers derived from tissue-cultured plants can often have a small area of attachment to the parent plant. This small area of attachment may restrict the flow of nutrients to the sucker. Another problem is that early suckers are derived from the base of the corm. These suckers can easily be detached from the corm by suckers higher up growing and pushing them outwards. Suckers developing from conventional planting material tend to come from the sides of the corm and have a much stronger attachment to it (Figure 12).

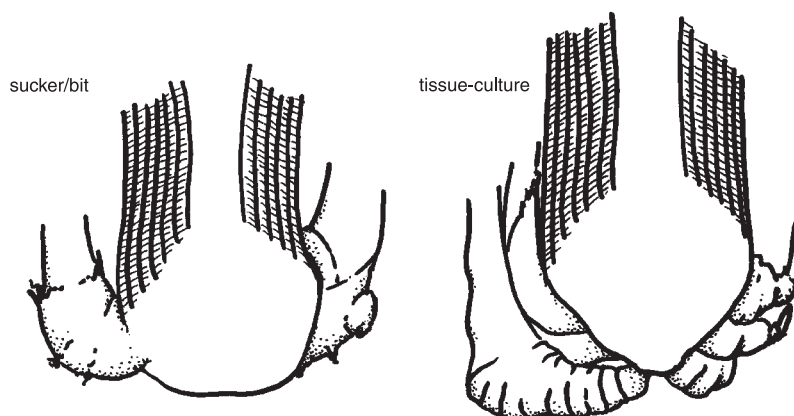


Figure 12. Sucker development on corms from bits (left) and tissue-cultured planting material showing differences in sucker attachment

Field management procedures for tissue-culture

A different approach to sucker management needs to be adopted with tissue-cultured plants.

Eliminate all suckers about four months from planting

Often there is some very early sucker development on tissue-cultured plants. These suckers show characteristics typical of water suckers (spindly stems, broad leaves) and should be eliminated carefully with kerosene.

About four months after field planting the tissue-cultured plants will have developed about four sword-leaved suckers. These early suckers should be eliminated carefully with kerosene because they are coming from underneath the corm. The next flush of suckers which comes away higher up the corm will give a better ratoon crop. The following sucker should be selected from these suckers.

Waiting until bunching to desucker can cause problems

If desuckering is left until bunching these problems can occur.

- Successful follower selection is much more difficult.
- Many suckers will tend to be weak and spindly because of competition from the large number of suckers that are produced by tissue-cultured plants.
- Many suckers will need to be killed at once, potentially destabilising the parent plant.

Remedying late desuckering

Late desuckering can be corrected by:

- removing obvious water suckers
- removing about four early sword-leaved suckers which are characterised by:
 - * green stem — no pink/red new growth
 - * choking — shortened internodes (no new growth)
 - * generally being the largest suckers
 - * another sucker sometimes coming up between it and the parent pseudostem
- removing other suckers not in the correct direction
- leaving two suckers instead of one in the desired direction. (A final choice can be made later, when it is more obvious which follower will grow away most vigorously.)

What to do if you selected followers too early

If follower selection is made too early and the resulting sucker growth is poor, you have two choices.

- Persist with the poorly growing follower. It will eventually make new growth but the first ratoon crop will be poor. The second ratoon will be almost back to normal.
- Once no growth is recognised in the selected follower, kill it and let other suckers higher up come away. It is likely that they will produce a better first ratoon crop.



Varieties

Choosing varieties is a relatively minor consideration in banana production because the industry is largely based on a single type of banana. This section describes some of the different bananas you can grow in Australia.

Varieties in the north Queensland industry	25
Niche marketing realities	25
Sources of planting material	27
The variety picture guide	27

Varieties in the north Queensland industry

About 99% of north Queensland production is Cavendish-type bananas. There are a few Cavendish cultivars available and of these Williams is the main one, with small areas of Grande Naine (released in 1990). About 70 ha of Lady Fingers are grown plus 60 ha of miscellaneous niche market varieties including Ducasse, Pacific Plantain, Red Dacca, Goldfinger and Sucrier.

The main varietal choice is Williams or Grande Naine. The following features should be considered:

- Grande Naine leans a lot, which is undesirable
- Grande Naine has longer fruit than Williams under favourable conditions
- Grande Naine is more prone to stress due to heat, water-logging and water shortage
- Grande Naine is shorter than Williams and suffers less wind damage under some circumstances.

Niche marketing realities

There may be the possibility of increasing banana sales by the development of niche market varieties. Alternative varieties may achieve this by meeting the following consumer needs:

- superior, preferred and different taste
- fruit with curiosity value (for example red fruit)
- better prospects for obtaining fruit produced organically or without pesticides
- fruit better suited to cooking
- fruit for traditional ethnic purposes.

Most of the alternative varieties yield only one to two-thirds that of Cavendish, and therefore must receive better prices or be cheaper to produce than Cavendish. This is the major obstacle to their expanded production and they will never be as important as Cavendish.

Without a significant marketing and promotional effort, increased production of alternative varieties will only result in gluts. A regular supply of small quantities of a few varieties will be essential to foster and sustain the development of niche markets. Coordination of supply from niche market producers would be advantageous.

Alternative banana varieties offer some of the following opportunities or advantages for growers:

- better prospects for producing fruit organically or without pesticides
- more resistance to wind damage
- markets for alternative varieties may be unaffected by gluts of Cavendish
- prospects for small export markets.

Varieties recommended for niche markets

These varieties are recommended for niche markets and are worth trying:

- Lady Finger and its dwarf variants Santa Catarina Prata and J.D. Finger
- Ducasse and its dwarf variant Dwarf Ducasse (Kluai Namwa Khom)
- Pacific Plantain
- Sucrier
- Goldfinger
- Dwarf Red Dacca
- Lakatan.

The relative susceptibility of these varieties to important disease is shown in Table 2.

Table 2. Relative susceptibility of banana varieties to diseases

Variety	Yellow Sigatoka	Black Sigatoka	Fusarium wilt Race 1	Fusarium wilt Race 4 (only occurs in south Queensland)
Williams (and other Cavendish)	susceptible	susceptible	resistant	susceptible
Lady Finger group	susceptible	susceptible	susceptible	susceptible
Ducasse group	resistant	resistant	susceptible	susceptible
Pacific Plantain	moderately susceptible	moderately susceptible	susceptible	susceptible
Sucrier	moderately susceptible	moderately resistant	resistant	susceptible
Goldfinger	moderately resistant	resistant	resistant	resistant
Red Dacca group	moderately susceptible	moderately susceptible	susceptible	susceptible
Lakatan	susceptible	susceptible	resistant	susceptible

Sources of planting material

Tissue-culture is the recommended form of planting material for the varieties mentioned in Table 2. The pest and disease-free status of tissue-culture ensures that Panama disease (Fusarium wilt) is not spread to new plantings. Tissue-culture laboratories and nurseries should be contacted for supply.

The variety picture guide

Edible bananas are believed to have originated from two species *Musa acuminata* (AA) and *Musa balbisiana* (BB). The letters refer to the chromosomes in the parent source. The varieties we know can have two (diploid), three (triploid) or four (tetraploid) sets of chromosomes. The letters also show the relative contribution to the variety from each the parent species.

more info



Tissue-culture suppliers
Section 6 page 4



Fertiliser management

Good fertiliser management is one of the vital components to achieving high yields. Both deficiencies and excesses of plant nutrients can adversely affect fruit yield and quality. Fertiliser use has to be managed carefully to ensure a balanced supply of all nutrients is maintained. Here are the important things you need to know.

Nutrient requirements of a banana crop	28
Strategies to reduce nutrient loss	29
Monitoring systems approach	30
How to use soil and leaf analyses	31
Liming considerations	33

Nutrient requirements of a banana crop

For high yields of quality fruit, bananas require large amounts of nutrients. A crop yielding 50 t/ha/year of fresh fruit extracts large amounts of nutrients from the soil (Table 3). These nutrients have to be replaced to maintain soil fertility and to achieve continuous high yields.

Table 3. Average amount of nutrients (kg/ha) in banana plantation yielding 50 t/ha

Nutrient	Amount removed in fresh fruit	Amount in remaining plant parts	Total	Proportion removed in fruit (%)
Nitrogen	189	199	388	49
Phosphorus	29	23	52	56
Potassium	778	660	1438	54
Calcium	101	126	227	45
Magnesium	49	76	125	39
Sulphur	23	50	73	32
Chlorine	75	450	525	14
Sodium	1.6	9	10.6	15
Manganese	0.5	12	12.5	4
Iron	0.9	5	5.9	15
Zinc	0.5	4.2	4.7	12
Boron	0.7	0.57	1.27	55
Copper	0.2	0.17	0.37	54
Aluminium	0.2	2.0	2.2	9
Molybdenum	–	0.0013	–	–

The amount of fertiliser to apply, however, is more complicated than merely matching the crop removal figures. The following points need to be considered.

- There is a large nutrient pool in the soil. Figure 13 shows the various nutrient pools and quantities typically present in each. For nitrogen there may be as much as 7 t/ha of nitrogen to a depth of 40 cm.
- The nutrients in the soil are subject to large losses from erosion, leaching, volatilisation and denitrification, all of which are particularly severe on the wet tropical coast (Figure 13).

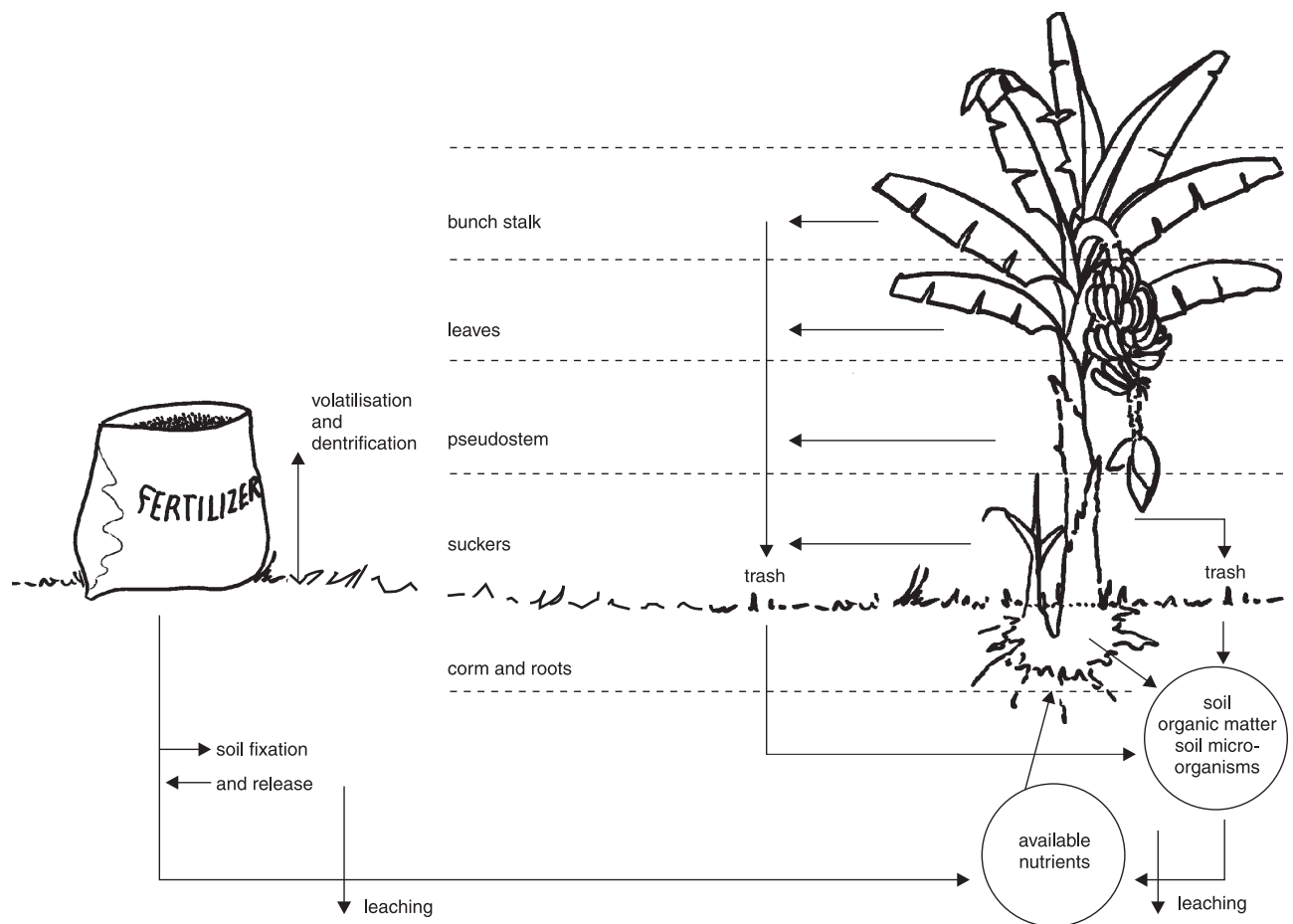


Figure 13. The nutrient flow within a banana plantation

Strategies to reduce nutrient loss

Frequent application of nutrients that are most readily lost

The two nutrients that are most readily lost are nitrogen and potassium. When broadcasting these fertilisers, it is uneconomical to apply them more frequently than every four to six weeks. If fertigation is available, small applications can be made every one to two weeks.

Fertigation

Fertigation offers a much greater efficiency of fertiliser use than broadcasting, and application rates can be reduced by 20 to 30% if fertigating. In tropical banana growing areas, about 70% of the fertiliser used for broadcasting is applied through fertigation. There are four advantages of fertigation.

- The regular applications mean that nutrients are always readily available to the plant. Any major leaching and erosion event will have less impact on growth.
- Fertiliser in the irrigation water is applied exactly where needed and is readily accessed by the plant.
- Erosion losses of fertilisers are nearly eliminated.
- Urea fertiliser can be used without gaseous losses.



Choice of fertilisers

If urea is broadcast, gaseous losses from volatilisation can be as high as 40%. Urea is the cheapest form of nitrogen fertiliser on a per tonne basis, but if gaseous losses exceed about 30% then ammonium nitrate becomes more cost effective because it is not liable to such losses.

Boosting soil organic matter content

Boosting soil organic matter content increases the nutrient holding ability of the soil. Fallows with green manure crops will bolster initial organic matter levels. Placement of banana trash in the row near the plants may also be beneficial over time.

Greater attention to improved soil drainage

With good drainage, denitrification (gaseous) losses should be less. Good drainage also promotes a deeper banana root system that is better able to use nutrients before they are lost by leaching.

Preplant incorporation of fertilisers

Incorporation of fertilisers before planting reduces erosion losses. This applies particularly to liming materials, which then become more effective deeper in the profile. Phosphorus should also be incorporated before planting. Basal applications of nitrogen and potassium should be broadcast in the planting furrow to supply nutrients for the first two to three months.

Monitoring systems approach

The growth rates, and hence the yield of bananas, differ between localities, properties and paddocks, any of which will influence the amount of nutrient required. In many cases, this variability influences farmers to apply more fertiliser than required while in others, insufficient is applied.

more info



Trash management
Section 3 page 20

To overcome this problem, farmers need to monitor nutrient levels in the soil and plant in each paddock as a guide to modifying their fertiliser program.

How to use soil and leaf analyses

Soil and leaf analyses taken only once have limited value. Samples should be taken each year (Figure 14). The change in soil and leaf nutrient levels from the previous year, and from the year before, are as important as the current levels. Any change you had made in the amount of fertiliser applied should be reflected in the changed levels of nutrients. The analyses will also tell you the amount of response in nutrient status from the change in fertiliser amount.



Figure 14. Samples are taken from the mid section of the third youngest leaf

The adjustment technique

To make leaf and soil analysis information useful you must maintain and record a fertiliser program for several years. The program should have known rates of fertiliser and a set system of application times, because this technique is one of adjustment, up or down, based on long term trends.

Changing the rate or timing constantly leaves no base line from which to adjust. The leaf and soil analysis tells you if you should increase or decrease the amount of fertiliser that you used for the last year on a given block. Without several years of records, the leaf and soil levels cannot tell you the level of fertiliser to apply.

Recommendations based on one analysis are a good starting point but are only an educated guess based on local experience. They are not as good as the adjustment technique based on annual soil and leaf analysis and good records of fertiliser products, rates and timing.

Here is an example of the adjustment technique:

In the past year you used 1000 kg/ha of muriate of potash and your potassium leaf levels were 2.4%. You know you haven't used enough because the desired potassium leaf level is between 3.33 and 4.00% (Table 4). How much more potassium do you need?

Until you have a lot of experience with your soil types and your climate, no exact amount can be recommended. The best approach is to lift your application rate in the coming year by 20%. This would mean putting on 1200 kg/ha of muriate of potash.

If in the next year the analysis for your leaf sample is 3.3% potassium, you will know you are near the right level. You could then lift the rate by say a further 10% to 1320 kg/ha in that year. If the potassium level goes over 4.0%, then drop the application rate by 5%.

Monitoring the nutrient status of your plantation is a valuable decision aid for your fertiliser management. The adjustment technique is most useful in helping to decide whether to change a fertiliser program and by how much. It is the only method of gaining a customised fertiliser management system for each banana block.

Despite the cost of the analyses, the potential savings in costs and gains in yield are great. The analyses provide valuable feedback to remedy nutrient deficiencies and imbalances before they become obvious.

Table 4. Optimum nutrient concentrations for banana leaves in north Queensland

	Optimum concentration range
Nitrogen	3.00 – 3.50%
Phosphorus	0.18 – 0.22%
Potassium	3.33 – 4.00%
Calcium	0.60 – 0.90%
Magnesium	0.28 – 0.36%
Sodium	0.0025 – 0.0050%
Chlorine	0.70 – 1.20%
Sulphur	0.25 – 0.40%
Manganese	900 – 4000 ppm
Iron	60 – 150 ppm
Zinc	21 – 35 ppm
Boron	15 – 50 ppm
Copper	7 – 20 ppm

Source: INCITEC Ltd

Note: These levels refer to the third last fully expanded leaf of unbunched plants and sampling strips of lamina 20 cm wide from each side of the midrib.

Liming considerations

Effects of soil acidity/low pH

Most banana soils in north Queensland have pH values ranging from 4 to 6.5. Lower pH values indicate greater acidity. The pH scale is logarithmic, so for each unit decrease in pH, the actual amount of acid in the soil is 10 times greater. A soil with pH 4 is 100 times more acidic than a soil with pH 6. The best information available is that a pH of 5.5 to 6.0 is optimal for bananas.

In highly acidic soils the quantity and availability of the essential nutrients calcium, magnesium, molybdenum and boron are greatly reduced and gross deficiencies of nitrogen and phosphorus are common. As well, aluminium and manganese toxicity may develop. These deficiencies/toxicities cause a general reduction in plant growth and yield. In New South Wales, poor banana root growth has been associated with very acidic soils.

Low pH also adversely affects soil microbial activity. The ability of the soil to hold plant nutrients against leaching can be reduced by a lowered cation exchange capacity in acid soils.

Causes of soil acidity

All of the banana soils in north Queensland are acidic (pH 4.5 to 5.0) in their virgin state. However, with cultivation and cropping, soil organic matter declines, so that nutrient availability is reduced. In addition, excessive applications of nitrogen fertiliser lead to reduced pH because nitrate leaching through the profile results in soil acidification. Inappropriate fertiliser use can also greatly enhance soil acidification. Examples include applying more fertiliser than is needed so that leaching losses are higher; and the use of nitrogen fertilisers such as sulphate of ammonia, which have a greater acidifying effect on the soil than other forms of nitrogen.

The removal of fruit from the plantation also increases soil acidity because the harvested material is alkaline and an excess of acidity remains.

How to reduce soil acidification rates

The main method of decreasing soil acidity is the addition of agricultural limes. There are a few other measures you can also take to reduce the rate of acidification:

- modify fertiliser practices; (Tailor fertiliser applications to meet the plants' requirements.)
- choose fertilisers which increase soil acidity the least; (The acidification rate of some fertilisers is highly dependent on whether there is leaching of nitrate after application. Table 5 (page 35) shows the relative acidifying effects of different fertilisers under two leaching rates.)

- schedule irrigation so that overwatering and leaching do not occur;
- apply fertilisers regularly, every four to six weeks or less; (This will enhance the opportunity for plant uptake.)
- apply fertiliser through an under-tree irrigation system to increase the efficiency of fertiliser use. (Overall acidification rates should be lower.)

Lime will still be needed to counter acidification despite these measures, but at lower rates.

Liming materials

To decrease soil acidity the excess of hydrogen and aluminium in the soil must be replaced by elements such as calcium and magnesium. This exchange is accomplished by adding oxides, hydroxides or carbonates of calcium and magnesium, which are referred to as agricultural limes.

Form of lime to apply

The following factors should be considered in the choice of liming material.

Neutralising value. This value shows how much acidity the product will neutralise compared with pure lime (calcium carbonate) which has a neutralising value of 100.

Cost per tonne applied. Different limes should be compared by dividing the cost per tonne by the neutralising value. The lower the outcome, the better value for money is the lime in question.

Fineness. Limestone is relatively insoluble. The finer the product, the more quickly it will react with the soil.

Choice. Which carbonate form to apply depends on price and the ratio of calcium to magnesium in the soil.

Amount of lime to apply

The amount of lime required to raise soil pH to the desired range depends on three things.

Existing soil pH. A soil analysis including pH should be obtained before applying lime so that you know how far to shift the pH, otherwise you are just guessing. Another pH test after the lime has reacted will tell you how effective your application has been, and whether or not you need to adjust (up or down) future applications.

Soil type. A complete soil analysis before lime application can also provide information on the buffering capacity of the soil. Some soils have a greater buffering capacity and need much more lime for the same change in pH.

Neutralising value and fineness of lime. These factors also influence the actual quantity of lime that must be applied.

Large quantities (5 to 10 t/ha) of lime may be required to adjust soil pH satisfactorily (Table 5). Beware of over-liming, that is taking soil pH above the optimum range. Over-liming can potentially lead to deficiencies of iron, manganese, copper, zinc, phosphorus and boron whose availability depends on pH. Heavy applications of lime to the soil surface without incorporation may also lead to high pH of soil near the lime.

Timing of application

Maintenance of soil pH is a continuing process and should start immediately a block is fallowed. The incorporation of a coarse lime at this stage will maintain the pH during the fallow period. Heavy applications of a coarser type before planting should be incorporated at least 40 cm deep. Incorporation will greatly increase the effectiveness of liming.

In ratoon crops the usual commercial practice is two applications of 2.5 t/ha of lime applied to the soil surface each year. Apply lime when it is less likely to be washed away by heavy rain. Fine limes are preferred when soil incorporation is not possible.

Producers should take particular care to separate lime applications by two to three weeks from pesticide sprays for burrowing nematode and banana weevil borer. The highly alkaline lime can readily deactivate the pesticides applied to the ground.

Table 5. Amount of lime required to counteract acidity caused by application and leaching of fertilisers

Fertiliser	Kilograms of pure lime required for 100 kg of applied fertiliser at two rates of leaching	
	Percentage of nitrate leached	
	Nil	100%
Sulphate of ammonia	78	149
Urea	0	166
Ammonium nitrate (Nitram)	0	122
DAP	32	95
MAP	44	85
Superphosphate	0	0
Potassium chloride (muriate of potash)	0	0
Potassium nitrate	0	48

more info



Fallow and replant
Section 3 page 27



Irrigation

Although tropical bananas are grown in areas with high rainfall, they still benefit from irrigation to supplement them in dry times. Here are the main things you need to know about managing the irrigation of your bananas.

The importance of irrigation	36
Choosing an irrigation system	36
Irrigation scheduling	37
Monitoring methods.....	37

The importance of irrigation

Despite the high annual rainfall in north Queensland (2000 to 4000 mm/year), irrigation improves the yield and quality of bananas on the wet tropical coast. This is because the rainfall is not evenly distributed. Trials have shown yield increases of 30 to 47% with irrigation when considering both bunch weight and time to harvest. Improvements in fruit quality from irrigation included a 5 to 10% increase in the quantity of extra large fruit, 15 to 60% increase in fruit greenlife, and less maturity bronzing. Greater yield responses to irrigation could be expected in drier years and in drier production areas.

The advantages of irrigation will vary from year to year depending largely on the rainfall pattern. The stage of plant development when water stress is experienced will also influence the plant's response. Water stress before bunching leads to a smaller plant and a smaller bunch. Water stress after bunching will reduce finger length and fruit greenlife but have less impact on bunch weight.

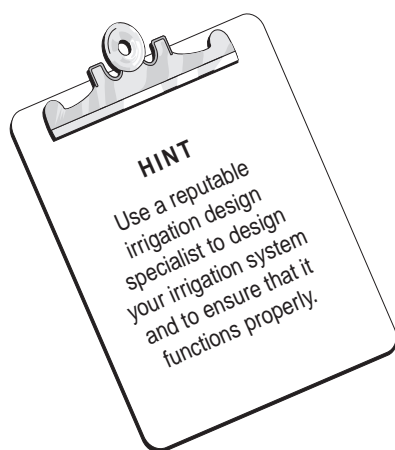
Choosing an irrigation system

Choosing an irrigation system is a complex task. Each method is capable of producing high yields of good quality bananas if it is managed correctly. What is best for your farm will depend on your system of crop management and how importantly you view the advantages and disadvantages of the various systems shown in Table 6.

more info



Maturity bronzing
Section 5 page 19



more info

Irrigation consultants
Section 6 page 9

A cost comparison of different systems showed that drip and travelling irrigators were the cheapest but prices will depend on your farm's special attributes.

Table 6. Advantages and disadvantages of different irrigation methods

Characteristics	Overhead solid-set sprinklers	Travelling irrigators	Under-tree mini-sprinklers	Drip
Running cost	high	high	low	low
Water use efficiency	low	low	high	high
Suitability for fertigation	no	no	yes	yes
Maintenance requirement	low	low	high	high
Leaf disease increased	yes	yes	no	no
Mites increased	no	no	yes	yes
Other management tasks obstructed during application	yes	yes	no	no
Suitability for automation	no	no	yes	yes
Filtration required	less critical	no	yes	yes
Distribution patterns affected by wind	yes	yes	no	no
Portability/flexibility	no	yes	no	no
Weed control costs	high	high	medium	low

Irrigation scheduling

How do you know when to start irrigating and how much water to apply? Many methods are available for scheduling, including soil inspection, plant inspection, plant water status, fixed time methods, meteorological methods (including pan evaporation), water budgeting and soil water monitoring.

Soil moisture monitoring, as part of irrigation scheduling, allows you to maximise profitability and water use efficiency while minimising leaching and runoff into the environment.

Growers should use some form of soil moisture monitoring because it provides the best integration of the environmental variables. Irrigation applied should be compared with pan evaporation rates (water use by a full crop canopy in summer will approximate pan evaporation rates) to ensure the soil moisture monitoring equipment is functioning correctly. Sound scheduling is best achieved with assistance from consultants.

Monitoring methods

Tensiometers

Tensiometers measure the force with which soil water is held within the soil. Irrigation is applied whenever the soil dries to a certain soil suction. Tensiometers (Figure 15) measure soil moisture around the ceramic tip. They are relatively inexpensive (about \$125 each) compared with probe systems such as the Enviroscan. Cheaper tensiom-

eters costing \$15 each can be made and used in conjunction with a Soilspec electronic vacuum gauge (cost \$400). This gauge gives greater precision and is particularly economical if you want to use several tensiometers.

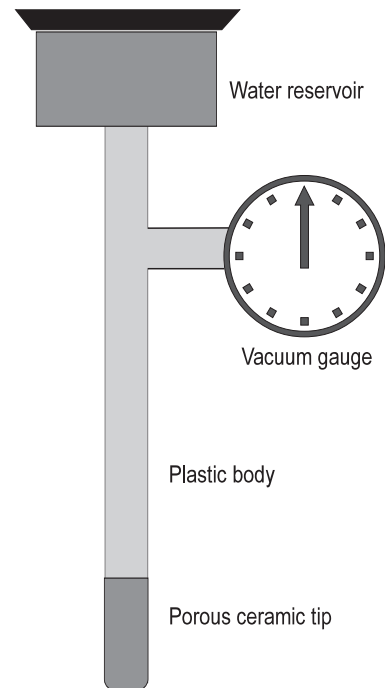


Figure 15. Parts of a standard tensiometer

Place tensiometers in the active root zone of the crop, about 50 cm from the base of plants in the row and where they will be reached by the irrigation water.

Two tensiometers are required at each site. Different sites are required where there are variations in soil type and crop development. Normally, the upper (shallow) tensiometer would be inserted 15 to 20 cm deep and the lower (deeper) one at 45 to 60 cm deep. The upper tensiometer is the main guide for timing irrigations. Both tensiometers are used to determine length of irrigations and to prevent under or over watering. The duration of irrigation will be sufficient once water has reached the lower tensiometer, as indicated by a reduction in soil moisture tension on the gauge.

Read the tensiometers each morning. Record and plot the figures on a graph so that you can see the crop's soil water use patterns. By keeping good records you will have a much better understanding of your soil and the water use by your crop.

Tensiometers are relatively simple instruments, but they need to be well maintained if they are to work properly. Without regular maintenance, they are likely to give false readings. The main requirements are:

- protecting the instruments from damage in the plantation
- ensuring the tensiometer tube is filled with water

- dealing with organic growths in the tensiometer water
- recognising and repairing failures.

Enviroscan

Capacitive sensors measure the soil's ability to store electric charge which is related to the soil water content. The Enviroscan system uses multiple sensors installed in PVC access tubes to continuously monitor soil water. Computer software with it will generate graphs to guide irrigation scheduling. A particular reading in relation to actual soil moisture content or suction is not as important as the trends in soil water use patterns.

Enviroscans need to be correctly positioned where the probe is in the active root zone and the area that is being watered evenly by the irrigation emitters. Two access tubes and eight sensors are recommended per site (Figure 16). Irrigation consultants will install them for you and provide training.



Irrigation
consultants
Section 6 page 9

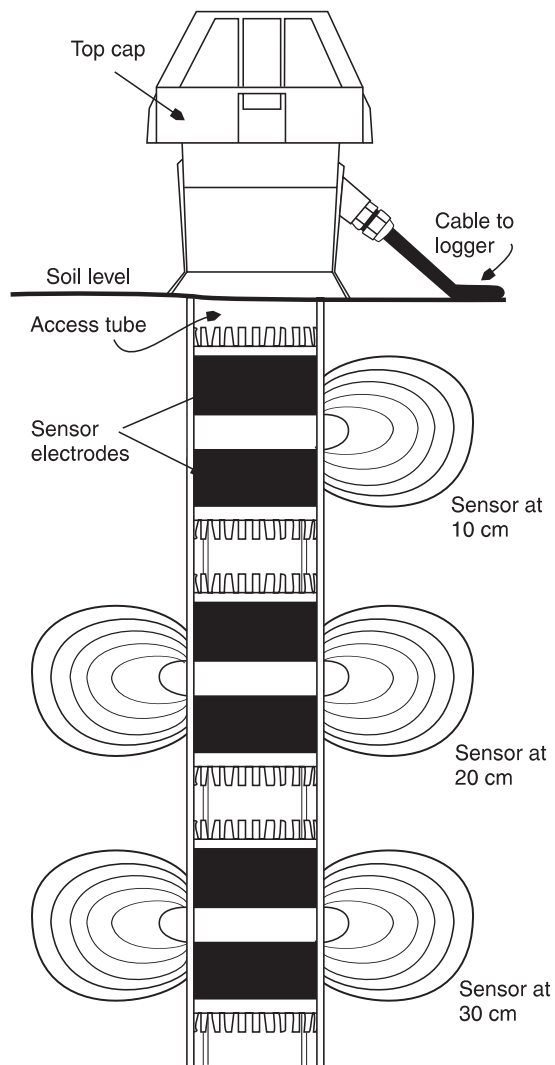


Figure 16. Diagrammatic representation of an Enviroscan probe

Neutron probe

Hollow tubes are inserted at various sites in the plantation. A radioactive source emits neutrons that are reflected off water in the soil back to a receiver. Neutron probes are more useful for crops where the soil is allowed to dry out between irrigations. They cost more than \$10 000, which limits use to irrigation consultants who can spread the cost over many farms. They also contain a potentially dangerous radiation source. Neutron probes are useful over a wide range of soil moisture and can measure effectively from 20 cm to deeper in the profile.

Neutron probe software is now available to allow similar scheduling capabilities as for the Enviroscan.



Insect and mite management

Managing insects and mites is an important aspect of banana production, particularly along the wet tropical coast. Different pests damage the fruit and plant at various stages in the life of the crop and well timed and targeted treatments are necessary for good results. While major pests require chemical treatment, minor ones occur sporadically and are usually kept in check by natural parasites and predators. Here are the key points you need to consider when planning your insect and mite management program.

The traditional approach	41
The Integrated Pest Management approach	42
Biological control of banana pests	42
Monitoring for major pests	42
Pesticide residues	43

The traditional approach

The traditional approach to insect and mite control is based on chemical applications by the calendar, or when labour is available to carry out treatments. This approach has several problems.

- Chemicals are wasted if pests are not present.
- If pests are present they may be in low numbers that will not cause any economic damage to the plant. This applies particularly to pests such as banana weevil borer that do not directly damage the fruit.
- Unnecessary treatments tie up labour and are not cost effective.
- It does not consider changing climatic conditions and their effect on insects.
- Extra treatments may result in increased danger to personnel from exposure to chemicals.
- Fruit may fail residue testing in the market place. The presence of visible residues results in buyer backlash.
- Overuse of certain pesticides increases the possibility of resistance. The introduction of new and often more expensive insecticides may be needed.
- It destroys beneficial insects and increases the importance of usually minor pests.

The Integrated Pest Management approach

The objective of Integrated Pest Management (IPM) is to change from a system that relies on regular insecticide treatments to one that uses the full range of pest management options.

The main elements of IPM are:

- using pesticides only if monitoring for pests indicates there is a need;
- using cultural control methods such as crop hygiene and insect-free planting material;
- allowing beneficial species to build up; (Use chemicals sparingly and carefully target all chemical treatments.)
- allowing adequate fallow to ensure that banana weevil borer and rust thrips have died out before replanting;
- applying chemicals properly; (This includes using the correct equipment, which is calibrated and maintained to avoid crop damage, excess residues and off-site contamination.)
- applying cover sprays only if essential. (Cover sprays are applied to the whole plant. They should be used only after careful selection of an appropriate chemical with minimal adverse effect on beneficial insects.)

Biological control of banana pests

In the banana plantation there is a range of insects and spiders which often go largely unnoticed by growers. These are the beneficial insects that act as biological control agents by feeding on or parasitising insects that are banana pests. Their contribution to insect management is only noticed when they are destroyed by the indiscriminate use of insecticides. Cover sprays to control greyback cane beetle, for example, can kill many of these beneficial insects. When they are absent, the mite population flares up. Because these beneficial insects are slow to establish, the effect of such treatments is often noticed for many months.

Monitoring for major pests

Monitoring techniques

Monitoring techniques vary for different pests. As only a small proportion of the crop or plantation is monitored, a good knowledge of the pest's behaviour and distribution will improve the efficiency of sampling. Before sampling you should determine whether the pest is:

- uniformly distributed or is clumped in 'hot spots'
- more likely to be found after rain.



Pest consultants
Section 6 page 5



Use this book to find out more about the important pests of bananas. Where to buy this book, see Section 6 page 16 & 21

When you are sampling the plantation you should include 'hot spots' because these areas can provide early warning of potential and more widespread outbreaks. Sampling techniques and detailed life cycle information for all of the important banana pests are described in the book *Bananas: insect and mite management* by Bruno Pinese and Richard Piper. If monitoring indicates that pest control is only required in certain 'hot spots' or blocks, then treat only those spots. Growers can do their own monitoring or employ specialist pest monitors to check their plantation.

Frequency

The frequency of monitoring for a pest can vary and depends on:

- the pest's mobility
- length of its life cycle
- severity of potential damage
- climatic conditions
- crop stage.

Most pests are more active when temperatures are high, so monitoring should be more frequent during spring and summer.

Pesticide residues

Residues, whether visual or not, are of major importance to the banana industry. Detection of pesticide residues in the market, especially if maximum residue limits (MRL) are exceeded, are detrimental to the industry's reputation. In the past, dust deposits from bunch dusting to control pests have resulted in fruit seizures at the market. Dusting methods have improved but attention to correct procedure is still important. Follow all label recommendations and adhere to withholding periods to ensure compliance with residue limits.



Managing nematodes in bananas

Burrowing nematode is one of the major pests of bananas in north Queensland. This section will tell you how to diagnose a nematode problem, monitor banana blocks to determine if burrowing nematodes are causing economic damage, determine the options for controlling the nematode and how to prevent nematodes from becoming a problem.

What are nematodes?	44
Diagnosis of burrowing nematode	45
Monitoring bananas for burrowing nematode	46
Controlling burrowing nematode	47
Preventing nematode problems	48

What are nematodes?

Nematodes are microscopic worm-like organisms that feed on the cells of root tissue and corms. In north Queensland burrowing nematode (Figure 17) is the most destructive nematode species. Burrowing nematode reduces plant growth and may cause the plant to topple by damaging the root system. Burrowing nematode causes characteristic red-black lesions in the root cortex (outer section of the root). Other nematode species such as root-knot nematode and spiral nematode attack the root system but do not cause economic losses in tropical banana production.

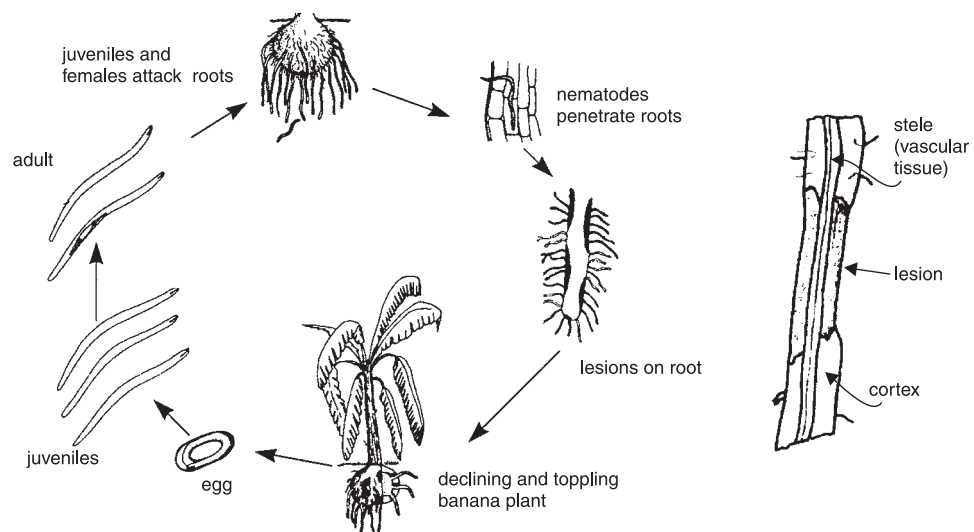
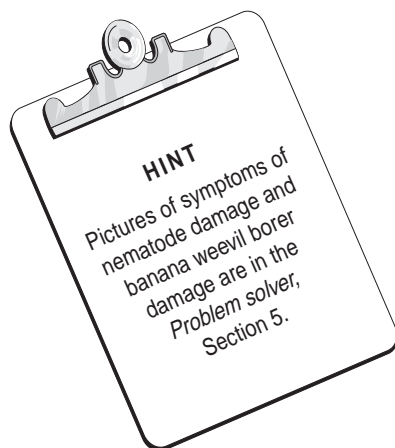


Figure 17. Life cycle of burrowing nematode and damage on banana roots



Diagnosis of burrowing nematode

It is often difficult to know whether nematodes are present in a banana crop. Above ground symptoms are not easily seen until nematodes start reducing yields. Nematode-infested plants grow slowly, their bunches are smaller and their bunching cycle is longer.

Severe nematode damage causes the banana plant to topple, breaking at the roots, so that the corm is lifted above the ground, exposing the roots as shown in Figure 18.

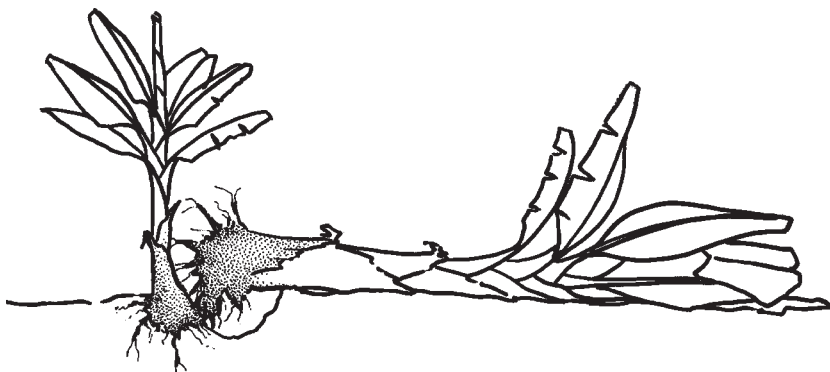


Figure 18. *Toppling of banana plants caused by burrowing nematode lifting the corm above the ground with roots exposed above ground level*

Other pests and disorders, such as banana weevil borer, can also cause plants to fall over. Plants that have fallen due to banana weevil borer damage look different because the corm snaps at ground level, leaving the roots intact and exposing the tunnelling caused by the weevils (Figure 19).

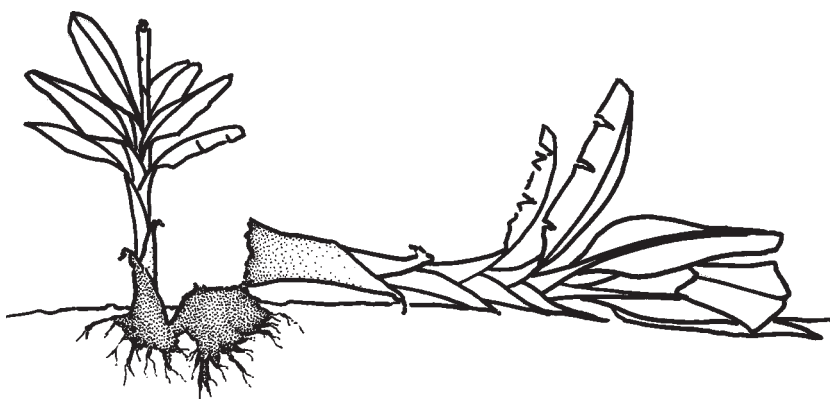


Figure 19. *Toppling of banana plant caused by banana weevil borer. Note that the corm remains below the soil surface and some tunnelling may be seen in the corm*

To confirm that nematodes are present in banana plants you must slice the roots lengthwise. If burrowing nematode is present you will see the reddish-black lesions (rotted areas) in the root cortex. The amount of lesion in the roots is used to monitor damage caused by burrowing nematodes.



Monitoring bananas for burrowing nematode

The aim of monitoring for burrowing nematode is to estimate the nematode status of the crop. From each banana block take 20 root samples to give a good estimate of the nematode damage. The best time to sample plants is at bunching. Use a spade to dig a soil block 25 x 25 x 25 cm from the base of the plant. Collect five roots at random from each of the 20 plants sampled (total of 100 roots). Place the roots in a bucket and rinse them with water to remove any loose dirt.

Cut each root lengthwise and use the rating scale in Table 7 to estimate the proportion of the root cortex which is occupied by reddish-black lesions.

Table 7. Rating scale for lesions caused by burrowing nematode on banana roots

Percentage of the root cortex with lesions	Rating
No lesions	0
1 – 25%	1
26 – 50%	3
51 – 75%	5
76 – 100%	7

When all roots have been rated, a disease index for the block can be calculated from the following equation:

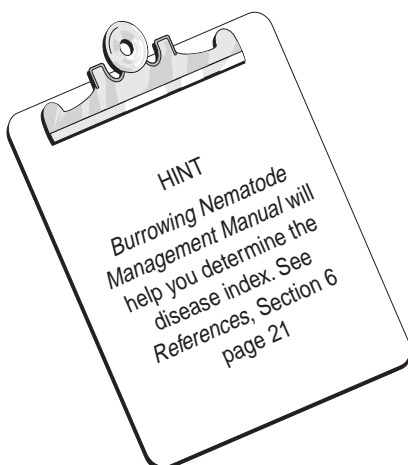
$$\text{Disease index} = \frac{\text{sum of all root ratings} \times 100}{\text{total number of roots} \times 7}$$

The disease index can then be compared with the action threshold to help you make decisions on nematode management. Once the disease index of a block reaches 10 to 15 you should apply nematicide.

Table 8. Disease index action levels

Disease index	Action
0 – 10	No action required. Sample again in 3 to 6 months.
10 – 35	Some yield loss may occur. Apply nematicide.
>35	Yield loss is occurring. Fallow should be considered.

If the disease index has reached 35, the damage is already very severe. It is unlikely that nematicides will be economically effective in improving bunch yields. With severe nematode damage it is more economical to fallow the field with a nematode-resistant rotation crop to allow the nematode population to decline before replanting.





Nematicides
Problem solver
handy guide

Controlling burrowing nematode

There are chemical and non-chemical strategies to control burrowing nematodes.

Chemical control methods

Nematicides

Five nematicides are currently registered for the control of burrowing nematode in bananas. These chemicals can suppress nematode populations when used correctly and the manufacturers have set several constraints on their use. They are:

- incorporate nematicides into the soil as quickly as possible;
- only use nematicides when rain is expected or if irrigation is available to allow for incorporation;
- do not use nematicides when flooding could be a problem;
- remove trash from around the base of the plant before applying certain nematicides;
- apply nematicides evenly, covering a 30 cm radius in a semi-circle around the base of the plant.

There is a lag time in response to the nematicide application because the plant needs to grow new roots. It is usually the following sucker that benefits from the chemical application. Most nematicides also have some action against banana weevil borer. Their control of this pest is limited, however, and they should not be relied on to control banana weevil borer.

Enhanced biodegradation

All nematicides are susceptible to enhanced biodegradation of the chemical which occurs when a single product is used repeatedly in the same area. The microorganisms in the soil will evolve to use the chemical as a food source, prematurely destroying it.

Most nematicides are active in the soil for six to eight weeks but with enhanced biodegradation the chemical is active for less than two weeks. This is not long enough to reduce nematode populations and banana plants will still be damaged.

Enhanced biodegradation can be prevented and overcome by rotating (alternating products from different chemical groups) nematicides regularly. This prevents the microorganisms responsible for enhanced biodegradation reaching a level that prematurely destroys the chemical.

Non-chemical control methods

Fallows and rotations

Fallows are commonly used to reduce nematode populations. Fallows begin with removing the old crop and destroying as much of the



existing corm as possible with cultivation. Corm residues which host nematodes can take as long as six months to break down. Therefore, a fallow should be longer than six months to ensure that few nematodes survive.

A non-host crop should be grown in the fallow to prevent nematodes from reproducing. Although few crops have been tested for their ability to allow nematode reproduction or host status, Table 9 shows the host status of some plants which might be used in a fallow.

Table 9. Host and non-host plants of nematodes

Nematode host	Non-host
Sugarcane cv. Q158, Q127	Sugarcane cv. Q96, Q124, Q135, Q117
Sorghum cv. Jumbo	Jarra Grass
Cowpea	<i>Brassica</i> spp. (canola, mustard, Hyola 42, MP7 Swede, Highlander, swede and Bonar rape)
Soybean	
Peanut	
Heliconia	
Maize	
Velvet bean	

The optimum length of a fallow and alternative fallow crops are being tested by the DPI.

Biological control

Fungi, bacteria, other nematodes and microscopic animals commonly found in the soil are able to parasitise and kill nematodes. Biological control of burrowing nematode in bananas, however, is difficult due to its biology. Most of the nematodes live inside root tissue of actively growing bananas. Only 10% of the nematode population lives in the soil around the plants where most nematode predators and parasites are found. This leaves most of the nematodes unexposed to biological control organisms. Biological control of nematodes is not yet commercially available.

Preventing nematode problems

Preventing nematodes from infecting banana plants can save yield losses and costs of nematicide treatments. Infected planting material is the most common way of introducing burrowing nematode into a new area. When you are establishing a banana block it is very important that your source of planting material is registered as being pest-free.

more info



Planting material
Section 3 page 11



Leaf spot diseases

*Leaf spot or yellow Sigatoka, caused by the fungus *Mycosphaerella musicola*, is a very serious disease in tropical banana growing areas. Another form of the disease black Sigatoka, *Mycosphaerella fijiensis*, is not present in Australia's banana growing areas but is a major threat to the industry. This section describes how yellow Sigatoka spreads and the important cultural and chemical strategies that you can use to control it.*

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About leaf spot disease

The leaf spot fungus produces two types of spores: sexual ascospores and asexual conidia.

Ascospores are produced within the tissue and are forcibly ejected into the air currents. They can be carried over long distances and are responsible for spread of the disease into new plantings, new plantations and within the plantation. Ascospore infection results in tip spotting of younger leaves. Ascospores are only produced during warm moist conditions and are generally absent or in low numbers during winter and dry spring periods.

Conidia are produced on the leaf surface and dispersed in droplets of water, so their spread is only over short distances, generally within a plantation. Conidial infection usually results in line spotting or scattered spotting over the entire leaf.

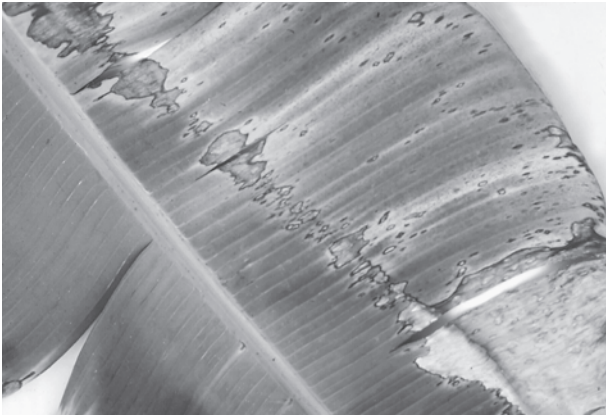


Figure 20a. Line spotting pattern caused by conidial infection



Figure 20b. Tip spotting pattern caused by ascospore infection

Life cycle — Sigatoka leaf spot fungus, *Mycosphaerella musicola*, 5 stages to leaf spot development

Asexual state

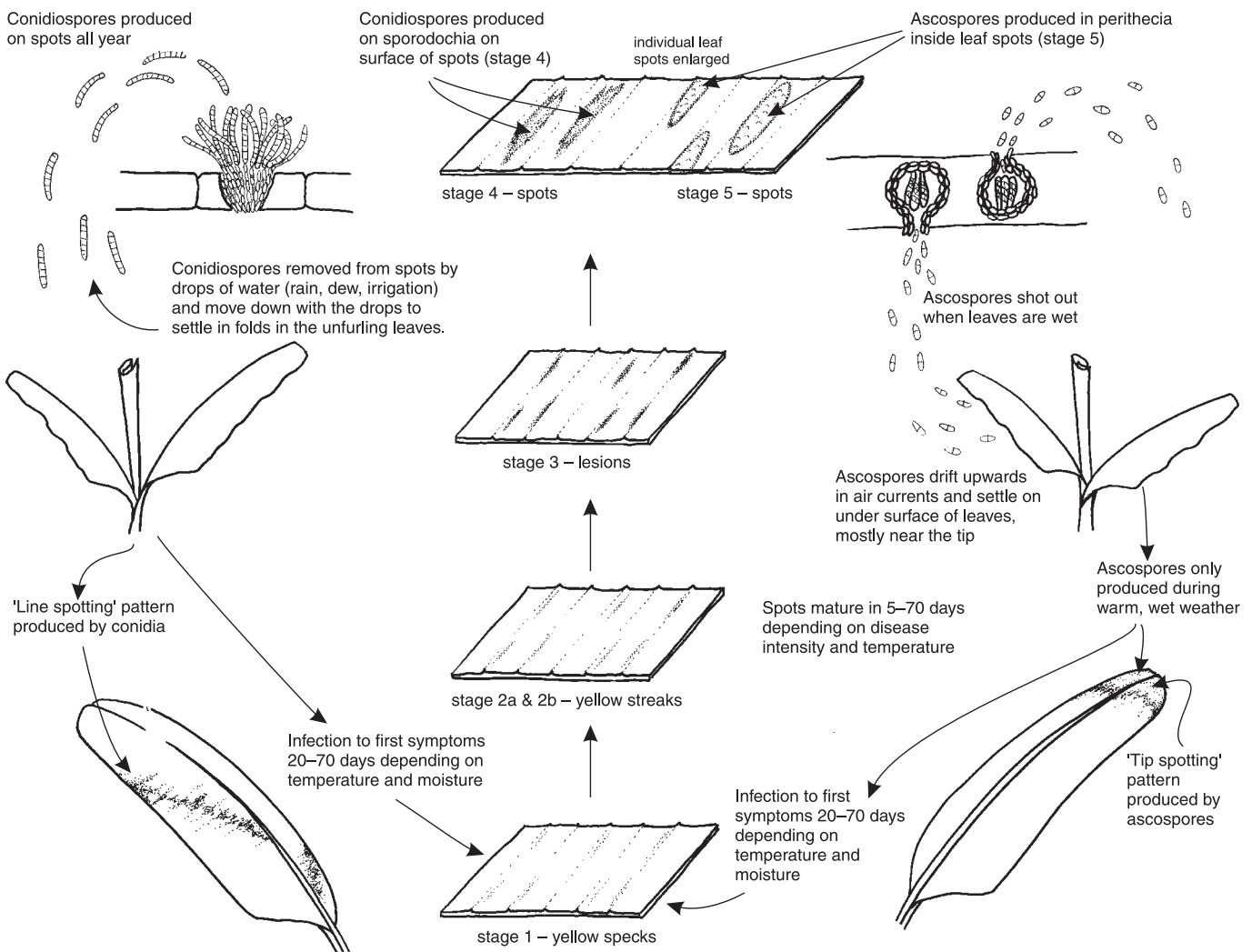
Type I spores — conidiospores (conidia)

Short distance spread only from within the plantation

Sexual state

Type II spores — ascospores

Long and short distance spread from within and from other plantations



Drawings: Ron Peterson and Carole Kroger.

Development of symptoms

Development of leaf spot symptoms can be divided into five distinct stages from the minute yellowish-green speck to the fully mature spot. The various stages are shown in Figures 20 and 21.

With massive infections several stages are skipped, the leaf tissue dies rapidly (burns) and large areas of the leaf turn brown and then grey. The outline of the individual streaks and spots is not well defined (commonly referred to as 'skipping and/or burning'). Colour photos of the thumbnails are found at the back of the *Problem solver* section.

more info



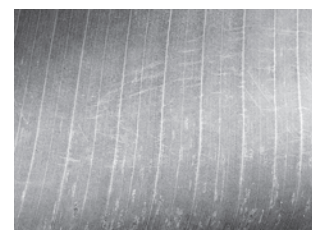
Pictures of leaf spot
Problem solver
Section 5



Stage 1 (speck/dot)
Yellowish green specks less than 1 mm long.



Stage 2a (early streak)
Specks become 3 – 4 mm x 1 mm long streaks, increase in length and turn yellowish.



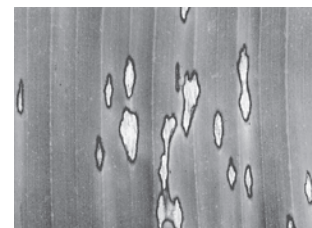
Stage 2b (late streak)
Streaks darken to a rusty brown.



Stage 3 (early spot)
Streaks broaden to a spot. They become longer and wider, with indefinite margins, which may be water-soaked in appearance and darken to brown.

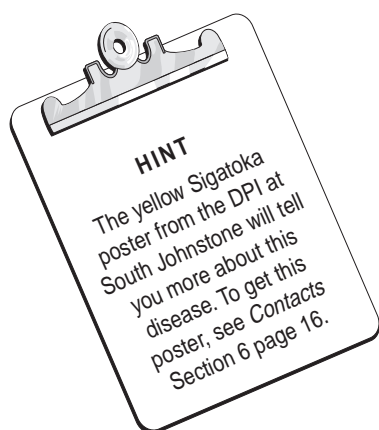


Stage 4 (brown spot)
Spots have definite dark brown edges, the centre becomes sunken and is sometimes surrounded with a yellow halo. Conidia are produced on the surface.



Stage 5 (mature spot)
The sunken centre of spots turns grey and is surrounded by a dark brown to black border, sometimes with a yellow halo. Ascospores are produced within the grey central area of the mature spots.

Figure 21. Stages of development of leaf spot disease



Controlling leaf spot

Leaf spot is very difficult to control under hot wet conditions. An integrated disease management program involving both cultural and chemical measures is required for effective control.

Cultural control practices

Cultural practices aim to reduce spore levels in the plantation and to reduce humidity levels around the leaves. Diseased leaf tissue (source of spores) should be removed (deleafing) regularly throughout the year. Deleafing hooks are available to deleaf banana plants. Every effort should be made to remove all diseased tissue during the dry

season so those plantations are 'clean' with the onset of the next wet season. Banana blocks should be designed to ensure all water is rapidly removed and air flow is not limited. Avoid planting bananas in wet areas or near areas of permanent water. Planting densities should be reduced in disease-prone areas. This will improve spray coverage and increase air flow in the plantation, which allows quicker drying of the leaves.

Chemical control practices

The fungicide program should include protectant and systemic type fungicides and oil should be included in all sprays.

Protectant and systemic fungicides

Three fungicide groups are used on bananas (Table 10).

Table 10. The protectant and systemic fungicide groups for leaf spot

Group	Active ingredients	Trade name
Group Y protectants	Dithiocarbamates	Dithane, Mancozeb
Group A systemics	Benzimidazoles	Benlate
Group C systemics	DMI	Tilt, Folicur, Bumper

Protectant fungicides must be applied before infection while systemic fungicides can stop or arrest the fungus after it has infected the leaf. Petroleum oils can arrest infection up to about two weeks after it has entered the leaf, whereas some systemic fungicides can kill infections up to the speck or early streak stage (stages 1 and 2a). Systemic fungicides, however, cannot prevent development of the disease if applied later than the late streak (stage 2b) or early spot (stage 3) stages.

Application frequency

Application frequency can be based on disease development monitored by competent consultants, on weather conditions or by the calendar on a regular schedule. Monitoring systems have been developed and various forms are used by consultants. With time-based (calendar) systems, sprays should be applied at:

- 10 to 14 day intervals during the wet season
- extended to two to three weeks during winter
- extended to three to four weeks during the dry spring period
- reduced to two to three weeks before the next wet season.

Targeting the chemical applications

Fungicides should be aimed at the younger leaves as these are most prone to infection. As the leaf ages, new infections are less though earlier infections will continue to develop. Aerial application is widespread in the banana industry as it allows large areas to be sprayed rapidly, when weather conditions permit. It is also highly effective for airborne ascospore infections.



During the cooler and drier periods, however, conidia are the main means of spread and these are produced within the canopy. Conidia mainly move downwards with dew or irrigation water, and under-canopy applications of fungicides are more effective for these infections.

Preventing chemical resistance

Repeated applications of systemic fungicides to severely diseased leaf tissue can lead to resistance to the fungicides in the leaf spot population. When a leaf spot fungus population becomes resistant (or less sensitive) to a particular systemic fungicide, do not use a fungicide from that group of fungicides until that particular population of leaf spot has been controlled.

Strategies to reduce this resistance have been developed and presented in a DPI poster (see the clipboard hint). The key points include:

- not using a chemical-only program; (Cultural practices are essential.)
- limiting the use of systemic fungicides; (Use them when conditions are most conducive to infection, not when symptoms are most obvious.)
- not applying systemic fungicides to heavily diseased plants; (Deleaf diseased leaves before applying the systemic fungicide.)
- observing systemic-free periods and monitoring the sensitivity of the leaf spot population. (If a shift in sensitivity is detected, do not use systemic fungicides until the shift is reversed.)

Leaf spot control is costly and can contribute significantly to the costs of production. Twenty to twenty-five sprays are generally applied each year.

Legislation for leaf spot

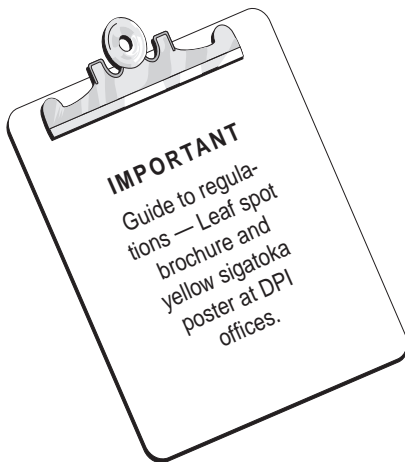
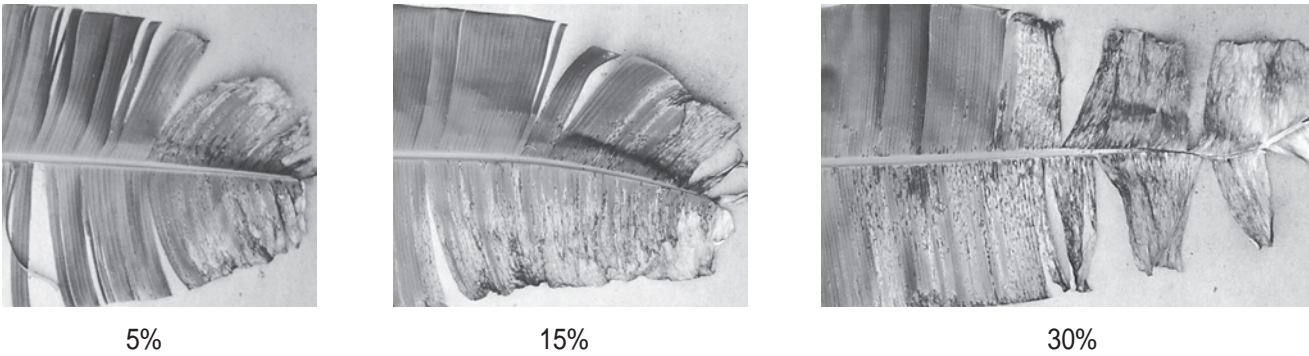
Legislation exists in Queensland to reduce the level of leaf spot disease because:

- leaf spot levels have a major effect on efficacy of fungicides
- disease-carrying ascospores are spread over long distances.

DPI plant health inspectors will assess the level of leaf spot in your plantation and may advise or order you to control your leaf spot problem. The action they take is based on the percentage of leaf spot, as shown in the pictures in Table 11.



Legislation
This section page 8

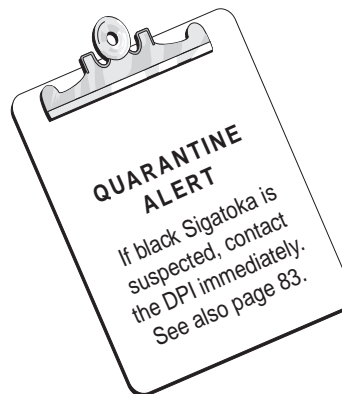
Table 11. Leaf spot levels (%) and relevant control actions issued by the DPI

Leaf spot level	Action	
	Summer – autumn Wet / warm	Winter – spring Cool / dry
5%	Control advice given	No action
15%	Control order given	Control advice given
30%	Control order given	Control order given

Black Sigatoka

Black Sigatoka, caused by *Mycosphaerella fijiensis*, is a more virulent, more devastating disease than yellow Sigatoka. It is not present in Australian banana production areas, but it is a major threat to the local industry because it is widespread in the Torres Strait/Papua New Guinea areas as well as other Asian and Pacific nations. Symptoms of black Sigatoka are similar to yellow Sigatoka, except the streaks are rusty red to brown. As the streaks develop, they darken to black. Heavily infected leaves with a large number of streaks become black. Black Sigatoka is a notifiable pest under the *Plant Protection Act 1989*.

Black Sigatoka is more damaging than yellow Sigatoka because it develops faster to the spot stage and produces up to eight times the number of ascospores.





Organic banana production

Bananas are generally grown by conventional methods, using inorganic fertilisers and pesticides, but the growing local and international market for organic produce is increasing the interest in this production method. Growers need to be aware of the difficulties with organic farming, especially in the tropics. This section outlines the things you need to know if you want to grow bananas organically.

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Why the interest in organic growing?

There are several reasons why interest in organic production is growing.

- Markets that are prepared to pay a premium for this produce.
- Health concerns that lead some consumers to demand produce with no residues of artificial substances.
- A belief that converting to organic systems can reduce production costs.
- Concern over excessive consumption of non-renewable resources used to make fertilisers and chemicals.
- Concern that artificial fertilisers and chemicals are polluting the environment.
- A desire to create a safer working and living environment by limiting exposure to toxic chemicals.
- Government regulation of the use of chemicals is increasing.
- Increased resistance of pests and diseases to chemicals is further limiting the number of effective chemicals available.

Changing to organic production

Despite the potential problems associated with organic banana production, some producers have demonstrated that it is possible in north Queensland. The extension of organic production systems to larger commercial farms, is difficult however, with the existing technology. There are several important problems to consider.

Pest and disease control

Effective organic control measures for leaf diseases and the main pests are limited. Leaf diseases can be controlled to some extent by the use of natural chemicals such as copper and sulphur, but significant leaf loss should be expected during prolonged wet weather. Plant damage from these natural chemicals is also much more likely. Scab moth can be controlled by the use of organic pesticides such as Bt (*Bacillus thuringiensis*, a bacteria that kills caterpillars), but fruit will be damaged by rust thrips in most years.

Crop nutrition

Organic fertilisers are slow acting and unpredictable in their release of nutrients, so it is difficult to develop an effective program to meet the plant's nutrient needs. It is also difficult to quickly correct nutrient imbalances when they occur.

Weed control

Weed control without herbicides is difficult during the establishment phase as mechanical cultivation is slow and expensive.

Myths about organic banana growing

The hype surrounding organic growing has led to some exaggerated claims about what can be achieved. Here are some of the common statements and our comments.

There's an export market for organic bananas. Its easy, I'll produce for that. False. The development of overseas markets and servicing them on a long term basis requires time and commitment. Exporting horticultural produce is a high risk business due to export costs, the distance and difficulties in communicating with buyers.

Organic production systems are just a matter of replacing inorganic fertilisers and pesticides. False. Organic production is also a different philosophy of farming. An organic system is one that tries to develop a healthy and biologically diverse ecosystem that is sustainable with minimal inputs over the long term.

Organically produced fruit will always provide me with better prices and returns. False. The market for organic fruit is currently limited to a small percentage of consumers willing to pay a premium

for clean fruit. It is also a market where fruit has to be marketed through known organic outlets. Poor prices may result if organic fruit is marketed through supermarkets, where most bananas are sold. Organic fruit then has to compete with conventionally grown fruit, which generally has better appearance and keeping quality. Returns may be no better than conventional crops as reduced yields and higher production costs erode the advantage of better prices.

I've grown bananas in the backyard and had few pest problems so I should be able to do this commercially. False. Beware of the argument that non-chemical home garden methods can be duplicated on a commercial farm. The success in home gardens is only possible because of the small numbers of plants grown and their isolation from other bananas. A large plantation will attract more pests and make it easier for them to establish and multiply. Home gardeners are not greatly concerned about yield, fruit appearance or keeping quality, whereas these are essential objectives of commercial production.

There's a biological control method for everything. False. If there is we certainly don't know them all for bananas. Rust thrips is one pest with no bio-control methods available.

Before you start

For prospective organic growers, here are some useful tips.

Read as much as you can on the subject and study what has made organic growers successful. Join local organic grower associations. Do an organic growing study course (where these are available). Local TAFE colleges often provide such courses. Contact certifying organic producer organisations for information on standards and the process for becoming a certified organic grower.

Talk to as many growers as possible who are using organic methods. See if you can work for one for a period to learn the ropes. It is also useful to work for a conventional banana grower to gain an insight into the nature of the banana plant and its problems.

Try a small area first (about 1000 plants) and learn how to manage the crop before you expand your operation.

Plan carefully by examining the suitability of your farm, your management capability and your proposed market. Remember that the local market for organic bananas at present is limited and can be easily oversupplied. Do a business plan to analyse what you are getting into financially.

Select a location where the impact from leaf diseases and pests is reduced, for example drier areas preferably new to banana production. Use pest-free tissue-cultured planting material to establish new plantings. Carefully check the history of the farm to ensure that the soil has not been contaminated with residual pesticides.

Some tips on growing organic bananas

If you elect to go ahead with organic banana growing, here are some useful growing tips.

Look after your soil

Keeping the soil 'alive' is a key to successful organic production. This includes lifting soil organic matter levels and promoting soil biological activity.

Improve soil health and organic matter levels before planting by liming, growing green manure crops and applying composted manures. Get a soil analysis done to check that the nutrient levels are right before planting. Permissible forms of fertiliser include unadulterated lime, gypsum, dolomite, rock phosphate, rock potash, quarry dust, manures, blood and bone, Epsom salts and laboratory grade trace elements.

Use biological, organic and cultural insect and disease control

Use Bt (*Bacillus thuringiensis*, a bacteria) against scab moth and diatomaceous earth and/or derris dust to suppress bunch pests such as sugarcane bud moth and rust thrips. Early bunch covering is also useful to reduce rust thrips damage.

Aerial application of permissible fungicides such as copper sulphate, sulphur and oil may give better disease control than ground-based applications.

Plantation layout should ensure complete drainage of surface water and good air flow to reduce humidity around leaves. Do not plant bananas near wet areas such as swamps. Do not allow disease levels to build up and regularly deleaf all diseased tissue.

Choose disease resistant varieties

The predominant commercial variety Williams is relatively susceptible to several pests and diseases so consider growing more pest and disease resistant varieties. Pest and disease resistance, however, is often associated with lower yields.

Use crop management strategies to reduce pest and disease incidence

Crop management strategies that reduce pest and disease incidence are a vital part of an organic production system. They include:

- fewer plant cycles; (A plant crop only or just one or two ratoons will help to break pest and disease life cycles, though this means greater weed problems and increased costs.)
- reducing crop density; (This will permit quicker crop cycling and promote better vigour and stronger individual plants. Lower



Varieties
This section page 25

densities also help control leaf disease by increasing air flow and reducing humidity, all of which allow quicker drying and better spray coverage with permissible fungicides.)

- deleafing regularly; (This will reduce spores that cause leaf and fruit diseases.)
- under-tree irrigation systems to reduce humidity and spread of spores;
- improving drainage and eliminating surface water; (This will reduce humidity and give better control of leaf disease.)
- using pest and disease-free planting material in association with 'clean' ground; (Tissue-cultured plants are the best source of pest and disease-free planting material.)
- application of permissible fungicides, such as copper sulphate, sulphur and oil. (Ensure complete coverage of all leaves, in particular the youngest leaves.)

Use cultivation for weed control

Weed control in organic systems can involve greater use of cultivation after planting. This could be combined with progressive mounding where plants are grown in single rows.

Apply nutrients

Nitrogen and potassium are the nutrients removed in the greatest amounts in harvested fruit and are the major nutrients for manipulating growth of the banana crop. Successful management of these nutrients will determine whether you get good yields using organic methods. Just as for conventional farming, regular soil and leaf analysis is important to help guide the management program.

Nitrogen

Nitrogen can come from several sources. About 20 to 40 kg/ha/yr could be obtained from the soil organic matter (1.5 to 4.0% carbon). A legume intercrop such as Pinto's peanut might provide 50 kg/ha/yr if it is regularly cut and tossed on the banana row. Storm rain can contribute 5 to 10 kg/ha/yr. Various manures, if composted, are another important source. Blood and bone is probably the cheapest form of nitrogen that is permitted but it is still much more expensive than conventional fertiliser. Molasses (about 1% nitrogen and about 3% potassium), should be considered as a fertiliser source.

Potassium

Potassium is available from several sources and potassium sulphate from natural rock is one option. Soluble fertilisers can be applied as a mixture with organic material to limit leaching of nutrients. This mixture must be composted before it is spread on the paddock.



Soil and leaf analyses
This section page 31

Becoming a certified organic grower

Once growers have developed an organic growing system, they should seek certification. This guarantees their credentials as legitimate organic growers and provides a marketing advantage.

Certification is possible under a national standard for organic and biodynamic produce released by the Commonwealth Government in 1992. Although this standard prescribes minimum requirements for organic labelling for the export market, the same requirements for certification may at some stage be applied to the domestic market. In the meantime, it acts as the unofficial benchmark for certification for the domestic market. Certification is administered by national organic grower organisations that have been accredited by the Australian Quarantine and Inspection Service (AQIS) as the auditors of the export standard for the Government.

Two grades for certification are available:

- organic/bio-dynamic (for growers who have developed their property and management skills to an acceptable level)
- organic/bio-dynamic in conversion (for growers who are new to organic farming).

Remember that it may take years to achieve certification.

The certification process

Here are the steps for the certification process.

1. Obtain a copy of the standards and an application form from one or all of the certification organisations.
2. Read the details carefully. If you wish to proceed, complete the application and send it with the prescribed fee back to the certification organisation/s.
3. You should then receive a questionnaire, which will ask for details on the history of the farm, your farm management skills and processes, and the risk of contamination from neighbours.
4. Complete the questionnaire and return it with the required documents.
5. Your property will then be inspected and soil and produce samples collected for testing.
6. Certification will then be considered, perhaps after a period of compliance, and offered or rejected.
7. If you are accepted, you will receive a contract of certification that enables you to use appropriate labels and logos.
8. You are then subject to annual re-inspection.



Personnel management

Finding and keeping a skilled labour force can be difficult for banana producers in north Queensland because production involves hard, physical labour, often in difficult climatic conditions. These conditions, and the nature of the work, can expose employees to physical, chemical and biological risks. This section will help you understand some of the issues you will need to consider when employing and training your workforce.

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The importance of staff training	62

Sources of labour

There are many factors which influence labour availability including working conditions, general economic conditions, owner's/manager's personnel management skill level and employee attitude. Often banana producers only recognise the last issue.

In recent times growers have relied more on backpacker tourists as a source of itinerant labour. Although backpackers are often willing workers they are unlikely to have encountered banana production before, so are not well suited to tasks requiring high skill levels such as bell injecting and packing. They also remain in districts for short periods.

Making contact with skilled and unskilled labour pools requires some persistence. You should:

- contact your local employment agency, particularly if you are looking for skilled employees;
- advertise in district newspapers;
- contact hostels, caravan parks, backpackers lodges and other accommodation for itinerant workers and backpackers. Sometimes these businesses run active employment services for their guests.

An alternative is to use contract labour services. In major growing regions such as Innisfail and Tully, contractors will perform certain tasks, particularly bagging and bell injection, for contract rates. These contractors are often not available in smaller centres.



The cost of labour

Labour can represent 20 to 30% of the costs of growing and marketing bananas. When you consider that there is some labour component in almost every operation, particularly those which influence fruit quality, you can begin to appreciate the potential cost of labour.

Minimum wage rates are set by the Queensland State Government and are available from the Department of Training and Industrial Relations. When considering your labour budget remember to allow for on-costs like superannuation, payroll tax and workers' compensation insurance. Details on the extent of these charges are also available from the Department of Training and Industrial Relations.

Most existing banana producers often use minimum wage rates as a base wage. To maintain skilled staff in important tasks producers often implement incentive schemes and higher pay rates. Staff involved in packing, harvesting and bell injecting, for example, are often offered incentives to do the job properly because of the crucial nature of their task.

The importance of staff training

Staff training is very important because of the specific tasks involved in banana production. However, this is often an area where employers are not well skilled. A lack of understanding by employees is often attributed to their attitude, without considering if poor communication has contributed to the problem.

People learn in three ways — by watching, by doing, and by listening/talking. Everybody uses these three learning methods at some time, but usually show a preference for one particular method. When training employees it is important to try and identify which is their preferred style and then use this information to decide how you will conduct your training.

The implementation and running of a quality management system focuses heavily on staff training and communication. Quality management is a logical place to start if you are serious about improving your staff training.

Getting help with personnel management

Training in personnel management is available from consultants and management companies in large regional centres. The Queensland Chamber of Commerce and Industry also offers training from some of its offices.



Workplace health and safety
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Workplace health and safety

As employers, farmers need to be aware of their duties and responsibilities under workplace health and safety legislation. This section outlines the main requirements of the Workplace Health and Safety Act.

By considering and ensuring the welfare of their workers (as well as themselves and visitors to the farm), farmers will meet their obligations under the Workplace Health and Safety Act and minimise risk of exposure through common law. They can also earn a good reputation amongst the pool of available labour, which will make it easier to maintain well trained and reliable staff.

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The Workplace Health and Safety Act

The banana industry cannot ignore workplace health and safety issues because banana production is traditionally associated with hard work involving uncomfortable and hazardous working conditions.

Legislation under the Workplace Health and Safety Act applies to all Queensland workplaces including farms. General obligations are outlined in the *Workplace Health and Safety Act (1995)*. The *Workplace Health and Safety Regulation (1997)* and *Advisory Standards* help define how these obligations can be met. The rural industry is defined under the Regulation and, though exempted from much of its content, **must provide a safe and healthy working environment for employees**. Section 146 of the Regulation lists the sections, which apply to rural industry. The Workplace Health and Safety program of the Department of Employment, Training and Industrial Relations (DETIR) administers the Act.

Due diligence is an underlying principle of much legislation. Under the Act, exercising proper diligence is about managing risk in the workplace. Practical guidelines and advice for implementing and ensuring workplace health and safety are covered in the various Advisory Standards. Where standards do not exist for a hazard,



farmers must take reasonable precautions to prevent harm to their workers. This includes conducting a risk assessment of identified hazards, providing appropriate training and information, providing adequate supervision and ensuring the effectiveness of adopted risk control measures.

Farmers should also realise that if they build or modify their own plant they need to be aware of the responsibilities of a manufacturer, since they will have been assigned those obligations. Additionally, where a 'service to agriculture' is provided from which there is a financial gain over and above that from core farm activities, then that part of the workplace providing the service is an industrial workplace and must be registered. A good example would be a farm which packs its own fruit but which also provides a contracted packing service for other producers.

An excellent *Rural industry guide to workplace health and safety legislation* has been compiled and is available through Farmsafe Queensland as a service to primary producers. For more information about obligations and regulations under the Workplace Health and Safety Act as they apply to agricultural workplaces, contact a workplace health and safety inspector.



Managing workplace health and safety

Ensuring workplace health and safety requires being aware of hazards and risks in the workplace and applying control measures to deal with them. This process involves three steps:

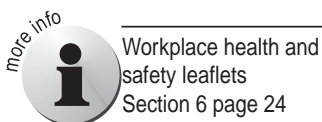
Hazard identification. This means checking the whole workplace and examining job tasks to identify hazards that could hurt people or things that could go wrong.

Risk assessment. This involves judging how dangerous are the hazards based on the likelihood of their occurrence and probable severity of the consequences.

Hazard and risk management. After the identification and assessment process, hazards can be given priority and managed by implementing risk control measures. This could involve job redesign, changing the workplace layout, introducing mechanical aids or providing staff with task-specific information and training. These measures need to be followed up by monitoring to assess the effectiveness of the control measures put in place.

Assistance and training

Workplace health and safety inspectors are a source of information and assistance. Inspectors appreciate the special circumstances of rural industries and want to help farmers develop risk assessment skills and implement reasonable control strategies. They can provide infor-





mation about implementing on-farm programs for training and competency assessment in things like tractor operation and safety. The DETIR also has information on workplace hazards and risk controls covering various topics.

Specialised training in risk assessment and management of farm safety is available through Farmsafe Queensland who now offer a nationally accredited Managing Farm Safety training program. This course is aimed at farmers, farm managers and supervisors of rural workplaces. Included in the course material are comprehensive guidance notes and industry specific checklists, which recognise that various rural industries have unique work practices. A checklist for horticulture (including bananas) is being developed.



Workplace health and safety issues in bananas

A comprehensive report on the health and safety risks associated with the banana industry is not available. Table 12 indicates some of the hazards which you should consider when growing bananas. You may also consult the *Tree fruit health and safety guide*. Alternatively, you may use a workplace health and safety inspector to independently audit your operation.

While the risks and control measures associated with hazards will depend on your particular operation, remember that the concepts of workplace health and safety risk management are generic to all hazards.

Table 12. Some of the potential hazards in growing bananas

Activity	What	Potential hazards
Field operations	tractor	roll-overs, run-overs, PTO, ROPS, seat belts
	quad-bike	roll-overs, knives (bell injection)
	4WD bagging machines	roll-overs
	chemicals	protective clothing, correct usage, first aid, field re-entry periods, storage, disposal, material safety data sheets, exposure from aerial spraying operations (not acceptable)
	ladders	failure, toppling
	deleafing	knives
	desuckering	chemicals
	general	skin cancer, heat stress, footwear
Harvest and handling	harvesting	knives
	carrying	knives, load weight and handling, worker age
	bunch trailers	lifting
general	heat stress, terrain, snakes and rodents, leptospirosis (Weils disease), footwear	

Activity	What	Potential hazards
Packing shed	unloading bunches	lifting
	dehanding	knives, repetition
	sorting	repetition, posture
	packing	repetition, lifting, posture
	pallet stacking	repetition, lifting, posture
	carton-making	repetition, machinery operation and guarding
Other	fork-lift operation	run-overs, load loss
	general	machinery guarding, electricity, noise, ventilation, light, protective clothing and footwear, drainage, slippery floors, obstacles; emergency procedures
	tool usage	power tools, hand tools, welding, protective clothing and footwear, eye protection
	hazardous materials	gas cylinders, pressure vessels, flammable/explosive substances
	working conditions	toilets and washing facilities, first aid visitors

Two important issues are tractor injuries and noise-related illness. In Australia, tractor accidents are responsible for most of the deaths and serious bodily injuries in rural workplaces. About one person a month is killed as a result of a tractor-related accident, caused mostly by roll-overs or run-overs. These deaths happened when:

- tractors did not have roll-over protection structures (ROPS) fitted
- operators boarded and dismounted moving tractors
- tractors moved off when 'parked' on slopes.

Many tractors used in the banana industry are not fitted with ROPS due to concerns about fruit damage caused by Australian-approved ROPS. American standard ROPS are now acceptable in Australia and would be more suitable for use in banana plantations.

Noise-related illness is a major source of workers compensation claims. Unfortunately, this condition often results from cumulative damage over time, cannot be treated and is usually permanent.

When an accident occurs

There are important legal requirements relating to workplace accidents.

Records of injury, illness and occurrences should be kept for accidents that do not result in hospitalisation (provided the accident has not resulted from a dangerous event). These records are retained by employers as a reference about injury and illness in the workplace.

All workplace incidents must be reported to Workplace Health and Safety within 24 hours. Death resulting from work injury or work caused illness must be reported to Workplace Health and Safety promptly.



A **work injury** to an employer, self-employed person or worker is an injury to a person or recurrence, aggravation, acceleration, exacerbation or deterioration of an injury in a person, in the course of doing work that requires first aid or medical treatment.

A **work caused illness** to a person is a disease contracted by a person or recurrence, aggravation, acceleration, exacerbation or deterioration in a person of an existing disease in the course of doing work to which the work was a contributing factor.

A **serious bodily injury** to a person causes death or impairs a person to the extent that the person is hospitalised.

A **dangerous event** is an event at a workplace involving imminent risk of explosion, fire or serious bodily injury.

A **workplace incident** is an incident resulting in a person suffering serious bodily injury, a work caused illness or a dangerous event.



Mechanisation

Due to high labour costs, the tropical banana industry in Australia is perhaps more mechanised than in any other banana producing country. Other factors, including workplace health and safety and the availability of reliable labour, are also driving increased mechanisation in the industry. This section describes the different ways that you can mechanise your production system.

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Mechanising field operations

Planting

Planting is mechanised with the use of modified cane and tree planting equipment. These require one or two operators on the machine to hand-place bits or plants.



Figure 22. Planting bits with a double row planter

Fertiliser application

A range of standard equipment is available and widely used in the industry for foliar and ground-spreading of fertiliser. Equipment such as belt spreaders spread fertiliser around the stool. Fertigation is another quick and easy way to deliver fertiliser to the plantation.

Chemical application

A wide range of commercial equipment is available which can be used or adapted for foliar and ground-based application of chemicals. Aerial spraying contractors are widely used for fungicide applications.

Bell injection

Bell injection involves walking through the plantation every three to seven days. Four-wheel motorbikes are now used to make the job quicker. They are equipped with chemical tanks (incorporating an electric pump) connected by hose to an injector pole, which can be operated from the bike. The bikes cost about \$10 000 to \$11 000 to buy and set up.

One person working from a bike can cover the same area as two 'walkers'. There is also less chance of the bell injector 'scouts' missing newly emerged bells since their attention is directed at the canopy as they travel the row (rather than looking at where they are walking). Most staff prefer to work from bikes.

Bagging and bunch support

Purpose-built 4WD bagging machines are widely used in the industry where plantation scale permits. A skilled operator using one of these machines can readily bag, spray (or dust) about 600 bunches a day. In addition, the operator can tie string near the top of the plant which is later anchored for bunch support. It would generally take two people using ladders to bag an equivalent number of bunches in a day (without spraying or stringing). These machines eliminate the tire-some work associated with carrying and climbing ladders.



Figure 23. Bagging and spraying bunches from a 4WD bagging machine

Initially, the cost of the machines (about \$40 000) dissuaded many growers from using them. However, it is now generally accepted that a machine can pay for itself in less than two years. Maintenance or running costs need to be considered.

One machine can service up to about 40 ha. Nominating a lower limit of area to justify using a machine is more difficult but plantations bigger than 10 ha may benefit from their use.

Harvesting

At present whole bunches are transported to the packing shed for dehanding. Harvesting is a manual operation, usually with a pair of workers — one to select and cut the bunches and another to carry them to the field trailer. Problems associated with carrying heavy weights in the field are causing the industry concern. Mechanical harvesting is being examined and prototype equipment has been developed. There is a belief in the industry that mechanical harvesting is inevitable, even if it requires a significant change to the production system.

Some growers are training workers to better handle bunches by alternating shoulders for carrying the bunch or requiring workers to use shoulder pads.

Bunch transport

A-frame trailers with two rows of bunches stacked upright either side of an angled central partition are commonly used in the industry. They carry about 40 to 50 bunches. Self-propelled versions are sometimes used. Bunches are loaded straight from the shoulder of the carrier. The level of protection afforded to bunches on these trailers depends on the maintenance of the fixed padding on the floor and central partition and diligence in placement of removable padding between bunches.

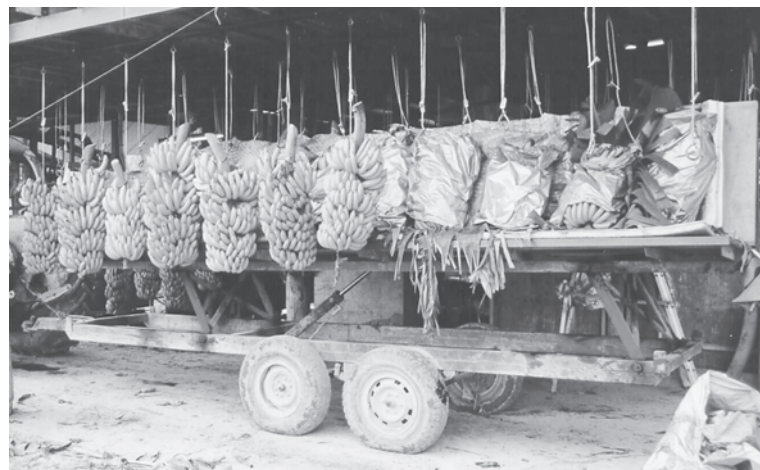


Figure 24. An hydraulic A-frame centre board trailer

Box trailers are also used and can carry up to 100 bunches. However they require an extra person on the trailer to manoeuvre bunches into position. It is also difficult to maintain cleanliness on the trailer deck.

Bunches are transferred from A-frame and box trailers to a gantry or bunchline at the packing shed because they cannot be washed or deheaded when stacked on trailers. This transfer operation only takes several minutes and the trailer can be returned to the field.

An hydraulic, gantry-based trailer has also been used which can handle up to 46 bunches. The bunches are suspended upside down and secured at the bottom. On arrival at the packing shed bunches are deheaded directly from the trailer. This trailer was not widely adopted by industry.

Mechanising packing sheds

General considerations

The packing shed will be a major capital expense and careful consideration should be given to siting, design and layout.

Here are some general issues that should be considered in the overall shed design.

- Capacity. (Over capacity is typical in current packing sheds. The maximum possible throughput is commonly double average throughput. This is necessary to handle peak production periods and suits the pattern of harvest management common to most small to medium farms, which usually harvest two to three days a week.)
- Product flow. (Carefully consider the layout and try to incorporate flexibility in the system to allow multi-tasking of workers during periods of low throughput.)
- The handling and packing system. (Examine alternatives and decide what's most appropriate for you.)
- Access. (Good access is needed for bunch trailers, deliveries and dispatch.)
- Adequate shaded area for incoming fruit.
- Packed product storage and cold store facilities. (At present cold stores are only common in sheds packing more than 20 pallets per day; 22 pallets equals one semitrailer load.)
- Noise. (Try to eliminate or locate sources of noise away from work areas. Water and conveyors are often overlooked noise sources.)
- Floor drainage. (This is usually poor in current sheds; install guards to prevent over spray.)
- Lighting. (Ensure there is adequate lighting as it is often overlooked. Consider natural lighting.)

- Ventilation. (As well as good ventilation, consider eliminating hazardous vapours from work areas.)
- Protection from earth leakage from electricity circuits.
- Staff amenities.
- Storage for:
 - * bunch covers
 - * empty cartons
 - * chemicals and fertilisers
 - * machinery
- Workshop space.
- Office space.
- Shed structure (position of posts).
- Parking.
- Quality assurance protocols.

Centralised packing

The emergence of contract packing services is a recent development in the north Queensland industry and some growers are also considering cooperative packing sheds (typically with near neighbours).

There are also some difficulties and disadvantages with centralised packing. They are:

- overcoming additional fruit damage due to longer transport distances;
- increased time between harvest and packing and consequences for fruit greenlife;
- delays over which you have no control;
- reduced flexibility in terms of when you can pack and being able to get all fruit packed during peak production periods;
- possible loss of control over packed product quality through loss of management input into handling and packing.

In future, increased centralised packing may make it easier for growers to 'get into' and 'jump out of' the industry.

Handling fruit in the packing shed

General

The type of handling system and degree of mechanisation implemented in a packing shed will be determined primarily by shed capacity. In larger sheds, increased mechanisation and job demarcation can lead to higher productivity. Higher capital costs can be amortised with higher throughputs. However, there is sometimes a degree of inflexibility with these systems, which means they may be less

efficient at low shed throughputs. Always consider the minimum number of staff required in the shed.

In smaller sheds, a degree of multi-tasking is often desirable. Unloading, dehanding, sorting, lidding and pallet stacking may be batch operations while packing is more or less continuous.

A measure of packing shed productivity widely used by producers is the number of cartons packed/person/day. This figure includes the harvest crew, people bringing fruit to the shed and all shed staff involved with packing and handling fruit. The industry has set a target of 100 cartons/person/day as the highest level of productivity. Producers often quote the best productivity for their sheds (the result of record or high throughput days) but long term running averages may be significantly less. On a daily basis productivity can be very much affected by the availability of fruit, fruit quality and market requirements. In any shed, productivity is limited by bottlenecks in the system rather than the number of people working.

Bunch unloading and washing

With most of the bunch trailers used in the industry the bunches must be unloaded for washing and dehanding.

In the simplest systems, the trailer bed is level with the dehanding platform so that bunches can be unloaded manually. More typically, bunches are hung on a moveable gantry or continuous bunchline before dehanding. There are many variations of each system.



Figure 25. Hanging bunches on a bunchline using a pneumatic bunch lifter

Gantries are favoured in smaller sheds where either the trailer or gantry can be respectively raised or lowered to attach the bunches. Once attached, the trailer is moved away, bunch covers are removed and bunches washed before dehanding. Unloading, washing and dehanding then becomes a batch process. In some sheds this situation has been avoided by using multiple gantries on a continuous rail, or by integrating the gantry with a continuous bunchline or overhead rails.

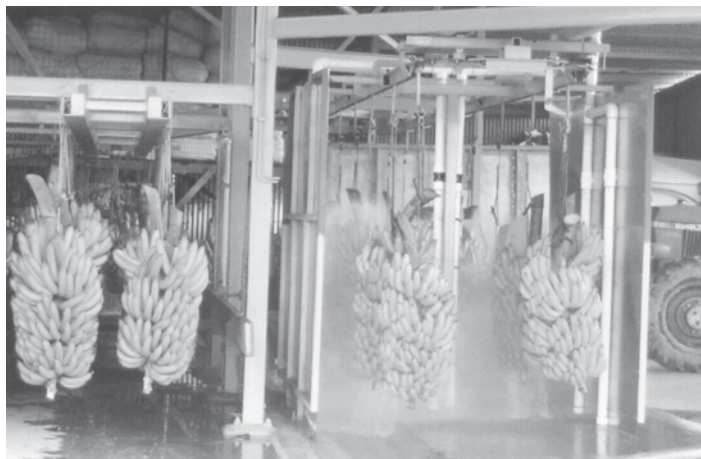


Figure 26. Automated in-line bunch washing system

Bunchlines are common in medium and large sheds (from about 100 000 cartons/year throughput). High throughputs can be achieved, especially where two or more dehanders are employed. Bunches are hung from ropes or chains (at 700 to 900 mm centres) suspended from a moving chain which passes in a loop from unloading to dehanding. Generally these systems are operated continuously and require regular fruit supply and dedicated staff for the bunch unloading, bunch cover removal and dehanding tasks. Pneumatic rams, mounted on rails above the trailer bay, are used to lift bunches to the bunchline. Bunchline hanging capacity generally ranges from 50 to 100 bunches (but up to 150 bunches in some sheds).

Bunch washing can be automated by installing an in-line washing booth. Electronic scales are readily incorporated in the line for automatic recording of yield and productivity data.

Bunchlines can also be set up to operate on a batch basis whereby the configuration of the line above the trailer bay allows an entire trailer to be unloaded to the line while the line is halted. Either the trailer is raised to the line or pneumatic rams are used. This means that the dehandler may also unload the trailer and remove the bag (usually with assistance). This is a more flexible system in terms of staff requirements.

Dehanding

In most sheds hand-held knives are used to dehand bunches. Pneumatically-operated knives are also used and should be considered for varieties which are tougher to cut (for example Lady Finger). Use of straight or curved bladed knives depends on the preference of the dehandler.



Figure 27. Dehanding Lady Finger bananas with a pneumatically operated knife

In the simplest systems, bunches can be dehanded without hanging by resting the bunch upside down against the thighs and with the stalk on the floor. Bunchlines and gantries make the process easier because bunches are at a reasonable working height and can be easily manipulated during dehanding.



Figure 28. Dehanding bunches on bunchlines into a trough

A waste conveyor or bin will be needed for disposal of dehanded stalks and discarded hands. To enhance efficiency it should be close to the dehanding area and require minimal effort. Choppers and shredders are available for processing waste stalks and fruit. They significantly reduce the volume of waste material and simplify handling waste.

A mechanical dehandler has been used previously in the industry whereby the bunch is lowered into a hollow tube within which spring-loaded cutting blades are rotating. This machine has never been widely adopted because of fruit damage and incompatibility with shed handling systems.

Desapping and sorting

A range of systems is used to convey fruit from dehanding to the packing stations. During this phase you may need to consider sorting, desapping, washing, chemical treatments and draining. It is also beneficial to have some storage capacity in this phase to act as a buffer between dehanding and packing. Sap-flow resulting from dehanding and sorting needs to have ceased by the time fruit reaches packing.

Packing wheel systems

Packing wheels are preferred by smaller sheds employing two to several people. The wheels are compact, relatively simple and cheap to install. Fruit is conveyed on shelves on the perimeter of the wheel, with dehanding and packing typically on opposing sides. With most wheels, the dehandler/s and/or packers sort the fruit. Double shelf wheels are used to separate different sized fruit. Washing and chemical application stations, with sufficient allowance for draining and drying, can be installed between dehanding and packing areas.

The smallest wheels are about 4.5 m in diameter and can accommodate one to two packers, with larger wheels (about 8.0 m diameter) allowing up to six packers. Packers can manually rotate wheels and this usually happens where no fruit is allowed to pass the last packer. This means fruit is not on the wheel for more than one revolution. Where wheels are power driven, fruit is usually permitted to pass the packers for multiple revolutions on the wheel.

Trough-wheel systems

Water troughs are also used in conjunction with packing wheels. This arrangement usually permits higher throughputs since such systems allow a greater division of work tasks. The trough is positioned adjacent to dehanding so the dehandler can toss fruit directly into the trough. Water depth is typically 500 to 700 mm. Circulating water in the trough pushes fruit away from dehanding to the end, adjacent to the packing wheel. Here, sorters can sort, grade and transfer fruit to the packing wheel.

Trough-wheel systems have several advantages:

- greater throughput by increased job specialisation;
- more effective cooling of fruit;
- additional buffer storage between dehanding and packing; (Delays at dehanding are less likely to be manifested at sorting and packing.)
- can be more compact than full belt or trough systems.

Belt conveyor systems

Belt conveyor systems have been adopted by industry as a way of increasing throughput (and productivity) in larger sheds. Bananas are dehanding directly onto a moving belt at benchtop height. Standard

belt width is 1.2 m and this generally limits the number of dehanders to two per belt. In large sheds this is overcome by running multiple belts in parallel or radiating from the dehanding area. In these situations, individual belts are typically loaded with one class of fruit (extra large or large).

Sorting is usually carried out adjacent to dehanding by two or more people stationed on each side of the belt. Water sprays wash fruit as it passes along the belt. Packing stations can be positioned at the end or sides, with up to seven stations per belt (more typically three to four). The exact arrangement and packing protocols will depend on your personal preference and experience.

A disadvantage with belt systems is that any delays at dehanding or packing are manifested along the entire belt since there is no buffering between operations. If no fruit is available for dehanding, the resultant gap on the belt will also pass to the sorters and packers. If the packers are overloaded and the belt is stopped, then it is also stopped at sorting and dehanding, which in-turn may delay bunch unloading. To operate efficiently, the capacity of dehanding, sorting and packing needs to be well matched and this is not always easy to achieve.

To alleviate this problem, belts are commonly installed in troughs, which allow significant storage of fruit and act as a buffer between dehanding and packing. The belt, running on the floor of the trough, ramps from the outlet end and conveys fruit from the trough to packing (with sufficient time for drainage). Sap build-up in trough-belt systems can be significant and weekly clean-downs may be required, depending on usage.

Sorting in troughs with the fruit partially immersed in water offers some advantages. The buoyant fruit is easier to handle and less prone to damage, particularly when manipulating fruit on the surface of belts. Fruit may be more difficult to inspect, however, and a good compromise is to sort fruit where the belt leaves the water. This also allows fruit to be positioned on the belt in an orientation suitable for the packers.

Packing

Packing is a manual and somewhat specialised operation. Although packer productivity will depend largely on the skill of the packer, it can be enhanced significantly by considering the ergonomics of the packing station. In even the smallest sheds, packing is usually a continuous operation.

The packing station should be as close as comfortable to the belt or wheel for easy access to fruit. A ready supply of cartons should be within easy reach (usually supplied from adjacent packing stations by a conveyor). Rollers running immediately from the packing platform to a packed product conveyor assist removal of packed cartons. Packing stations need to be furnished with dispensers for carton liners, slip sheets and absorbent paper.



Figure 29. Packing station for a wheel system

In current sheds there is no consistency in the height of the packing platform relative to the belt or wheel. Adjustable platforms to suit the preference of the packer can increase productivity and reduce posture problems.

Most belt systems have a bar at the packing end. When fruit reaches the bar it is deflected and operates a limit switch, which stops the belt until fruit is cleared by the packers. Some growers find that belt systems work most efficiently when a packer controls the belt speed and sets it to run continuously at a rate which matches packing. This means packing and upstream tasks are not delayed by belt stoppages.

Carton handling

The efficiency of carton handling before and after packing can influence shed productivity significantly. Good layout is important and even a mechanised system can be inefficient if the layout is ill conceived.

Most sheds use pre-formed cartons and lids. In larger sheds lid and carton forming machines are common and they can save costs and space, but will require additional labour.

In longer sheds, conveyors supply empty cartons to the packing stations. Packed cartons are conveyed to the lidding and stacking area on the return loop of the same conveyor. Separate conveyors are used in large sheds where a greater division of work tasks is required and multiple trough-belt systems are used.

In small sheds it is common practice to position empty cartons on a pallet close to the packing station. Packed cartons are dispatched along a roller conveyor to the lidding and stacking area.

Pallet stacking

Palletisation of packed cartons has been fully adopted by industry. Stacking against backing boards achieves well-formed stacks, which is important for downstream transport and handling. Stacking becomes awkward as the stack grows and a raised board or stepladder is usually necessary to access the top of the stack. This situation is not ideal as it presents added workplace risks and becomes less efficient.

Hydraulic pallet platforms with built-in backing boards are now common, even in small sheds, and allow the operator to lower or raise the stack to maintain a comfortable working height. Two platforms are usually installed back to back (a stack for each of large and extra large fruit) and one pair is enough for at least 4000 cartons/day. Sets of pallet wells are common in large sheds if more product segregation is required.

Automated pallet stacking technology is available. It should be possible to use it with bananas but such systems have not yet been implemented in large banana packing sheds.

Pallet handling

Pallets loaded with packed fruit or packing material will need to be moved throughout the shed. In smaller sheds manually operated pallet jacks are used. A fork-lift would be highly desirable for sheds packing more than 50 000 cartons/year (about 1000 pallets).

Common shed layouts

Common shed layouts for a gantry and wheel system, and a bunchline and trough system are shown in Figures 30 and 31.

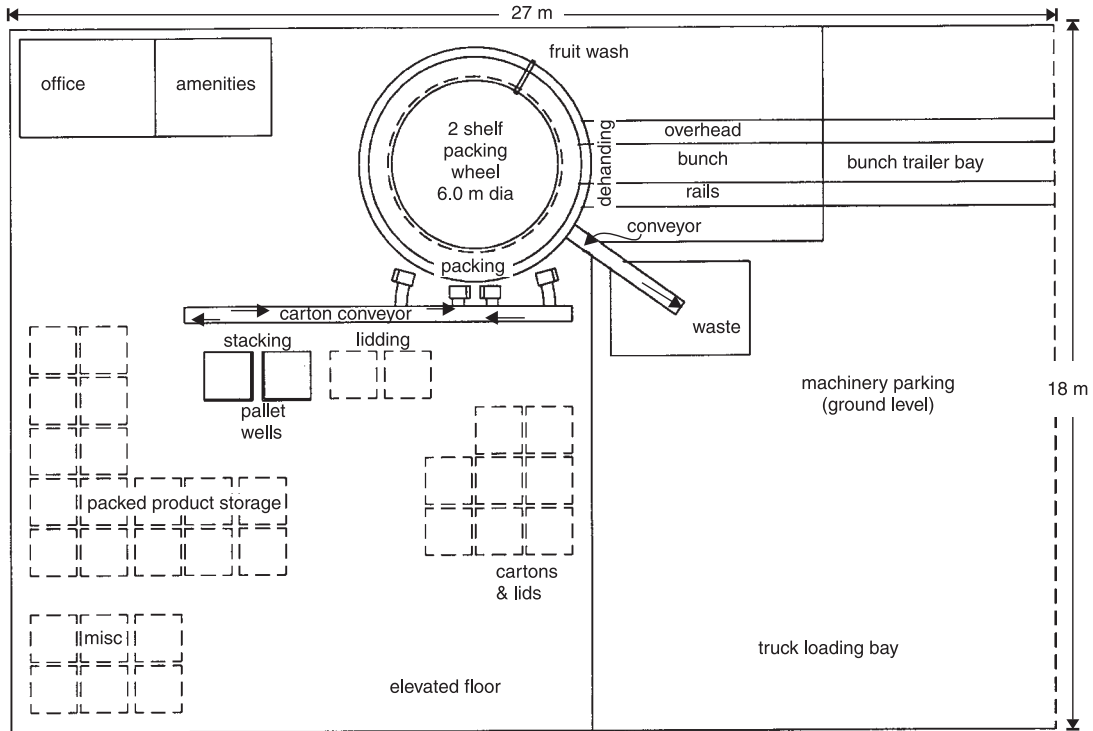


Figure 30. Common packing shed layout using a gantry and wheel system — up to 1250 cartons per day

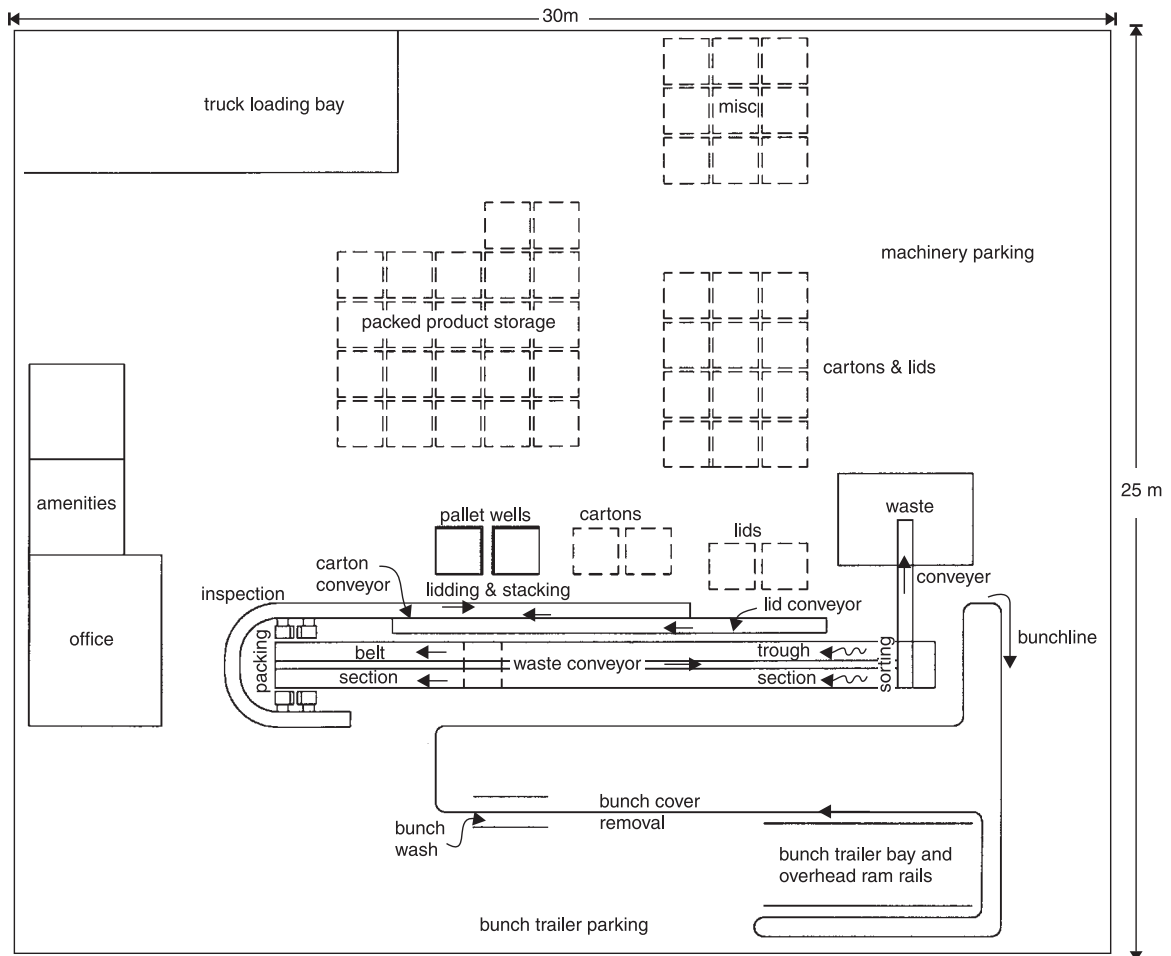


Figure 31. Common packing shed layout using a bunchline and trough system — up to 2500 cartons per day



Quarantine

Australia doesn't import bananas because of the threat from several serious pests and diseases. Some of these have the potential to destroy the Queensland banana industry. It's not only the loss of production and increase in production costs, but also the importation of cheap fruit that will make growing bananas unviable. This section describes the main quarantine pests.

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Threats from other areas of mainland Australia

Banana bunchy top

Cause

The disease banana bunchy top is caused by the banana bunchy top virus.

Current location

Bunchy top has been in Australia since 1913. In 1926 and 1954 the disease was found in north Queensland and eradicated. Currently Queensland's northern quarantine area is free of this disease but it does occur in south-east Queensland and north-east New South Wales.

The virus is transmitted by the banana aphid and also by the movement of infected plant material. All varieties of banana plants are susceptible.

Significance

Banana bunchy top is a notifiable pest under the Plant Protection Act 1989. If the disease is introduced to north Queensland it will result in large scale eradication of plantations in attempts to get rid of it or control it. Bunchy top is likely to be extremely difficult to control in north Queensland because of the large concentration of commercial bananas in a relatively small area and the problem of native banana

plants. In the 1920s and 1930s this disease almost devastated the Australian banana industry. More recently it had a similar effect on banana growing in India.

Banana Panama Race 4

Cause

The disease banana Panama Race 4 is caused by the fungus *Fusarium oxysporum* f.sp. *cubense*.

Current location

Two strains of Panama Race 4 disease have been found in Australia. Race 4 Tropical has been detected on one banana farm in the Northern Territory near Darwin. Race 4 Subtropical is found on many farms in south-east Queensland and on several farms in the Bundaberg area.

Significance

Panama disease is a notifiable pest under the *Plant Protection Act 1989*.

Once infected, the site cannot be cleared of the disease because the spores remain viable in the soil for many years. The disease is spread in infected soil, water and planting material. Unlike other races of Panama, the two strains of Race 4 will affect Cavendish.

Spiralling whitefly

Cause

Spiralling whitefly, *Aleurodicus dispersus*, which is a small, white, moth-like insect.

Current location

Spiralling whitefly is widespread throughout the Tropics. In Australia it is in the northern areas of Cape York Peninsula and Torres Strait Islands. In March 1998 it was also detected in Cairns.

Significance

Spiralling whitefly is a pest of many plants. Its sap-sucking reduces the vigour of plants and the secretion of honeydew, a honey-like sticky substance that is difficult to wash off, supports the growth of sooty mould.

Spiralling whitefly has developed resistance to insecticides in other countries, so long term chemical control may be difficult. Biological control by a small parasitic wasp, *Encarsia* sp., is possible. It has been introduced into Australia but we do not know how successful *Encarsia* will be.



Pictures of black
Sigatoka
Problem solver page 4

Threats from outside the Australian mainland

Banana black Sigatoka

Cause

The disease banana black Sigatoka is caused by the fungus *Mycosphaerella fijiensis*.

Current location

Black Sigatoka has been found at six locations on the Cape York Peninsula but these have been isolated and eradicated at each site. It is known to occur on the northern and eastern islands in the Torres Strait and is endemic in Papua New Guinea.

Significance

Black Sigatoka disease is a notifiable pest under the Plant Protection Act 1989.

Initial infection with the disease appears similar to banana leaf spot, but black Sigatoka is much more infective and more difficult to control. Similar control methods for leaf spot are used in commercial production areas overseas, but because it is more virulent much greater use of chemicals and more deleafing are required. The cost of chemicals and the amount of labour needed for adequate control of this disease would make the north Queensland banana industry much less profitable.

Banana skipper

Cause

The larvae of the banana skipper butterfly, *Erionota thrax*.

Current location

This pest is found in Papua New Guinea and south-east Asian countries.

Significance

Chemical control of banana skipper is difficult because the caterpillar is protected within the rolled leaves. Biological control is possible, but we do not know how successful it would be under Australian conditions.



Pictures of banana
skipper symptoms
Problem solver page 13



Pictures of Moko disease *Problem solver* pages 27 & 31

Moko disease

Cause

Moko disease is caused by the bacterium *Pseudomonas solanacearum* Race 2. Moko causes symptoms somewhat similar to Panama disease. It causes wilting and collapse of the young leaves and yellowing of the older leaves. There is a dark discolouration of the stem when it is cut off. This dark discolouration may extend through the veins into the fruit. Fruit discolouration does not occur with Panama.

Current location

Moko disease appears to have originated in Central and South America where it is widespread. It is also found in India and the Philippines. (Blood disease is closely related to Moko and is currently found in Indonesia.)

Significance

Moko disease is a notifiable pest under the Plant Protection Act 1989.

This soil-borne disease is spread by infected planting material, knives and desuckering tools that come in contact with plant sap, and contaminated soil. Extensive disinfection procedures would be required should Moko become established in Queensland, which would add considerably to the cost of production. As with Panama disease, infected soil remains contaminated for many years. This would limit the land that could be replanted to bananas.

There is no practical cure for plants affected by Moko.