Subtropical banana information kit

Reprint – information current in 2004

REPRINT INFORMATION – PLEASE READ!

For updated information please call 13 25 23 or visit the website www.deedi.qld.gov.au

This publication has been reprinted as a digital book without any changes to the content published in 2004. We advise readers to take particular note of the areas most likely to be out-of-date and so requiring further research: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- Financial information—costs and returns listed in this publication are out of date.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 2004. 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 subtropical banana production. 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.

While every care has been taken in preparing this publication, the State of Queensland accepts no responsibility for decisions or actions taken as a result of any data, information, statement or advice, expressed or implied, contained in this publication.

Queensland Government

Chapter 4

Key ISSUES

This section contains more detailed information on some of the important decision making areas and information needs for subtropical bananas. The information supplements our growing and marketing recipe in Section 3 and should be used in conjunction with it. Where additional information may be useful, we refer you to other parts of the kit. Symbols on the left of the page will help you make these links.

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Legislation

The Queensland banana industry produces around $250 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. Banana growing is a highly regulated industry. Anyone who grows bananas needs to be aware of and comply with a range of legislative requirements.

Things you should know about the regulations

Legislation and codes of practice exist to protect workers, owners, managers and consumers; govern employment of staff; marketing of fruit; and the use of chemicals and dangerous equipment. State department officers have responsibilities under state legislation relating mainly to pest and disease control and chemical use, residues and spray drift.

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

- monitoring and regulating plant movements
- ensuring control is regained over unacceptable levels of banana leaf spot
- monitoring and treating outbreaks of serious diseases
- monitoring weed problems
- eradicating pest bananas.

Copies of the regulation can be obtained from the Internet web site of the Office of the Queensland Parliamentary Counsel at www.legislation.qld.gov.au/LEGISLTN/SLS/2002/02SL022.pdf

Banana regulations operate under the *Plant Protection Regulation (No1) 2002*, which is subordinate legislation under the *Plant Protection Act 1989*.

The main points in the legislation that banana growers need to know are:

'Inspector's Approval to Move and Plant Bananas'. The name of the 'planting permit' has been changed. It is now referred to as an '*Inspector's Approval to Move and Plant Bananas*' and all plantings of bananas in Queensland and NSW must have this approval. Also included are situations where growers want to expand their plantation with their own planting material. Permits are issued free of charge by plant health inspectors and will be granted if the source plants are known to be free of any notifiable pest or disease.

Growers should apply for approval to plant **at least one month** before starting to plant

Growers should apply for this approval at least one month before starting to plant. The movement of planting material is covered by a policy developed by DPI Queensland, the Banana Industry Protection

Board (BIPB), NSW Agriculture and the Banana Industry Council (BIC). Planting material may only be taken from a property that is not infected and is more than 1 km from a known Panama-infected site or banana bunchy top virus-infected site. Contact a plant health inspector for current regulations regarding movement in and out of black Sigatoka quarantine areas and between different quarantine areas.

- **Movement of soil and appliances.** In Queensland, a person must not move soil in which a banana plant has been growing or an appliance that has been in contact with a banana plant without an Inspector's Approval.
- **Notifiable pests.** These are extremely serious pests. An owner of land who discovers or becomes aware that there is a notifiable pest on the owner's land and any consultants or contractors who discover or become aware of the existence of a notifiable pest must contact an inspector within 24 hours. The legislation provides for the eradication of affected plants.

Notifiable pests include: all races of banana Panama disease, banana bacterial wilt, banana blood disease, banana bugtok disease, banana moko disease, banana black Sigatoka, banana bract mosaic virus, and banana bunchy top virus. Pest banana plants, which include any plants of the genera Musa or Ensete other than a plant that produces edible fruit or an indigenous plant that is not a volunteer plant, are also notifiable.

- **Leaf speckle and leaf spot.** In Queensland, these are prescribed pests. This means that growers need to keep these diseases under control or risk the issue of an order to control the disease.
- **Weed control.** In Queensland weeds within 2 m of a banana plant should be less than 60 cm high (30 cm in NSW) to allow easy inspection and clear identification of disease symptoms on banana plants.
- **Residential plantations.** In Queensland, these are allowed with an inspector's approval but only to a maximum of 10 banana plants and must not maintain more than 30 pseudostems. The varieties that can be grown are restricted. In NSW, there are no restrictions on numbers of plants that can be grown in home gardens and the Cavendish types are permitted with the required permit.

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Permitted varieties for residental growing in QLD Chapter 3 page 26

Levies

The Queensland government has removed legislation that allows the compulsory collection of statutory levies. Voluntary levies are currently in place with a possible return to compulsory levies.

Approved planting sources

There is no longer a field inspection system operating for banana planting material. Field planting material supplies are approved when the grower applies for and is issued an Inspector's Approval to Plant. A nursery wishing to grow tissue-cultured plants can seek approval under the QBAN scheme by contacting the QBAN administrator in DPI Queensland. Strict guidelines apply to the pest and disease status and general culture of these planting sources.

You must first contact your local DPI Queensland Plant Health Inspector or an Inspector from NSW Agriculture to obtain the necessary approval if you are considering planting or moving banana plants.

Quarantine areas

In each state, special quarantine districts have been set up to control the movement of planting material and prevent the spread of pests and diseases. A summary of the districts and the main restrictions is shown in Tables 12 and 13.Most of the Queensland industry is located in the Northern Pest Quarantine Area.

Table 12. Quarantine restrictions in Queensland

Quarantine Area	Movement In	Movement within	Movement Out
Southern Buffer–includes the local government areas of Livingstone to Calliope and Eidsvold includes part of the Broadsound Shire south of latitude 22°south	Prohibited	With inspector's approval	Only to Special or Southern with an inspector's approval. Prohibited to Plant Quarantine Area (PQA) north
Special–includes local government ares of Miriam Vale to Cooloola Shire. This quarantine area has Panama Race 1 and 4	From Southern Buffer with inspector's approval	With inspector's approval, providing area free from Panama infested sites	Generally prohibited. Inspector's approval may be issued for movement from Panama free source into Southern PQA north of Brisbane City. Prohibited to PQA north
Southern–includes all local government areas from Noosa Shire to the QLD/NSW border. This quarantine area has Panama Race 1 and 4 and banana bunchy top virus	From Southern buffer and Special with inspector's approval	Prohibited movement from north of Brisbane City to south of Brisbane City. Movement between bunchy top and Panama free areas and infested areas subject to inspector's approval	Prohibited

Table 13. Quarantine restrictions in New South Wales

Quarantine Area	Movement In	Movement Out
Northern area—north of latitude 29° 7' (approximately in line with Grafton) and south to the Queensland border	With permit from all areas south	Prohibited
Southern Area (all areas south of latitude 29° 7'south)	Prohibited	With permit.

Only tissue-cultured plantlets with appropriate certification can be moved between Queensland and New South Wales.

Regulations require growers to maintain plants in good cultural condition and free from pests, diseases and weeds. Abandoned or neglected bananas may be eradicated at the owner's expense. Failure to comply with the direction of a banana inspector is an offence under the legislation and severe penalties apply.

Requirements for produce movement

more info
Planting permits/material supplies Chapter 5 page 182

Some restrictions apply to the movement of banana fruit interstate, and sometimes intrastate (within Queensland). Contact DPI Queensland and NSW Agriculture Plant Health Officers for the current restrictions.

Business management

Growing subtropical bananas should be looked on as a business, not just a lifestyle. Treating a subtropical banana enterprise as a business involves looking at the development of business and marketing plans, recording farm information, financial management, marketing and quality management. In this section, the business and financial management issues are considered.

Business planning

A business plan helps to focus on what the core business is and what the business hopes to achieve. This will show you where the main risks lie and where you will have to focus special effort to keep your business viable. A business plan is generally drawn up for a 5 to 10 year period and is a living document which means it must be reviewed and modified annually to ensure objectives are met.

A business plan is essential as it is characterised by relatively long periods of lean returns interspersed by occasional periods of high returns. The good periods often result from cyclone damage to the large North Queensland industry. The business plan needs to allow for a low return on capital, efficient management of resources during the lean periods, and preferably little dependence on borrowed funds with either off-farm or other farm income.

Some important points to note when developing the business plan are:

- Develop a forward plan for progressive replanting of the plantation. Although a banana plantation may have a long productive life, pest and disease problems that reduce yield and quality generally limit this to five to seven years. There is no commercial sense in continuing to put resources into plants that are economically inefficient.
- Operate your enterprise as a business, not as a hobby. Carefully monitor and record your costs, prices received and actual market receipts. Also carefully manage your labour resources so that you are using them as efficiently as possible.
- Be prepared to use professional advice, and pay for it where necessary. In an increasingly specialised world, expert advice is now an essential part of modern business and is available in a wide range of areas including plantation layout, pest monitoring, spray application, irrigation monitoring and quality management.
- Be prepared to get involved in the activities of your grower organisation. This will enable you to learn about new developments and provide the opportunity for you to become involved in ensuring the future of your industry.

A typical business plan includes the following sections:

1. Mission statement
2. Goals and objectives
3. Situation analysis—SWOT (Strengths, Weaknesses, Opportunities, Threats)
4. Action plan/implementation
5. Budget
6. Control plan

Business planning advice and draft business plan documents may be obtained from most banks and financial institutions and State Government Small Business Departments.

Recording of farm information

Accurate and ordered recording of information on the farm is essential for good business management. Carefully monitor and record your costs, prices received and actual market receipts. Also carefully manage your labour resources so that you are using them as efficiently as possible. Types of information that should be recorded include:

- preharvest factors (pest and disease monitoring records, spray program, labour inputs, leaf and soil analyses, soil moisture monitoring, fertiliser and irrigation schedules);
- postharvest factors (labour, harvesting, packouts, handling and storage logs);
- quality management records and financial details.

This information is ideally recorded on a computer where information can be quickly accessed and compared, or it can be recorded in books, diaries or on forms and accurately filed in a filing cabinet. A large amount of this information is used to develop business and marketing plans, check if planned objectives have been met, compare performance from year to year and establish best farm practice.

Farm recording information has other significant benefits:

- Meet the needs of quality management systems, approved supplier programs and Interstate Certification Assurance (ICA) protocols.
- Record of operations for Workplace Health and Safety audits.
- Record of operations for legal requirements and environmental audits that may be required in the future under Farmcare, Landcare and Catchment Management schemes.

Options for developing farm block recording systems include:

- Available proprietary farm recording software such as Farm 2000 and SprayPal.
- Recording systems captured in quality management manuals.
- Your own recording system. A simple option is to use 12 month wall calendars with a series of adhesive colour coded dots for the various operations. Use one calendar for each block – multiple calendars can be stored one on top of the other using a backing board, cover strip, bolts and wing nuts. The adhesive dots are colour coded to the operations performed. For example, green dots may refer to fertiliser application, with the type of fertiliser and rate being written on the dot. The dots are then stuck on the relevant dates on the calendar. The dots can also be placed on future dates as reminders. Some benefits of this system include:
- Dots recording bunch covers applied can be used to work out bunch harvest figures for the future.
- Dots recording bunch harvest numbers and weights can be related to carton pack outs.
- Monthly totals can easily be recorded on the calendar, making it easier to calculate annual inputs and production.
- Rainfall and other useful data can be easily recorded on the calendar.
- The calendar quickly gives a broad picture of the plantation and year by year, builds into a very useful resource.
- The records can be used as part of quality management records where required.

Consultants may be able to provide assistance in setting up your recording system.

Remember that it is still advisable to use a diary to record specific details such as chemical rates, weather conditions during spraying etc. In NSW under the Pesticides Act growers must record details of all spray operations within 24 hours of carrying out the operation.

Economics

Accurate recording of financial inputs and outputs (including costs such as family labour, loan interest and depreciation) ensures that the true financial situation of the business is known at all times. This is important for decision making. There are many financial recording packages available on the market (mainly for computer use). Quicken is probably the one most widely used by horticultural producers.

As a guide in setting up your own financial recording program, an economic analysis of subtropical bananas is shown below. It provides the following details:

- variable costs for one full cycle of production (includes growing, harvesting and marketing costs);
- a summary of fixed or overhead costs (includes an allowance for family labour, administration and machinery costs);
- annual profit and loss statement for the plantation including a gross margin (the difference between gross income and variable costs), and a net return after fixed or overhead costs are taken into account.

Assumptions

The main assumptions used in this analysis are:

- The hypothetical plantation consists of either 5 ha of Cavendish or 7 ha of Ladyfinger. It is important to note that to provide for areas of new plants coming into production, fallow land and infrastructure, around 8 to 15 hectares, respectively, will need to be developed to consistently achieve these production areas in the long term.
- The plantation is not irrigated.
- Yields are assumed to be industry averages for non-irrigated bananas in subtropical growing conditions at 1540 cartons/ha for Cavendish and 500 cartons/ha for Ladyfinger.
- Price received is $12/carton for Cavendish and $25/carton for Ladyfinger. This is the gross price, including wholesaler fees.
- Capital equipment costs are not included.
- Machinery operation includes fuel and oil costs only.
- No permanent labour is used. Labour intensive activities such as bell injection, bunch covering, propping and tying, deleafing and harvesting and packing are mainly done by the owner. A limited amount of casual labour is employed for plantation operations, harvesting and packing to supplement owners labour.
- Plants and planting costs are not included.

- The plantation is well managed.
- The capital cost investment for machinery, buildings and equipment are not given in this analysis.
- The variable costs for the plant crop are not given in this analysis, these will be lower than those given for the ratoon crop, however yields will be much lower probably only 60 to 70 % of the ratoon crop yield.
- Eradication of the crop at the end of the ratoon cycle will cost around $100 per hectare

Variable costs

Item	Cavendish $/ha	Ladyfinger $/ha
Fertiliser		
Leaf and soil analysis	150	150
N, P,K Fertiliser	1050	400
Lime/dolomite		
Hortilime @ 1t/ha/yr Dolomite @ ¼ t/ha/y	150	150
Herbicide	60	80
Bunch covers (used twice for Cavendish; 3 times for Lady Finger)	400	150
Pest and disease control		
Leaf diseases	350	150
Pest control (weevil, mites, thrips)	400	300
Post harvest dip	20	10
Transport		
To nearest major market @$1.20/carton	1850	600
Industry charges and levies	500	500
Packaging		
Cartons and liners etc.	3400	1250
Agents commission @12.5%	2310	1550
Casual labour (15 days/ha for Cavendish; 7.5 days/ha for Ladyfinger)	1800	900
TOTAL VARIABLE COSTS/HA	**12440**	**6190**
VARIABLE COST/CARTON	**$8.08**	**$12.38**

Fixed or overhead costs

	5 ha Cavendish	7 ha Ladyfingers
Family labour allowance	30 000	30 000
Rates, insurance, administration	4 000	4 000
Depreciation, machinery repairs and maintenance	4 000	4 000
TOTAL OVERHEAD COSTS	**$38 000**	**$38 000**

Annual profit and loss statement

	5 ha Cavendish	7 ha Ladyfingers
Annual return	92 400	87 500
Variable costs	62 200	43 330
GROSS MARGIN	**30 200**	**44 170**
Overhead costs	38 000	38 000
NET RETURN	**-$7 800**	**$6 170**

This data provides a very basic guide to the economics of banana growing and is not intended to represent a definitive financial outcome for banana growing. Yields and prices can vary significantly depending upon management skill. The top 20% of growers achieve much better yields than those used in this analysis (up to 2000 cartons/ha for Cavendish and 1000 cartons/ha for Ladyfinger) and whilst production costs for harvesting, packing and marketing increase proportionately, these yields provide much higher net returns. The critical issue is that it may take several years for a new grower to gain the management skills needed to become one of the top 20% of growers, during which time net returns similar to the ones given in this analysis are likely.

It is essential that anyone thinking of investing in subtropical banana production, should carry out a detailed, economic analysis for the specific situation they are considering and seek professional financial advice.

Marketing

Be driven by consumers, not by tradition or what other people have told you. Investigate existing and potential markets and set yourself up to meet their requirements. Involvement in marketing will probably make the biggest difference to your success as a grower. Understanding what marketing is all about provides you with a base on which to plan how the product will be produced. No matter how good the product, the business will only be successful if there are markets that can be profitably accessed. In this section, the marketing issues are considered.

Marketing plans

All successful businesses need to have some type of marketing plan. Development of a marketing plan will ensure you are considering appropriate market issues.

A typical marketing plan includes the following sections:
- Summary
- Current marketing situation: Domestic, Export, Competitive situation
- Opportunity and issue analysis: SWOT analysis (Strengths, Weaknesses, Opportunities, Threats, Issue generation and prioritisation
- Objectives: Financial, Marketing
- Marketing strategy: Pricing, Product description and lines, Positioning and segments, Distribution strategy, Sales, Advertising and promotion strategy, Research and development;
- Action program and control;
- Budget.

Understanding marketing

Marketing is not selling or waving your product goodbye at the farm gate in the belief that someone else will look after your best interests.

Marketing is putting yourself in the consumer's shoes and profitably meeting their needs within the limitations of your resources.

Successful marketing therefore implies knowing who and where your consumers are, what they want, at what level of return you are making a profit and how cost of production is linked to marketing success. Many growers blame problems that they experience on the 'marketing system', but this is virtually admitting that growers are somehow outside the marketing system. Nothing could be further from the truth. Here are some ideas as to how a grower of subtropical bananas can get inside marketing.

Think as if you were a consumer

What does a consumer of bananas look for? Is it price, eating quality, appearance, size, colour, shelf life, or a combination of these factors? If growers cannot make even a reasonable guess at the answer, how can they set targets for production? At what point (price), are market returns the best? How can a grower make these management decisions in the absence of information about what consumers want and how much they are prepared to pay?

Market research has shown that the three main determinants of consumer purchase of bananas are quality, price and family needs. Quality (appearance, freedom from blemish, eating quality) is the most important and it is well known that the availability of high quality fruit in the marketplace can significantly influence consumer purchase and increase consumption.

Important sources of knowledge and information about what the market wants are:

- **Market research studies.** A number of these have been conducted by the banana industry. Results are published in special reports. The Australian Banana Growers Council and Horticulture Australia Limited are sources for this information.
- **Marketers who are in close contact with buyers and consumers.** For the domestic market, agents, banana merchants and banana marketing representatives in the major metropolitan markets are an invaluable source of detailed market knowledge. Market authorities in each of the major markets can direct you to appropriate sources of this information. For the export market, banana exporters are an equivalent source of expert market knowledge. Currently only very small quantities of bananas are exported from Australia.
- **Banana industry development officers or representatives specialising in marketing.** These exist in some regions and have accumulated extensive market knowledge.

more info
Banana wholesalers
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Know the marketing chain for your fruit

Identify all the steps and all the people linking your fruit at the farm gate to particular groups of consumers. One chain might include a transport company, an unloading company, a wholesale merchant, a supermarket buyer, a grocery section manager and consumers from a particular region of a city. Knowing how the chain works is important because you actually choose some of its players, and each of the players in the chain make decisions about your product that collectively influence its marketing performance.

Visit the markets in which your fruit is wholesaled and retailed

There is no substitute for actually seeing how your fruit is performing in the markets. But just looking at the fruit is not enough. Monitor the fruit's physical and financial performance, and also assess the performance of the people who handle these marketing functions. Remember that they are in essence working for you, but they will happily ignore this fact if you are not interested in them.

Actively seek market information

You should not only visit the market but also actively seek information about each consignment of fruit. Ask your agent to send you a report to indicate if the fruit is acceptable. No news is not necessarily good news. Often growers do not get feedback unless they set up a system to receive this information—faxes or email are ideal. Out-turn inspections by independent assessors is a useful way to get information about your product. Digital photos can also be very helpful.

more info
Market information
Chapter 5 page 184

Join a marketing group (where available)

Small growers on their own have little impact in the market, and also miss out on sharing information with other growers. If you're considering marketing on your own so that you can closely guard information that you don't want others to have, think again. Chances are that while you're busily guarding this information, the rest of the industry will pass you by because no one will want to share their information with you. Joining a grower group is a very positive step towards overcoming the dual problem of lack of marketing impact and lack of information.

Market development

From a marketing point of view, bananas have a number of very significant characteristics. These include:

- staple fruit, with over 80% of households making weekly purchases;
- very versatile fruit and convenient to handle and eat;
- excellent nutritional value, and high in vitamins particularly vitamins C and B_6;
- good eating quality and flavour, popular with most consumers.

However, maintaining sales means that consumers must experience continued satisfaction with the product (consistent quality) and perceive it to be value for money. They now are better educated and are demanding more convenience in their food purchases. To maintain a competitive advantage, growers need to be actively involved in researching new and improved market opportunities.

Possible ways to increase sales and potential returns

- Support continuing market research proposed by your industry.
- Support promotional activities implemented by your industry, including those aimed at improving fruit handling and shelf life in the wholesale and retail markets.
- Consider any value-adding opportunities such as marketing fruit in clusters and pre-packed bags.
- Follow up on the product as it moves through the supply chain after it leaves the farm gate.
- Consider different sized cartons (smaller cartons for display purposes, take-home family packs and assorted varieties).
- Consider any niche marketing opportunities such as organically grown bananas. Note that niche markets are small and may support a very limited supply of product; for example the 0.5% of banana production sold on the organic market is easily supplied by the 100 to 150 ha currently growing organic fruit. Look for and develop a competitive marketing advantage, provided the product can be carefully differentiated through branding and promotion.
- Consider combining with other growers to develop group cooperative marketing under a common quality management system. The longer lines of consistent quality produced under this system give growers possible access to market segments unavailable to most individual growers.
- Groups should consider using a professional marketing coordinator, particularly for niche or export markets who can maintain close contact with all the markets and direct the product to each market based on an intimate knowledge of how much it can handle before it is oversupplied and prices fall. A coordinator may also undertake market development and promotion on behalf of the group.
- Where possible, work cooperatively with supermarket chains. As supermarkets currently handle over 80% of the retail volume of bananas, they are obvious targets for grower groups interested in taking an active role in market development. Working collaboratively with appropriate representatives of supermarket chains on a state or regional basis, backed by contributions of cash and product for promotion, is one strategy aimed at putting marketing power (and responsibility) in the hands of groups of growers. In return, growers gain a much more informed view of consumer preferences, expand consumption of their product and develop long term relationships with retailers of their product. This is not a strategy aimed at improving *prices*– it is aimed at improving *returns* through continued customer satisfaction and higher sales from repeat purchases. Note that growers or grower groups who wish to supply major

retailers direct, will need to implement on-farm HACCP based quality management systems such as SQF 2000 or Freshcare.

Developing export markets

Although there is currently no significant export of bananas from Australia, there is potential in the future for some niche export markets. Growers must be prepared to adopt an *export marketing mentality* if they are to benefit from the potential rewards of export. This means acceptance of the following principles:

- Strict quality standards apply.
- Growers must work collectively with other growers. Building good relationships is the key to developing markets—go to the market and find out what it wants and how much the consumers are prepared to pay. While individual growers can achieve this, they would probably be unable to supply enough product to build any meaningful relationship with exporters, importers and retailers. Groups of growers can command more product, and therefore can command more attention from marketers. They can also build brand names that identify their product for the benefit of consumers.
- By networking, growers accept the responsibility for the performance of their product all the way to the consumer in another country. Good relationships with people along the marketing chain are built on reliability—a 'win-win' situation is developed. This is a somewhat non-traditional view of export marketing in Australian horticulture. Groups of growers can join networks of existing relationships—accessed through exporters and importers known to be open to active grower involvement. Developing new networks demands more effort, but has the advantage of being untainted by the effects of previous performance by all parties.
- Returns may be no better than domestic market returns at some times of the year; at other times they may be worse.
- Growers need to travel overseas, partially at their own cost. It is not possible to build reliable relationships in export markets without actually visiting them on a regular basis.
- Growers may have to trial new and uncertain technologies with no guarantee they will work.
- Growers need to know exactly whether the export market wants the conventional product or are looking for clean and green, organic or specific varieties.

Quality management

An understanding of the principles of quality management will help producers to decide what type of quality system they need to implement to meet their customer's requirements. Aim for quality, quality, quality. Remember that of the three options for maximising profits—improving price received, increasing yields and minimising costs, improving price is the most powerful. It is difficult to reduce costs any lower as over two-thirds of the costs lie in packaging, freight and other marketing areas. As quality is the main determinant of price, marketing success is largely determined by consistency of fruit quality as well as timing of production.

Supermarkets, market agents and processors are now requesting that their suppliers have quality management accreditation. Australia is also developing national arrangements for safe and hygienic production of food. National legislation and food safety standards have been designed to ensure that safe practices are used at all stages of food supply chain. Food businesses from primary producers to retailers will have to meet the requirements of these new standards. The standards are risk-based, meaning that businesses with higher food safety risks will have to take more precautions when developing their quality management systems than businesses with lower food safety risks.

Once you have a better understanding of marketing and have established what the market wants, the next step is to gear your production and marketing system to deliver a product with those specifications. The only way of ensuring this is to have a quality management system. All business and marketing plans need a control process in order to be monitored, evaluated and modified. Quality management systems are a method of developing a flow chart of the business with a series of checks for critical operations to ensure that they are carried out correctly.

Understanding quality management

Quality has been described as the fitness for purpose of a product. It implies a predictable degree of uniformity and dependability, but quality goes beyond the product to also include services such as packing true to label and delivering on time. Quality management, then, is the way you run your business to satisfy customers. This means that good growers are constantly engaged in quality management, perhaps even without being totally aware of it. In the past, the suitability of the product for its intended market was determined by 'end point inspection'—inspection at the market level. This system has several important flaws:

- It is expensive to reject product at this late point in the chain.

- It is difficult to predict product performance during the rest of the marketing process when its past history is unknown.
- It is often driven more by tradition than by real market needs.

Modern quality management aims to build quality right through the production and marketing process so that there is minimal need for rejections later. This system also provides consumers with documented evidence that the product they buy will meet their needs. Quality management, therefore, may be seen as a marketing tool to achieve repeat sales, as well as a tool to identify areas for improvement, prevent mistakes and reduce wastage. It also helps growers access markets with quarantine and other barriers to normal entry and promotes greater trust and cooperation throughout the marketing chain.

What makes up a quality management system

A quality management system consists of the following parts, which are common to all growing and packing businesses.

Product specifications. These describe the features of the product for sale so that there is no confusion for either customer or staff. Many customers, for example Woolworths, are developing product specifications for their suppliers.

Product identification and traceability. The methods used to trace product from point of origin in the field through the packing shed to the customer. It also enables trace-back from the customer to the product's point of origin. A traceability code could be a packed-on date but many packers prefer a code that only they can interpret. Letters of the alphabet can be printed on the carton, and circled for different days, blocks etc. This gives the grower the ability to trace back from individual cartons to the field. Computer-aided equipment that prints a code on each carton is also available.

Control of production processes. This involves planning the production process and carrying it out correctly.

Monitoring products processes and services. Checks to ensure that products meet specifications and processes and services have been done correctly.

People managers and staff. Motivated and well-trained managers and staff are critical to the success of a business.

Customers and suppliers. Developing relationships with customers for mutual benefit and working with suppliers to ensure raw materials, for example carton or chemical suppliers, are satisfactory.

Documentation. Documents that are used to support a quality management system. They may include manuals, records, checklists, procedures, work instructions, job descriptions and training guides.

Reviewing and improving the system. Developing a process to regularly review operations and plan and implement improvements.

Core principles of quality management. There are five core principles of quality management:
- The customer defines quality, not the grower.
- Decisions are based on facts, not feelings.
- Problems are identified at the earliest possible point, not at the end point.
- QA has to be planned, organised and managed—it does not happen by itself.
- QA is the responsibility of everyone in the business, including the workers—it is not just the responsibility of management.

To implement an effective quality management system, you will need commitment, good planning, staff involvement and well organised documents (including records and product specifications).

The push for quality management

The major supermarkets in Australia are now demanding that all their suppliers have some level of quality management to assure safety and quality of products. This is in response to consumers wanting fruit and vegetables that are consistently attractive, nutritious, tasty and safe to eat. Outbreaks of food poisoning from other food products have made the community very concerned about food safety. We cannot be complacent about food safety because fruit and vegetables have been implicated in a number of overseas food poisoning outbreaks.

What level of quality management do you need?

The quality management practices being requested by customers can be separated into three broad levels:

1. Approved Supplier Program;
2. Hazard Analysis and Critical Control Point (HACCP) plan;
3. HACCP-based quality management standard or code.

The level of quality management you need to implement will depend on your marketing arrangements and the potential risk of your product causing a food safety problem. If your product is supplied to a supermarket either directly or indirectly, Figure 32 shows the minimum level of quality management needed by different businesses in your supply chain.

Some food service businesses, such as fast food outlets and supermarkets, are requesting a HACCP plan or specific quality management practices under an approved supplier program. Exporters will require some level of quality management depending on their customers. There are no demands at this stage from non-supermarket retailers.

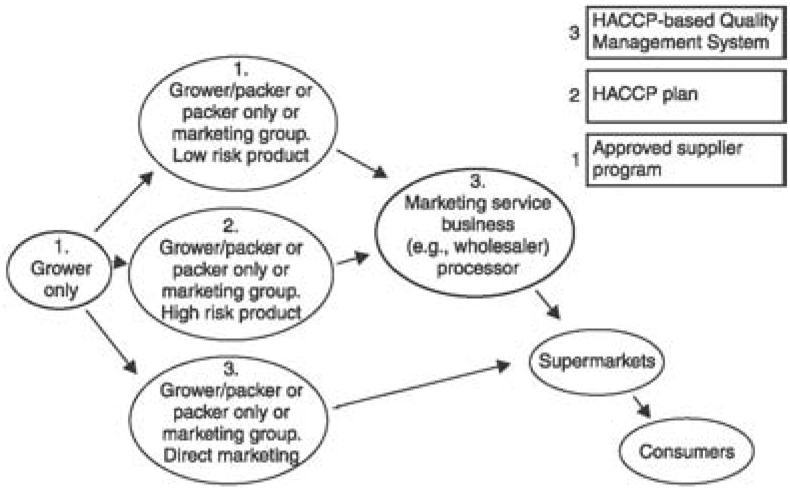


Figure 32. Minimum levels of quality management required for businesses to supply supermarkets

It is likely that in time, other quality issues and price look up stickers (PLUs) will also be required as conditions of approved supplier status. In future it is possible that without at least approved supplier status, growers will only be able to supply the non-supermarket sector of the market, which was only 20% of the total market in 2002.

1. Approved Supplier Program

An Approved Supplier Program involves suppliers carrying out agreed practices that will provide assurance to customers that the product is safe to eat and of acceptable quality. Suppliers will need to keep sufficient records to demonstrate that the practices are a part of everyday operations. The customer or someone on behalf of the customer will periodically check that suppliers are carrying out the agreed practices.

Direct suppliers to supermarkets need to develop approved supplier arrangements with their own grower suppliers. This could include:

- wholesalers or processors who supply direct to a supermarket;
- packers who supply direct to a supermarket;
- marketing groups who supply direct to a supermarket. The marketing operation within the group would need to have a HACCP based quality management standard or code (level 3) and have approved supplier arrangements with their growers.

This publication is available from DPI, 80 Meiers Road, Indooroopilly, QLD 4068
Ph: (07) 3896 9865
Fax: (07) 3896 9446

Copies of the Code of Practice and further information can be obtained from Freshcare, PO Box 3175 South Brisbane QLD 4101
Ph: 1800 630 890
Fax: (07) 3247 7222

Further information about specific practices and documents that may be included in an approved supplier program is contained in the publication *'Developing an approved supplier program for fresh produce—a guide for customers and suppliers'*.

The fruit and vegetable industry have developed an on-farm food safety program, called Freshcare which wholesalers, processors, packers and marketing groups may use as a minimum requirement for their approved supplier program. Certification to Freshcare is achieved through an independent audit on farm for compliance with the Freshcare Code of Practice.

2. HACCP system

HACCP is an internationally recognised method to identify, evaluate and control hazards (things that can go wrong) to food products. HACCP was originally developed to provide assurance that food was safe to eat, but is now also being used to ensure that customer quality requirements are met.

HACCP is being requested of some growers who supply products that are perceived to have a high risk of causing food safety problems or where the next business in the supply chain demands it.

HACCP relies on prevention to control potential problems. Potential hazards are assessed for significance and control measures are established to eliminate, prevent or reduce the hazard to an acceptable level. Typical food safety hazards include excessive chemical residues, microbes causing sickness, and physical contaminants such as glass, sticks and so on that may lodge in the product.

Some independent auditing companies will certify HACCP plans according to guidelines set by the Codex Alimentarius Commission, the highest international body on global food standards which establishes international guidelines and recommendations to enhance food quality and safety and facilitate international trade in food.

3. HACCP-based quality management standard or code

The quality management standards or codes incorporating HACCP that are relevant to the horticulture industry are:
- ISO 9002 plus HACCP
- SQF 2000™
- HACCP 9000
- Supermarket quality management standards.

This level of quality management is required where growers or packhouses directly supply supermarket chains or where the next business in the supply chain demands this requirement. Check with each supermarket to see what standards or codes they will accept.

For SQF 2000™, ISO 9002 and HACCP 9000, an accredited independent company conducts audits to certify that the business meets the quality system standard.

For supermarket quality management standards, the supermarket, or an independent company on their behalf, does the auditing.

ISO 9002

ISO 9002 is an international standard for quality management systems and the system on which most others are based. It was developed originally for manufacturing companies and is now used by many industries. It consists of 20 elements covering all aspects of producing products and servicing customers. Supermarkets are requiring their direct suppliers to include HACCP in their ISO 9002 systems.

SQF 2000™ quality code

This code was developed by Western Australia's AGWEST Trade and Development, specifically for small businesses in the food industry. It is recognised in Australia and in some Asian countries. The code has specific requirements that must be addressed to achieve certification. It includes HACCP, and requires a HACCP plan to be developed, validated and verified by a HACCP practitioner.

HACCP 9000

HACCP 9000 is a quality management standard incorporating both ISO 9002 and HACCP.

Supermarket quality management standards

An example of supermarket quality standards is the new Woolworths quality management system developed for their direct suppliers in Australia. It is aimed at food safety and quality requirements and is a HACCP-based quality management system.

Understanding the banana plant

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

About the plant

The banana plant is a tree-like perennial herb. It consists of a compressed, modified stem technically known as a rhizome and a false stem (pseudostem) with a crown of large leaves (Figure 33). Most growers refer to the rhizome as a corm and this is the term used elsewhere in this book.

The pseudostem

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

The rhizome (corm)

The roots of the plant grow from the rhizome (Figure 34) that is a storage organ for carbohydrates. The main bud or growing point is positioned at the top centre of the rhizome (corm), in the middle of the pseudostem. This bud produces leaves before changing from a vegetative to reproductive state when it produces the inflorescence (which eventually becomes the bunch).

The suckers

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

Figure 33. *A banana plant showing a bunch and a following sucker*

The inflorescence (or bell)

The main bud produces no further leaves after it has initiated the bunch. 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. 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 35). 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 36). Only the female flowers develop into fruit and the hands of male flowers fall off soon after their bracts.

The growth cycle of the plant

Bananas plants tend to clump, with the main stem usually called the mother plant and subsequent suckers called daughter plants or followers. Once the bunch has ripened or is removed by harvest, the mother stem dies and the suckers develop into mature plants which will continue the cycle. The cycle can be described as a series of stages (Figure 37).

Growers 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.

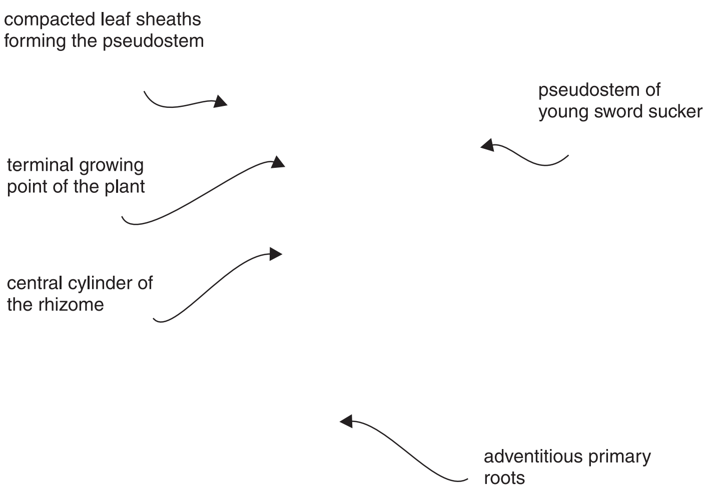


Figure 34. Vertical section through the base of a banana plant

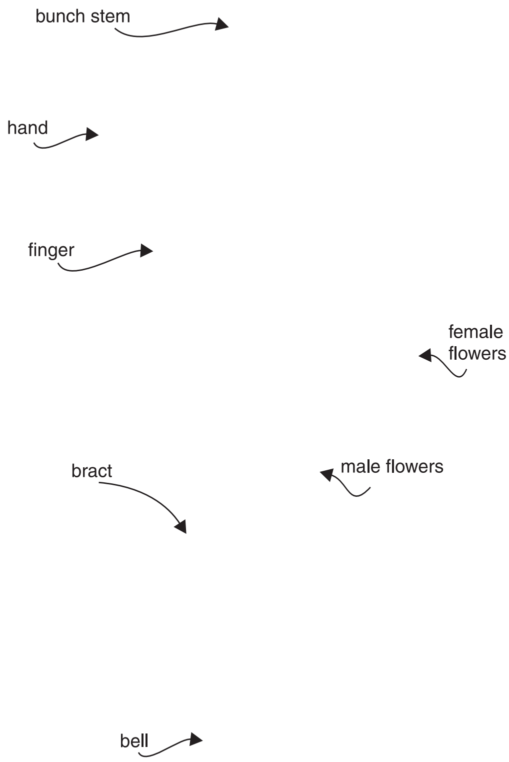


Figure 35. A developing bunch of bananas

Figure 36. *Flower types on the banana bunch*

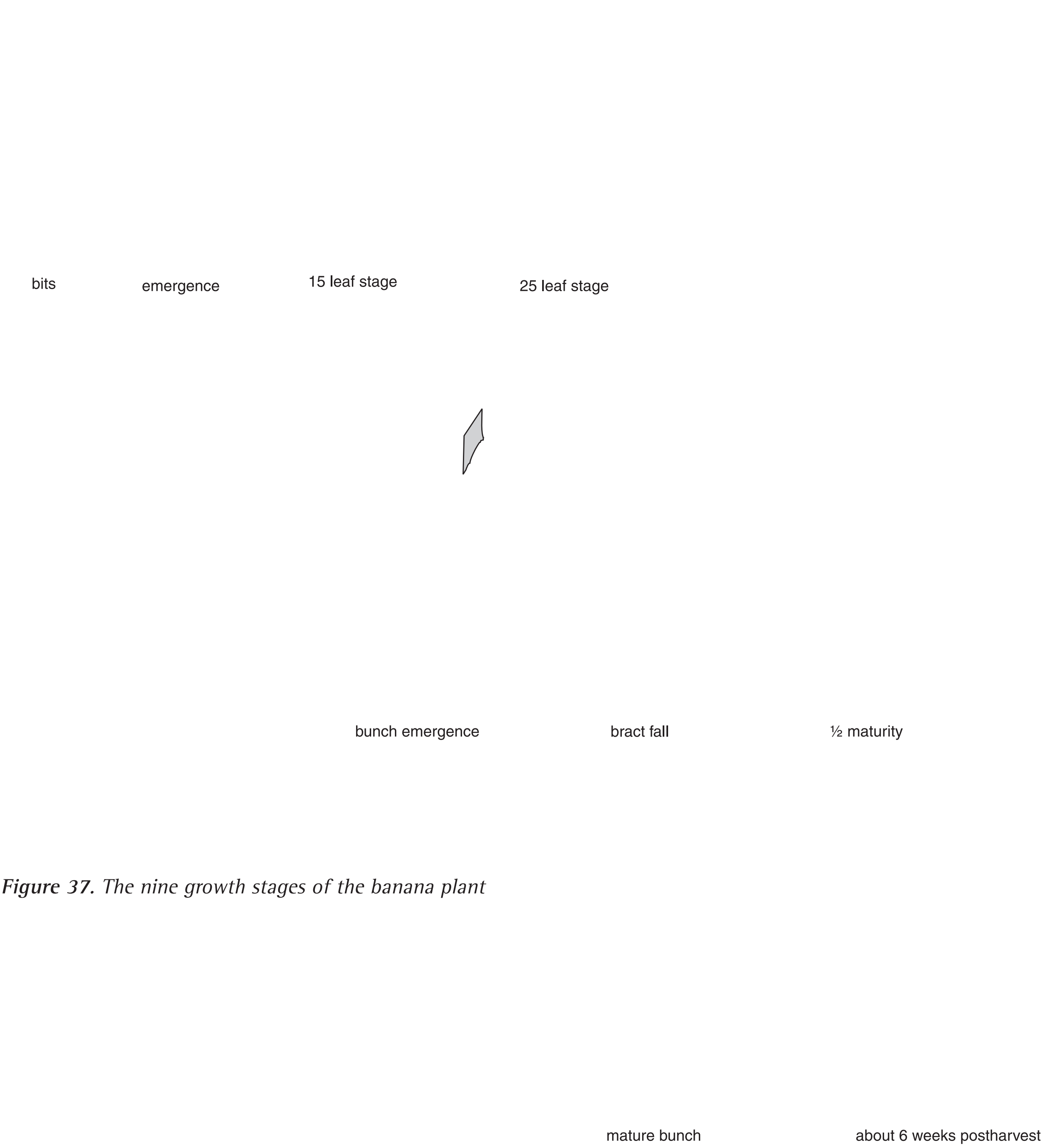


Figure 37. *The nine growth stages of the banana plant*

Varieties

Choosing varieties is an important consideration in banana production in subtropical Australia. This section describes some of the different varieties you can grow, their current production status and specific points important to achieving success in their production and marketing.

Varieties in the Australian industry

The north Queensland industry is based almost entirely on Cavendish-type bananas (96% of the total area) whilst the subtropical industry has moved away from Cavendish in recent years. Currently non-Cavendish varieties account for 59% of the area in southern Queensland and 27% in New South Wales. Table 14 shows the area of banana cultivars grown in each state.

Table 14. June 2001 area statistics (ha) based on data supplied by growers

Variety	NQ	SQ	NSW	WA	NT	Australia
Cavendish	9697	337	2630	250	200	13114
Lady Finger	230	411	930	-	-	1571
Goldfinger	10	66	25	-	-	101
Ducasse	107	4	20	-	-	131
Sucrier	32	-	-	-	-	32
Pacific Plantain	9	-	1	-	-	10
Red Dacca	10	1	3	-	-	14
Bananza	-	3	4	-	-	7
Others	7	1	-	-	-	8
Total Area	**10102**	**823**	**3613**	**250**	**200**	**14998**

The future of the subtropical industry

The north Queensland industry has been expanding at a rate of 10% per year for the last 20 years largely at the expense of southern producers because of greater production efficiency and more level ground. In more recent years, the longer lines of product required by the major supermarkets readily sourced from the north has contributed to the decline of the southern industry. Moves to strengthen subtropical Cavendish in the market place by promoting it as a distinct product based on its size and sweetness, have been initiated. The Ladyfinger industry has remained fairly solid, despite the major ongoing problem of Panama disease.

Niche marketing

Niche market development offers the best opportunity for continuation of a banana industry in the subtropics. Existing production of varieties other than Cavendish and Ladyfinger is very modest and may already meet current market demands. You cannot simply plant 50 ha of Ducasse

and expect to sell it at a profit without a significant marketing and promotional effort. Large increases in production of niche varieties will only result in gluts and reduced prices. A regular supply of small quantities of a few varieties will be essential to foster and sustain the development of these markets. Nevertheless, these niche markets (non-Cavendish/non-Ladyfinger) have grown from an estimated 20 ha in 1994 to 260 ha in 2000 and will continue to grow in view of the trend towards continued product differentiation in the marketplace. The term 'niche' is not just confined to varieties but also method of production (Clean & Green/Organic) and method of marketing (e-commerce/door-to-door). Niche marketing may also offer export opportunities.

The rights to cultivate and market Bananza in Australia are managed by the Australian Nurserymen's Fruit Improvement Company/Breeders Rights International (ANFIC/BRI). Contact: Rod Curly (BRI) (03) 9775 3113

Varieties recommended for niche markets

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

- Ladyfinger and possibly its dwarf variants Santa Catarina Prata and J.D. Finger
- Ducasse and its dwarf variant Dwarf Ducasse (Kluai Namwa Khom)
- Pacific Plantain
- Red Dacca and its dwarf variant Dwarf Red Dacca
- Goldfinger
- Bananza (FHIA 18)

The relative susceptibility of these varieties to important diseases is shown in the table below.

Table 15. Relative susceptibility of banana varieties to diseases

Variety	Yellow Sigatoka	Black Sigatoka	Fusarium wilt Race 1	Fusarium wilt Subtropical Race 4
Williams and other Cavendish	susceptible	susceptible	resistant	susceptible
Ladyfinger	susceptible	susceptible	susceptible	susceptible
Ducasse	resistant	resistant	susceptible	susceptible
Pacific Plantain	moderately susceptible	moderately susceptible	susceptible	susceptible
Goldfinger	moderately resistant	moderately resistant	resistant	resistant
Red Dacca group	moderately susceptible	moderately susceptible	susceptible	susceptible
Bananza	moderately resistant	resistant	resistant	resistant

Whilst the dwarf selections mentioned above are better from a crop management point of view, they sometimes have poorer fruit quality related to choke throat and reduced greenlife which needs to be considered. Other niche varieties that could be trialed on a small scale to determine their adaptability to subtropical conditions and to judge the market include:

- **Sucrier**—low yielding dessert variety less well suited to cool conditions
- **Lakatan**—dessert variety
- **Kluai Khai Bonng**—dessert variety
- **Pisang Ceylan**—dessert variety

- **Sugar**—dessert variety, extremely susceptible to Fusarium wilt Race 1
- **Dwarf French Plantain/Horn Plantain**—cooking varieties
- **Pisang Gajih Merah**—cooking variety (Saba type)

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. Collectively these chromosomes form the genome eg AAA, ABB, AAAB etc., the letters also show the relative contribution to the variety from each the parent species.

Subtropical banana varieties

Williams

(Cavendish)

Genome AAA

High yielding, crop cycle 12 to 15 months

About 87% of Australian production

This and other Cavendish varieties represent most of the world export trade

Dessert variety, 2 to 4 m high

Ladyfinger

(Pome)

Genome AAB

Low yielding, crop cycle 12 to 17 months

11% of Australian production (mostly south Queensland, Atherton Tableland and New South Wales

Popular also in Brazil, India and Hawaii

Dessert variety, 3.5 to 5.5m high

Fruit has long shelf life

Ducasse

(Pisang Awak, Kluai Namwa)

Genome ABB

Low-intermediate yielding, crop cycle 11 to 19 months

About 131 ha grown in Australia

Popular in Thailand and Vietnam

Dessert and cooking variety, 3.5 to 5.5m high (Dwarf form exists—Kluai Namwa Khom)

Goldfinger

(Pome hybrid, FHIA-01, SH-3481)

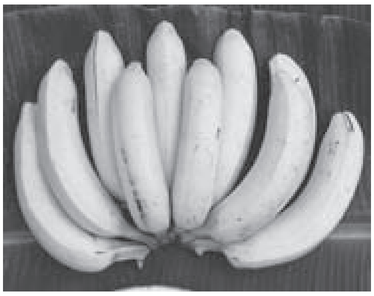
Genome AAAB

Intermediate-high yielding, crop cycle 15-17 months

Approximately 101 ha grown in Australia (mostly south Queensland and New South Wales)

Dessert variety, 2.5 to 4.0m high

Pacific Plantain



(Maia Maoli, Popoulu)

Genome AAB

Intermediate yielding, crop cycle 13 to 15 months

About 10ha grown in Australia

Popular type with the Pacific communities

Cooking variety, 2.5 to 4m high

Dwarf Red Dacca

(Kru, Figue Rose Naine)

Genome AAA

Intermediate yielding, crop cycle 15 to 21 months

About 14 ha in Australia

Tall version is widespread overseas but of minor importance; the dwarf is rare

The red form can revert to a green form naturally or by tissue culture

Dessert variety, 2.5 to 3.5m high (Tall Red Dacca variety grows to 5.5m high)

Bananza

(FHIA-18)

Genome AAAB

Intermediate-high yielding, crop cycle 15-17 months

About 7ha grown in Australia

Dessert variety 2.5 to 4m high

Currently under commercial assessment

Good disease resistance, tolerant to Fusarium Races 1 and 4

Crop scheduling

Crop scheduling is about timing production to increase uniformity of cropping and enhance the uniformity of harvest. You can use crop scheduling to coincide your peak harvest time with periods of low production and thus higher prices, or to avoid producing a crop at a certain time of the year (for example, November dumps). This section will help you understand the techniques you can use to influence your cropping schedule.

Why schedule your crop

Growers may want to schedule production for the following reasons:

- Maximise profits by producing more fruit during expected periods of higher prices—for example the winter months, traditionally a time of higher prices.
- Avoid an expected period of oversupply or when there are production problems, for example November dump fruit.
- Achieve efficiencies in the production cycle. Uniform crops facilitate crop forecasting, help break pest/disease life cycles and improve overall bunch bagging and harvesting efficiencies.

When supplying product to niche markets, a steady supply throughout the year is necessary to foster market development.

How to schedule your crop

Several crop management strategies can be used to schedule the crop. These rely on manipulating the time of planting, using different types of planting material, careful selection of following suckers and the use of nurse suckering practices.

Uniformity is achieved in plant crops when good quality planting material from specially prepared and graded planting material is used. Planting material grown-on from bits, suckers or tissue culture in bags in a nursery prior to planting out in the field gives the best results. Plantations established from tissue culture normally have very uniform fruiting.

Time of planting

Expected times of bunching and harvest from different plantings will vary depending upon plant development rates in different districts and climate conditions prevailing in a particular year. Planting during spring has the advantage of allowing plants to establish quickly under good growing conditions through late spring and summer before cooler weather slows growth. The period between planting to harvest ranges from 12 to 17 months depending upon the time of planting.

Replanting commonly occurs after a five to seven-year ratoon cycle, followed by a 6 to 24 month period of fallow. In subtropical production areas, regular replanting of blocks can be more difficult than in the tropics because sites are generally steep, limiting mechanisation and possibly enhancing erosion. Using purely time of planting to meet the requirements for crop scheduling would be inadequate so we also need to look at the type of planting material and following sucker selection.

Type of planting material

Different types of planting material and different sized planting pieces can influence the time from planting to harvest. Suckers will emerge two to three weeks earlier than most bit material, while tissue cultured plants will vary depending on plantlet size at planting and time of year.

Tissue cultured plants have the advantage of producing the most uniform plant establishment, growth and cropping but they must be well managed after planting to maximise these benefits. Tissue cultured plants are disease-free when purchased, but are more susceptible than other types of planting material to Fusarium wilt infection during the early stages of establishment if fungal spores are already present in the soil.

Selection of following suckers

The time of production of the next ratoon crop can be influenced by the size and age of the following sucker selected. Selecting a later follower instead of an early one could delay the next crop by two to three months, and possibly result in some yield reduction. The selection of late suckers may require the removal of all suckers at various intervals before bunching. Select vigorous suckers that have emerged from buds lower on the parent corm.

Suckers that emerge later will arise from buds higher on the parent corm and, being shallower in the soil, are liable to fall over more easily. Likewise, uniformity in harvest of the next ratoon crop will depend on the uniformity of the followers which are selected.

Nurse suckering

Nurse suckering is a system of sucker management that can be used to schedule fruit production to a particular period of the year. This method can produce an even crop by skipping a ratoon cycle.

How to nurse sucker

The nurse suckering method is shown in Figure 38. 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.

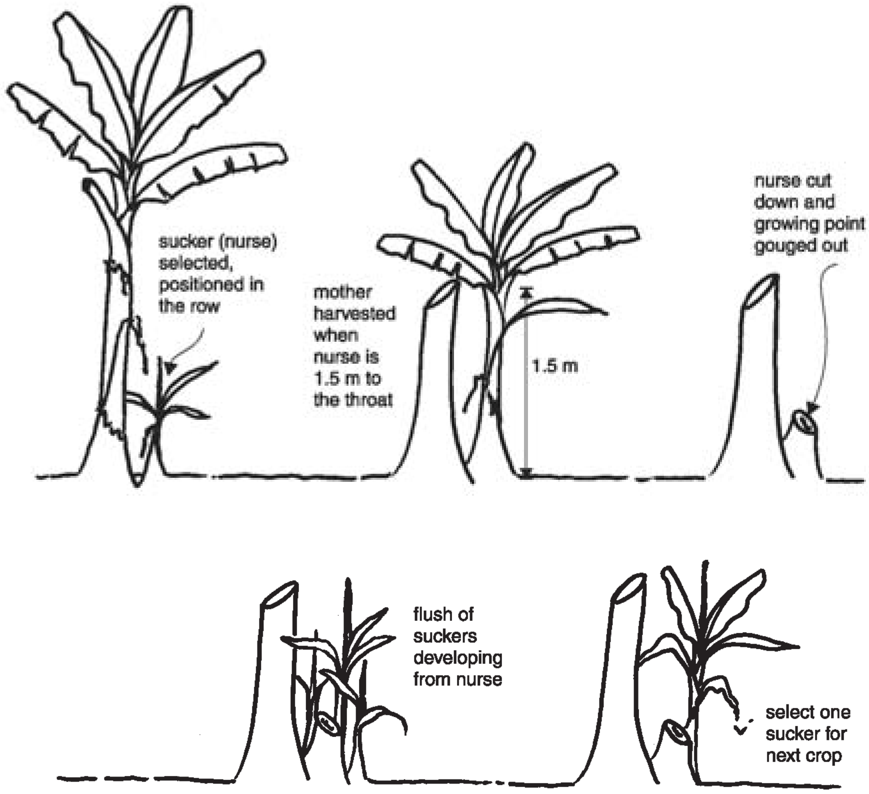


Figure 38. A nurse suckering technique

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.

There are variations on how to deal with the growing point of the nurse sucker. Cutting a wedge on the nurse at knee-height 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

This depends on when production is scheduled, the farm environment and crop management procedures—the next crop harvested will be about 12 to 13 months after cutting down the nurse. Experience helps to determine how much to vary these times to suit the district and crop management practices—for example, low temperatures require cutting the nurse down earlier to achieve harvest at the same time as warmer areas. Higher plant densities and water/nutrient stresses can 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.

Successful use of nurse suckering depends in 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.

Other issues

Crop scheduling is about gaining some control of the timing and quantity of your production— anything you can do to help guarantee production is important. This is especially relevant when trying to minimize the impact of adverse climatic conditions.

For instance, bunch support (tying/propping) can be beneficial in reducing losses due to wind provided wind speeds are not too high. Drought conditions can greatly delay production and reduce yield and fruit quality, thus irrigation can help you control production.

Good pest and disease management is also important in avoiding delayed production, reduced yield and quality. The same is true of plant nutrients—nitrogen deficiency leads to delays in production.

Temperature, during bunch filling is also important. For Cavendish, a bunch emerging in warm spring weather will fill in three to five months, while a bunch emerging at the begining of winter can take up to seven months.

Sucker selection

A very important aspect of banana management 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. Choosing uniform healthy followers and maintaining row alignment can extend the life of the plantation.

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 39) reduce production costs because fewer passes are necessary for bunch covering, dusting and harvest.

Early compared with late suckers. Early (largest) suckers will produce the next crop sooner. The time to harvest varies depending upon the locality and weather conditions, typically it can be from from 12 to 16 months in NSW and only 8 to 10 months in the warmer areas of south Queensland in the Bundaberg area. They will usually produce larger bunches, so that yield in cartons per hectare per year is greater.

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 39. *Uniform plant size in a block planted with tissue-cultured plants*

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 (where slopes are not too steep) 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 40). **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. Water suckers usually develop from the rhizome (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.

narrow leaves
broad leaves
swollen rhizome
under developed rhizome

Figure 40. *A sword sucker (left) and a water sucker*

The following sucker should be one that 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 inter-row 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 making it 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

O• O• miss •O• O•

where O 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.

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 41).

sucker/bit
tissue-culture

Figure 41. 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.

Plant selection and establishment

Getting off to a good start with your plantation makes a big difference. This section deals with the selection of 'clean' planting material and ensuring good establishment in the field.

Making a 'clean' start

Figure 42. Tissue culture plantlet growing in a sterile jar

Serious pests and diseases in bananas like Fusarium wilt (Panama disease), banana bunchy top virus, banana streak virus, nematodes, rust thrips and banana weevil borer are spread in infested planting material. Therefore it is important to ensure that only clean planting material (free from infestation by pests and diseases) is used.

Clean planting material can be obtained by using tissue cultured plantlets from a tissue culture laboratory (Figure 42) that have been grown on in a clean field nursery (Figure 43). Alternatively pest and disease risk can be minimised by purchasing field grown vegetative material (suckers and bits) from known clean sources.

Figure 43. A tissue culture nursery

Sources of clean planting material

Contact QBAN registered banana nurseries, Chapter 5 page 182

Tissue cultured plantlets

Advantages for choosing tissue culture are:

- clean planting material that is guaranteed free of nematodes, banana weevil borer, Fusarium wilt and banana bunchy top virus;
- 5% to 25% higher yield depending on management;
- increased establishment, up to a possible 100% with suitable management and irrigation when grown in clean soil;
- greater crop uniformity.

Tissue cultured planting material needs to be ordered 12 months in advance of planting.

Tissue culture is the only source that can be guaranteed free of pests and diseases. We recommend you use tissue culture when you first establish your plantation, particularly in land not planted to bananas before and if you have chosen to plant Ladyfinger. This variety is susceptible to

Fusarium wilt Races 1 and 4 that are widespread in subtropical areas and generally spread via infected planting material.

Tissue cultured plantlets are more susceptible to pests and diseases that are already present such as Panama disease, burrowing nematodes, banana weevil borer and cucumber mosaic virus. Thus clean planting material should be combined with clean ground. Where clean ground is not available, fallow periods between plantings can help to reduce burrowing nematode and banana weevil borer presence in the soil.

While off-types occurring in tissue cultured plants can produce poorer plants and fruit, less than 3% of Cavendish plants supplied by QBAN will be off-types. Tissue culture material however can cost two to three times the cost of suckers or bits, and the method of planting, early weed control and irrigation can also be more intensive. Under good management these costs are covered by increased yields.

Planting material nurseries

more info
Growth cycle of a banana plant
This chapter page 88

more info
Fallow and rotation
This chapter page 150

Vegetative planting material may be multiplied by planting a field nursery (Figure 44). This enables growers to have control over production and timing of their planting material. The aim of on-farm nurseries is to provide clean planting material at a cheaper cost than tissue cultured plantlets.

Establish nurseries with tissue cultured plantlets on land that has never grown bananas, and does not receive soil and water runoff from banana land. If clean land is not available, choose land that has been fallowed from bananas for a few years with a suitable non-host crop. The nursery site should have no history of nematodes or Panama disease.

Nurseries established from tissue cultured plantlets should not be dug for planting material until after the plants have bunched so that any off-types can be eliminated. These mutant plants do not produce the required characteristics needed for commercial banana production and should not be planted. This is especially important for Ladyfingers because one of the off-types of this variety is a poor bunch.

Figure 44. *A vegetative planting material nursery, cut down and ready for harvest of rhizomes (corms)*

Quality Banana Approved Nursery (QBAN)

QBAN relates to a set standard of pest and disease freedom for tissue culture and nurseries. The standards are set by the banana industry through the Banana Industry Protection Board and are audited by DPI Queensland plant health inspectors.

QBAN—tissue culture

The standard procedure for tissue culture nurseries starts with the selection and certification of the parent material, ensuring it is free of all serious diseases. Parent material is multiplied in laboratories that are accredited by DPI Queensland and NSW Agriculture.

Plantlets produced from the QBAN laboratories are moved to nurseries that grow the plants in pots to a stage where they can be planted in the field. These nurseries have strict requirements and are inspected regularly and produce vigorous, disease-free plants with less than 3% off-types.

QBAN—field

A QBAN inspection/certification system can also apply to field-grown planting material. Field nurseries are required to have a history of no major pests and diseases—samples taken during inspections should confirm this.

Keys to good plant establishment

Planting

Photos of November dumps are found in the companion book, *PICTURE GUIDE: Subtropical banana problem solver*

While planting can legally be done at any time of the year, September to December are recommended (October and November preferred) in the subtropics. Depending upon type of planting material, the area and climate, there is a possibility that spring planted bananas will initiate and flower during the following winter months and as a consequence misshapen fruit (November dumps) or skin dullness due to fruit chilling may be a problem. Local knowledge should be sought regarding the best planting time for your area to avoid this problem.

Whatever time you plant in the subtropics there are risks.

- In warm areas, winter planting is possible but in practice, growth is very slow until spring.
- During summer months, planting during very hot or wet periods can cause bits to rot in the ground, resulting in poor establishment.
- Autumn planting normally gives good emergence and establishment but the small young plants may be damaged by cold winter weather.

Irrigation where available, can be used to maximise plant growth prior to the onset of cooler winter temperatures—bigger plants are able to withstand cool winter temperatures better than small plants.

Figure 45. 100% strikes are readily achieved with tissue cultured plants

Correct soil moisture is critical

To achieve best establishment of suckers and bits, plant into moist soil a few days after receiving about 25 mm of rain. Where irrigation is available and soil conditions are very dry, 25 to 50 mm of irrigation should be applied immediately after planting.

Tissue cultured plants will need to be irrigated regularly (every second day) for the first two weeks until the root system becomes established. If irrigation is not available, they should be watered (a few litres per plant) at planting and then weekly for a few weeks to aid establishment.

Use reliable forms of planting material

Tissue culture gives 100% strikes (Figure 45). On clean ground where no Fusarium wilt is present, 100% strikes are easier to achieve with tissue culture provided that they receive sufficient water during establishment. If tissue cultured plants are potted in 5 L bags, they can be grown-on to become bigger, tougher plants needing less attention once they reach the field, however this is not often practised because of the extra cost involved.

Figure 46. Potted suckers are ideal for replanting misses

Potted suckers also give 100% strikes (Figure 46). Small suckers and bits (300 to 600g) that are established in 5 L plastic bags can give strike rates comparable with tissue culture, particularly if they are taken from clean areas and clean potting mix is used. They cost about $2 to $3 to produce. Potted suckers are also ideal as replants in blocks established from suckers and bits.

Planting material nurseries produce vigorous material. Planting material produced from nurseries established with clean planting material in clean ground should not require paring or hot water treatment—both these operations reduce plant vigour. Because no paring is required and very forward eyes on bits may be used, plants emerge from the soil more quickly. Rots are less likely to occur with less cut surfaces.

Larger planting pieces give better strikes. Shoot emergence is more reliable with larger suckers or bits. However, you need more plants from which to prepare the planting material and the cost per piece increases. Larger pieces usually have more than one eye so the surplus shoots that emerge will have to be thinned out later. Alternatively the extra eyes can be removed from the bit before planting.

Allow cut surfaces to air-dry for one to two days. Cut surfaces on suckers and bits are possible points of infection for organisms causing rots. Once suckers and bits are prepared, they should be left to dry in the shade for one to two days. This allows the cut surface to form a seal, which reduces the likelihood of rots occurring. Do not leave planting material in the sun because too much moisture will be lost and do not store in plastic lined fertiliser bags as the planting material is more likely to rot. Do not store bits close to planted bananas as they may attract banana weevil borer adults.

Other points to note

Take care not to cause internal bruising of the sucker's rhizome (corm) when digging out as bruised material is more likely to rot.

Bit material should preferably have the eye centrally located and should be shaped so that it is not too thin.

Plant suckers and bits about 15 cm deep (from the top of the bit to the soil surface). Firm down soil to ensure good contact around planting material by treading over the position or using rollers attached to mechanical planters. Importantly on sloping land, plant so that the eye of the bit is uphill ensuring the plant emerges on the uphill side of the bit so that the developing plant will be securely anchored in the soil.

Nutrition

Plant nutrition is one of the keys to achieving good plantation performance. Both deficiencies and excesses of plant nutrients can adversely affect fruit yield and quality. Fertiliser use has to be carefully managed to ensure a balanced supply of all nutrients is maintained at the critical times during leaf growth and fruit development. Here are the important things you need to know.

Nutrient requirements of a banana crop

For high yields of quality fruit, bananas require large amounts of nutrients. A Cavendish crop yielding 25 t/ha/year of fresh fruit extracts large amounts of nutrients from the soil (Table 16). These nutrients have to be replaced to maintain soil fertility and to achieve continuous high yields.

Table 16. *Replacement nutrients (kg/ha) in a plantation yielding 25 t/ha*

Nutrient	Amount removed in fresh fruit	Amount in remaining plant parts	Total	Proportion removed in fruit (%)
Nitrogen	95	199	294	32
Phosphorus	15	23	38	39
Potassium	390	660	1050	37
Calcium	50	126	176	28
Magnesium	25	76	101	25
Sulfur	11	50	61	18
Chlorine	38	450	488	8
Sodium	0.8	9	9.8	8
Manganese	0.25	12	12.25	2
Iron	0.45	5	5.45	8
Zinc	0.25	4.2	4.45	6
Boron	0.35	0.57	0.92	38
Copper	0.1	0.17	0.27	37
Aluminium	0.1	2.0	2.3	4
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 47 shows the various nutrient pools typically present in the plant and soil. For nitrogen there may be as much as 7t/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.
- Nitrogen and other nutrients can also become available to the plant through microbial activity and the break-down of minerals in the soil.

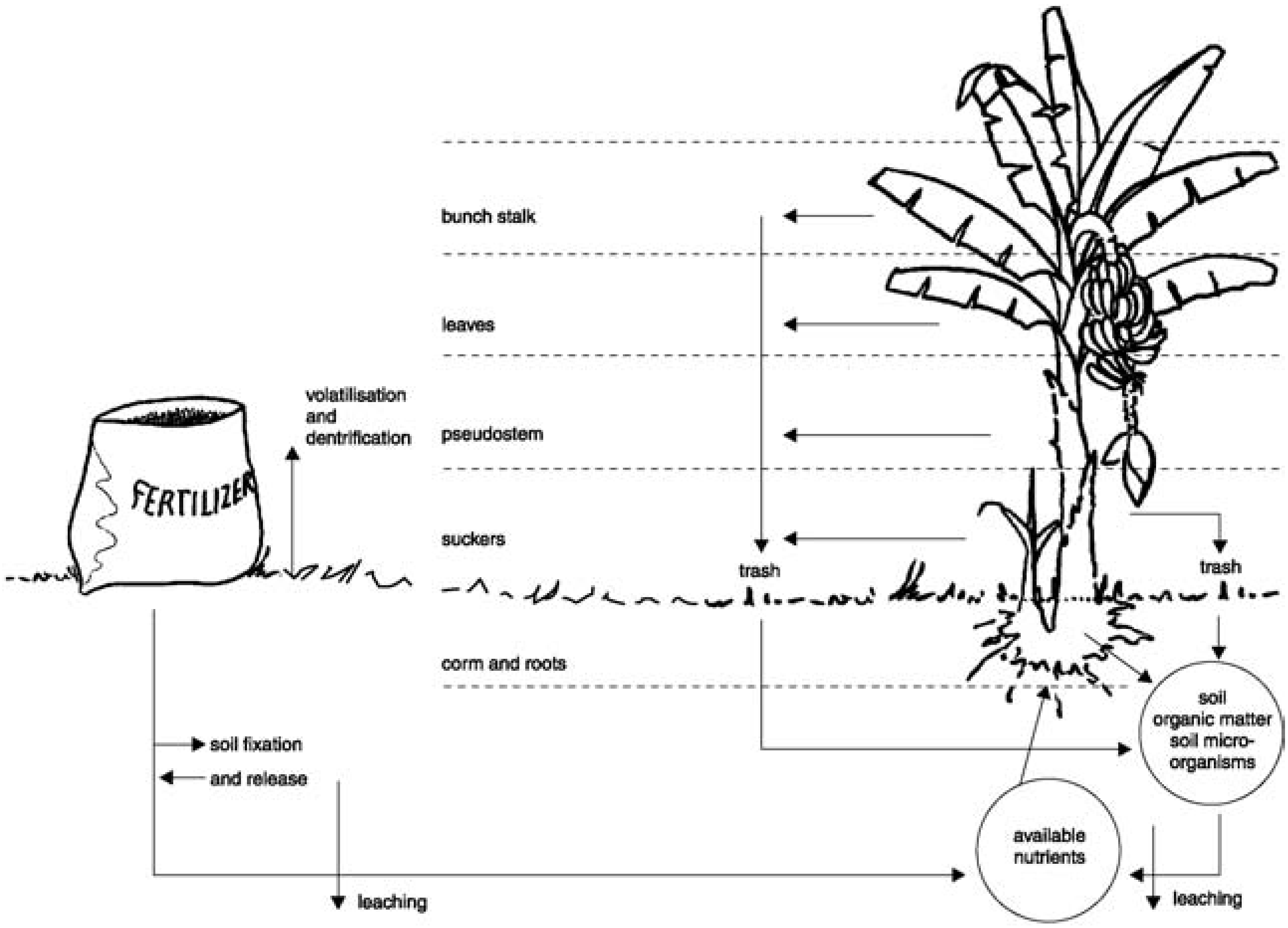


Figure 47. Nutrient flow in a banana plantation

Why nutrition needs to be carefully managed

The unmanaged approach to fertilising bananas involves applying fertiliser throughout the season without knowing whether the soil or the plant needs it. This can lead to excessively low or high levels of some nutrients, resulting in a range of production and fruit quality problems. Blanket fertiliser applications fail to recognise that different varieties, different blocks and different soil types have different fertiliser needs—too much for some and too little for others. This is expensive in terms of either fertiliser being applied where it is not needed or yield loss through inadequate nutrition. Excessive fertilising results in nutrient runoff into watercourses causing environmental damage both within and outside the property.

The managed approach—monitoring nutrients

The modern approach to fertilising relies on regular monitoring of soil and plant nutrient levels so that nutrients are retained at optimum levels for the plant. Three different monitoring analyses are used:

- **Pre-plant soil analysis** ensures the soil is suitable for the crop, and that nutrient levels are at their optimum levels before planting. It is particularly important to allow for the adjustment of less soluble nutrients such as phosphorus and calcium. Fertilisers containing these nutrients are more effective when they are incorporated in the soil, which is easily done before planting.

- **Annual leaf analysis** allows the fertiliser program to be fine-tuned each year to keep all nutrients within the optimum range. It allows variables such as the season and the crop load to be taken into account.
- **Regular, annual soil analysis** ensures that soil pH is kept within the desired range and monitors the important balance between pH, calcium, magnesium and potassium. Soil analysis results can also assist greatly with interpretation of leaf analysis data; soil and leaf analyses should be done simultaneously.

  Soil and leaf analyses taken only once have limited value. Samples should be taken at the same time each year. This allows comparison of yearly samples to be made knowing that any differences are not the result of seasonal changes in environmental conditions and/or growth stages in the plant. The *change* in soil and leaf nutrient levels is as important as the current levels—any change in the amount of fertiliser applied should be reflected in the changed levels of nutrients. Conversely the analyses will also tell you the amount of response in nutrient status from the change in fertiliser amount.

The adjustment technique

To make leaf and soil analyses information useful, you must maintain and record a fertiliser program for several years. Without several years of records, the leaf and soil levels cannot indicate the level of fertiliser to apply. The program should have known rates of fertiliser application and a set system of application times, because the adjustment technique is one of fine-tuning applications based on long term trends. Changing the rate or timing constantly leaves no base line from which to adjust. The leaf and soil analyses tells you if you should increase or decrease the amount of fertiliser that you used for the last year on a given block. Recommendations based on one analysis are a good starting point but are only an educated guess founded on local experience. They are not as good as the adjustment technique based on annual soil and leaf analyses and good records of fertiliser products, rates and timing.

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.

Example of the adjustment technique:

In the past year you applied 200 kg/ha of potassium and your potassium leaf levels were 2.4%. You know you haven't used enough because the desired potassium leaf level is between 3% and 4%. How much more potassium do you need?

Until you have a great deal 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 240 kg/ha potassium.

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 265 kg/ha of potassium in that year. If the potassium level is higher than 4%, drop the application rate by 5%.

Leaf analysis

Sampling can be done in summer, autumn or spring, whichever is most convenient as long as it is done at the same time each year. The suggested leaf nutrient standards for interpreting leaf analysis results (based on the Williams variety) are shown in Table 17.

Table 17. Leaf nutrient standards for Williams bananas

Nutrient	Percent	Nutrient concentration Deficient	Low	Optimum	High
Nitrogen (N)*	"	< 2.6	2.6–3.0	3.0–4.0	> 4.0
Phosphorus (P)	"	< 0.13	0.13–0.19	0.19–0.25	> 0.25
Sulphur (S)	"		0.20–0.27		
Potassium (K)	"	< 2.4	2.4–3.0	3.0–4.0	> 4.0
Calcium (Ca)	"		0.4–0.74	0.74–1.25	>1.25
Magnesium (Mg)	"	< 0.20	0.2–0.3	0.30–0.46	>0.46
Chloride (Cl)	"			0.8–0.9	
Manganese (Mn)	mg/kg or ppm	< 10		1000–2200	4000–6000**
Copper (Cu)	"		3–7	7–20	
Zinc (Zn)	"	< 15	15–20	20–35	> 35
Iron (Fe)	"			70–200	> 300***
Boron (B)	"	< 10	10–20	20–50	> 300***
Molybdenum (Mo)	"			1.5–3.2	
Aluminium (Al)	"			50–240	

(Source: NSW Agriculture AGFACT H6.3.5. *Fertilising bananas—leaf analysis as a guide,* D.Turner, 1985)

* If leaf sampling is done in spring/summer, nitrogen levels in the leaf will be at the high end of the range; if the same plants are sampled in autumn/winter, the nitrogen levels will tend towards the lower end of the range.

** If Mn > 3000 ppm, soil P levels may be high, or pH may be too low.

*** Levels > 300 for iron and boron, may be toxic.

For Ladyfinger bananas, the optimum ranges for the N, P and K leaf nutrient levels are thought to be 20% lower than the standards given here for Williams bananas.

Soil analysis

Rather than using a set fertiliser recipe, you should tailor a program to your soil and the specific needs of the crop. Remember to allow time for the analysis and for the required pre-planting treatments so that nutrients are available to plants. Soil sampling kits are available through several analytical laboratories and fertiliser companies. Sampling directions are provided in the kits. A broad guide to the optimum soil nutrient levels is shown in Table 18.

more info

Plant, soil, water testing labs
Chapter 5 page 183

NOTE: Commercial soil testing laboratories express soil pH results according to the testing procedure used: 1:5 water test or 1:5 $CaCl_2$ test. As the different test results require different interpretation, it is important to always differentiate which test is used.

Throughout this book, soil pH results are generally always expressed using the 1:5 water test, for example, pH 5.5 (1:5 water test).

Table 18. Optimum soil levels for pH, conductivity and macronutrients for subtropical bananas

Element	Optimum soil levels
pH (1:5 water test)	4.6 – 5.5
Phosphorus (Colwell)	Podzolic soils: > 70 – 80 mg/kg Kraznozem soils: > 100mg/kg
Potassium (exchangeable)	> 0.4 to >0.5 meq/100g depending upon yield
Calcium (exchangeable)	4.0 – 10.0 meq/100g
Magnesium (exchangeable)	1.0 – 3.0 meq/100g
Conductivity (1:5 aqueous extract)	< 0.15 dS/m
Calcium:magnesium ratio	3 – 5:1
Cation balance (%)	Calcium 75%; magnesium15%; potassium 6%; others 4%

(Sources: *Fertilising Bananas in NSW* , I. Vimpany, G. Johns and I. Atkinson, NSW Agriculture 1995. *NPK Fertilisation of Bananas in NSW* by I. Vimpany and G. Johns, NSW Agriculture 1991)

Understanding the important nutrients

Soil pH

Soil acidity or alkalinity is measured on a pH scale that runs from 0 to 14, with 7 being neutral; below this the soil is acid and above is alkaline. The pH scale is a logarithmic scale; soil with a pH of 5 is 10 times as acid as a soil with a pH of 6 (Figure 48). In Australia, soil pH is usually either measured in water or in a dilute calcium chloride solution. The value measured with calcium chloride (pH(Ca)) is usually about 0.7 units below the water (pH(w)) value. For example, a calcium chloride pH value of 5.0 corresponds to a water value of about 5.7. If soil is too acidic, a complete soil analysis will show whether lime or dolomite is most suitable. While dolomite con-

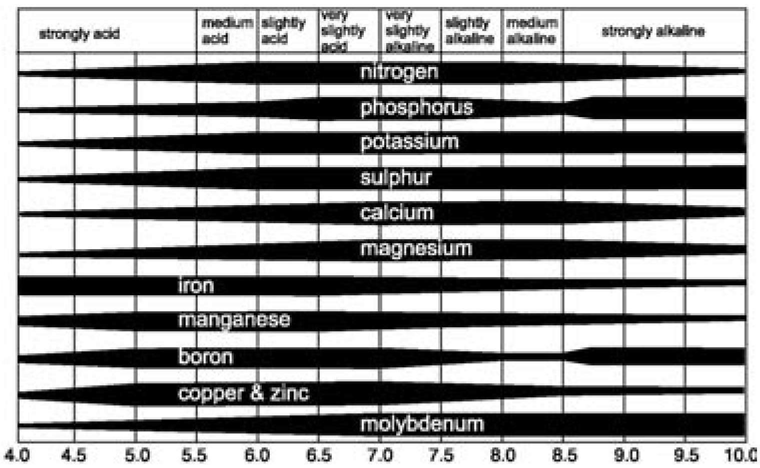


Figure 48. Effect of pH on nutrient availability

tains calcium and magnesium, lime only contains calcium. Lime and dolomite are highly insoluble and should be applied as early as possible—at least six weeks before planting, as well as being properly incorporated into the topsoil.

At low soil pH, aluminium, iron and manganese may be present at toxic levels. This is intensified if the soil is waterlogged or has low organic carbon levels. Nutrients such as molybdenum are only slightly available to plants below a pH of 6.0. On the other hand, soil pH above 6.5 reduces the availability of trace elements such as boron, copper, iron and zinc.

Lime

Soils in the coastal area of south east Queensland and far northern New South Wales are usually acid and require applications of lime to raise the pH. Do not apply lime at the same time as pesticide sprays for burrowing nematode and banana weevil borer—the highly alkaline lime can deactivate the pesticides.

Fertiliser forms and application rates

Most limestones or dolomites contain small amounts of impurities such as silica and clay. Usually they are 95–97% pure, but if material of a much lower purity is used, allow for the extra weight that would be needed for the same result. Very heavy applications of lime can lock up micronutrients such as zinc, iron and boron.

- On **sandy soils**, application should not exceed 2.5 t/ha per application.
- On **clay soils**, do not exceed 5 t/ha in any single application. Rates in excess of this should be applied as split applications, two weeks apart and after the first application has been incorporated in the soil.
- **Soil pH levels** should be tested by soil analysis and corrected annually.

Experiments conducted at the Centre for Tropical Horticulture at Alstonville in NSW indicate that for bananas there may be no economic response in liming above pH(Ca) 4.8 or pH(w)5.5.

Soils respond differently to lime, but for many subtropical banana soils, 1 t/ha of lime will raise the pH of a 30 cm deep layer of soil by about 0.05 units (or about 20 t/ha to raise the pH by 1 unit).

Fine limes are much more effective than coarse limes. In northern NSW a microfine lime is available with 80% of particles finer than 10 microns and 50% finer than 4 microns. Although it is more expensive than coarser products, its use is recommended as it reacts more quickly and can raise the pH deeper in the soil than other lime products.

Table 19 shows the amounts of lime normally required to achieve pH correction. However, these are a guide only and should be fine-tuned by soil analysis.

Table 19. Lime requirements to adjust pH levels

pH range		Soil type		
Water	**$CaCl_2$**	**Sandy soil t/ha**	**Loam t/ha**	**Clay loam t/ha**
4.5 to 5.0	3.5-4	5.0	6.25	7.5
5.0 to5.5	4-4.5	1.5	3.75	5.0
5.5 to 6.0	4.5-5	Not necessary to adjust pH 's in this range		

Different lime and dolomite products may have different neutralising values and application rates vary accordingly. The neutralising value shows how much acidity the product will neutralise compared with pure lime (calcium carbonate) that has a neutralising value of 100. Pure dolomite (a mixture of calcium and magnesium carbonates) has a neutralising value of 109, so 0.92 kg of dolomite has the same neutralising value as 1kg of lime.

Causes of acid soil

Nitrogenous fertilisers containing ammonium acidify the soil when some of the nitrogen in the fertiliser leaches into the soil, and liming is required to balance this effect. The main causes of acidification are:

- The conversion of ammonium ions in fertiliser to nitrate ions (the form of nitrogen used by the plant), by microbes in the soil, is an acidifying process.
- Nitrate leached from the soil is accompanied by the loss of base cations such as calcium, magnesium or potassium. This depletes the surface soil of cations, resulting in an increase in soil acidity.
- Removal of the cations derived from the soil in the harvested crop also removes cation bases from the soil, raising acidity.

Reduce soil acidity

The lime required to offset acidification depends on fertiliser type, and the amount of nitrate (ammonia in the fertiliser is converted to nitrate by microbes in the soil) that is leached past the roots during wet conditions. Table 20 shows how much lime is needed to neutralise the acidification caused by leaching and fertilisers. Note that fertilisers containing nitrate do not acidify the soil; the negative figures in the table indicate what the effect will be equivalent to when adding that amount of lime to the soil.

While it is desirable to avoid strongly acidifying sources of nitrogen, many blended fertilisers that are cost-effective and convenient may use these forms. The possible increased lime requirement should be taken into account when choosing these mixes.

Table 20. Amount of lime required to counteract acidity

Fertiliser	Lime required (kg lime/100 kg fertiliser)	
	Assumed nitrate leaching loss	
	Nil	100%
Sulphate of ammonia	78	149
Urea	0	166
Ammonium nitrate	0	122
DAP	35	103
MAP	46	89
Superphosphate	0	0
Potassium chloride (muriate of potash)	0	0
Potassium nitrate	-47	0
CAN (calcium ammonium nitrate)	-20	77
Rock phosphate	0	0
Potassium sulphate	0	0
Calcium nitrate	-54	0

Nitrogen

Nitrogen is the most important nutrient for plant growth and is also a key component of chlorophyll, the green pigment in leaves, which is why deficient plants are pale green.

Productive bananas need an adequate supply of nitrate in the soil. Nitrogen is very soluble, and easily leached below the root system that in turn acidifies the soil. To minimise leaching, it is best to apply nitrogenous fertilisers in small amounts, frequently (monthly during the growing season).

Fertiliser forms

Urea is the cheapest form of nitrogen appropriate for bananas. However, a problem with urea is that nitrogen will be lost as gas (ammonia) directly to the atmosphere (up to 30% in a week) if not washed into the soil immediately after application. Consequently, in plantations where irrigation is not used, nitrogen is best applied as ammonium nitrate (Nitram) during the dry season.

Rates of application

Nitrogen requirements are determined by fruit removal and losses including leaching, erosion, volatilisation and denitrification. A 25 t crop (1500 cartons and 4 t of unpacked fruit and stems) removes about 60 kg of nitrogen. To allow for leaching and other losses, apply nitrogen at about 120 kg/ha, or 8 kg for every 100 cartons produced. If 10 applications per year are to be made, then for a 25 t crop, apply 12 kg/ha/application. For a population of 1666 plants/ha this translates to about 7 g of nitrogen/plant/application that can be supplied as 16 g of urea (46%N) or 21 g Nitram (34%N). Where more than 1500 cartons/ha/year is expected, heavier applications are appropriate.

Table 21 shows the nitrogenous fertiliser requirements for 1666 plants/ha for different production levels and two alternative fertiliser types, assuming 10 fertigation applications per year.

Table 21. Nitrogenous fertiliser requirements for 1666 plants/ha

Cartons /ha/year	kg N/ha /year	kg N / application	grams N/ application/plant	grams urea /plant	grams nitram /plant
1200	96	9.6	5.8	13	17
1500	120	12.0	7.2	16	21
1800	144	14.4	8.6	19	25
2100	168	16.8	10.1	22	30

These examples are meant as a guide only and applications of nitrogen should be adjusted on the basis of leaf analysis. The normal range for leaf nitrogen is 3% to 4%. A target value of 3.3% should be used and the above recommendations should be increased by 10% for every 0.1% the leaf levels are below target, or decreased by 10% for every 0.1% the levels exceed the target.

Phosphorus

Phosphorus is essential for energy metabolism in plant maintenance and growth. It is particularly important for good root development and growth. Phosphorus is very immobile and can be fixed in the soil so it is only slowly available to plants, therefore it is necessary to add more phosphorus than is removed in fruit. The fixing process varies with soil type, and is most pronounced on krasnozems (red volcanic loams). Phosphorus tends to be fixed in the top few millimetres of soil and is thus easily lost by erosion and, when the soil is dry, it is inaccessible to plant roots.

Fertiliser forms

Although soil tests are an indication of the phosphorus status of the soil, they do not indicate exactly how much of the soil phosphorus is available to the banana plant. Experience with bananas and other horticultural crops in the subtropics have shown very poor relations between soil tests for phosphorus and plant response.

While superphosphate is not the cheapest form of phosphorus, its use for part of the phosphorus addition is recommended as it also supplies sulphur and some calcium. If compound fertilisers containing a high proportion of phosphorus are used regularly, phosphorus levels may become excessive.

Rates of application

A rough guide for phosphorus fertilising is 50 kg/ha/year on podsols, and 90 kg/ha/year on red volcanic loams. At least 300 kg/ha/year of superphosphate (8.8% P) should be used if no other sources of sulfur are applied. The rest of the phosphorus can be in a cheaper form or in a proprietary mix.

When planting, 200g of superphosphate should be mixed into the soil below the plant. This will supply about 30 kg/ha of phosphorus where the roots of the young plants can access it readily.

Once the plantation is established leaf analysis is the best guide. Normal leaf phosphorus values are between 0.19 and 0.25%. A mid-value of 0.22% is the target, and phosphorus additions can be reduced below the values above by 10% for every 0.01 by which leaf phosphorus exceeds the target, or increased by 10% for every 0.01 the test falls below the target.

Potassium

Potassium influences water balance and movement in the plant and synthesises starch and sugars with a direct effect on fruit quality. It increases the vigour and disease resistance of plants.

Healthy banana plants contain large amounts of potassium and it is usually necessary to make heavy applications during the first 3 years of a plantation's life. After that, potassium fertilising should be cut back to balance losses from the system.

Fertiliser forms

Potassium can be supplied either as muriate (potassium chloride) or sulfate of potash (potassium sulphate). The muriate form is the cheapest form of potash and is continuously used, unless leaf sulphur concentrations are low or soil electrical conductivity is too high—about 0.15 deciSiemens per metre (dS/m). Low leaf sulphur values are unlikely where superphosphate is used regularly.

Rates of application

Potassium fertilising in the first three years can only be based on soil tests. After that, both leaf analysis and fruit yield are important guides. A mature plantation will require potassium to replace that removed in fruit. A 25 t/ha crop (1500 cartons packed plus 4 t of culled fruit and stems not returned to the plantation) requires the addition of about 220 kg/ha potassium. This is equivalent to 15 kg of potassium for every 100 cartons. This can be applied as a mixture, or as 30 kg of muriate of potash or 36 kg of sulphate of potash for every 100 cartons packed.

Leaf potassium concentrations should be between 3.0% and 4.0% but aim for 3.5%. Potassium could be applied at the removal replacement rate, but adjusted up by 5% for every 0.1% that leaf concentrations are below 3.5%, or adjusted down 5% for every 0.1% that leaf concentrations are above target.

Calcium

Calcium plays an important role in cell division and cell development in leaves, fruit and root tips. Calcium has a role in fruit ripening and fruit quality. Calcium levels in the leaf are important, and reflect not only the absolute amount of calcium in the soil but also its balance with magnesium and potassium. Low leaf calcium values can result from an excess of these other two elements. Although coarse lime on the soil surface may show up in soil tests, it is largely unavailable to the plant.

Fertiliser forms and application

Calcium applied in lime (calcium carbonate) or dolomite (calcium and magnesium carbonate) will increase soil pH. If calcium levels in the soil are low and pH is within the desired range, gypsum (calcium sulphate) which does not change pH, can be used. Gypsum is more soluble than calcium carbonate.

Magnesium

Magnesium is an essential component of chlorophyll, the green pigment in leaves, which is used by the plant to convert light energy to chemical energy used to produce sugars. It also regulates the uptake of other plant nutrients and is essential for many biochemical cellular functions.

Application

Use soil and leaf analysis. The soil test should have a ratio of exchangeable calcium to exchangeable magnesium of between 3:1 and 5:1. If a magnesium product is added it should only be to bring the Ca:Mg ratio down to 5:1.

Because of its concentrated nature and ease of handling, Granomag (magnesium oxide) may be the most cost effective source of magnesium.

Sulfur

Sulphur is an important component of proteins and chlorophyll. Soil tests for sulfur are not well calibrated for bananas—leaf analysis is the best way of checking. Leaf sulfur concentrations should be between about 0.20 and 0.27 but these values are not absolute.

Application

Superphosphate at the rate of 300 kg/ha/year should make certain that adequate sulfur is available. The use of superphosphate in the planting hole below the bit, ensures the availability of sulfur for the first crop. You may apply phosphorus in mixes containing little or no sulfur; in this case you should closely monitor the leaf analysis.

Trace elements

Trace element such as boron, zinc, iron, manganese and copper are important nutrients involved in cell division and growth, root health, chlorophyll formation, photosynthesis and the production of enzymes and plant hormones. Iron and manganese are most unlikely to be deficient under subtropical conditions unless very heavy applications of lime have been made.

Soil tests for trace elements are generally of little use in managing bananas. Leaf testing is the most reliable way of diagnosing trace element deficiencies.

Element and application

HINT
Take extreme care when applying boron. Do not apply more than the amount indicated by leaf analysis.

Boron deficiency is common in subtropical areas. If leaf boron concentrations fall below 20 mg/kg (or perhaps 25 mg/kg for Ladyfinger), apply 10 g/plant of Borax or alternatively 5 g/plant of Solubor. While Solubor costs more per bag, the price per unit of boron is similar and it is easier to mix and spread. **Apply boron only if soil and leaf analyses results indicate a requirement—boron toxicity can easily be produced by overdosing.**

Zinc becomes less available under high pH or high soil phosphate conditions and can often be deficient. If leaf zinc concentrations fall below 20 mg/kg, apply zinc sulphate monohydrate to the soil at at 30kg/ha or a foliar application of a 0.5% solution of zinc sulphate heptahydrate.

If leaf **copper** concentrations fall below 7 mg/kg apply copper sulphate at 25 kg/ha .

Proprietary mixes

It is not possible to evaluate all aspects of the mixes on the market—they have compositions that may suit one situation better than another. Some mixes are very good value with appropriate compositions for bananas and at a cost which is similar to buying the ingredients separately.

Fertigation

Fertigation (application of fertiliser through the irrigation water) is recommended and has many advantages over application of solid fertilisers. With efficient fertigation, annual rates of nitrogen and potassium can generally be reduced by up to 25%. The advantages are:

- uses less labour;
- nutrients are always readily available to the plant because of regular applications;
- nutrients are readily accessed by the plant since fertiliser in irrigation water is applied exactly where it is needed;
- erosion and leaching losses of fertilisers are almost eliminated;
- urea fertiliser can be used without gaseous losses.

With fertigation, fertiliser is dissolved in water in a drum or tank and sucked or injected through the watering system using a venturi injection pump or a pressure differential system. Fertilisers used must be highly soluble to avoid pump damage and pipe blockages. Mixtures of fertiliser must also be compatible to avoid the development of precipitates that can block sprinklers and also cause root damage. Other major requirements are good filtration and a uniform irrigation system that delivers similar amounts of water to all plants in the plantation.

When fertigating, irrigate enough at the start to thoroughly wet the root zone, then inject the fertiliser. After injection is completed, continue irrigating just long enough to wash any fertiliser residues out of the irrigation system then stop. Irrigating for a long time after injecting the fertiliser will leach nutrients out of the root zone.

You can fertigate every time you irrigate if you wish, but once every fortnight or once a month is sufficient and most practical. Before you start fertigating, get a water testing laboratory to fully analyse your irrigation water. Make sure an iron test is included. Seek professional advice from an experienced irrigation designer when planning the system.

Several suitable commercial soluble fertilisers that supply a range of nutrients are also available. These include Flowfeed and Liquifert. The most suitable fertilisers for fertigation are listed in Table 22.

Table 22. Soluble fertilisers for fertigation

Fertiliser	Main nutrient supplied	% of elements
Urea	Nitrogen	46% N
Ammonium nitrate (Nitram)	Nitrogen	34% N
Calcium nitrate	Calcium, nitrogen	18.8% Ca, 15.5% N
Potassium nitrate	Potassium, nitrogen	38.3% K, 13% N
Potassium chloride	Potassium	50% K, 50% Cl
MAP (mono ammonium phosphate technical grade)	Phosphorus, nitrogen	12% N, 26.6% P
MKP (mono potassium phosphate)	Potassium, phosphorous	28.6% K, 22.8% P

Strategies to reduce nutrient loss

Nutrient losses can be reduced by:

- applying smaller amounts of fertiliser more often;
- using fertigation methods to apply fertiliser;
- using nitrogen fertilisers that do not volatilise;
- improving soil organic matter;
- improving soil drainage.

Irrigation management

Subtropical bananas are grown in areas with moderate rainfall. Much more than half the production area is not irrigated but irrigation is important for maximising both yield and fruit quality. Here are the main things you need to know about managing the irrigation of your bananas.

The importance of irrigation

Average annual rainfall in northern New South Wales and southern Queensland banana growing districts ranges between 1000 to 1800 mm. However, this is not evenly distributed throughout the year—it is often very dry in late winter, spring and early summer and this quickly affects the rate of growth and bunch maturity. Supplementary watering can increase yield, often doubling production. 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

HINT
Use a reputable irrigation design specialist to design your irrigation system and to ensure that it functions properly

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 different systems shown in Table 23.

Table 23. Advantages and disadvantages of different irrigation methods

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

Figure 49. Mini sprinkler irrigation in a banana plantation

The high water-use efficiency of the under-tree mini-sprinkler system or the drip irrigation systems make them the best options for most situations (Figure 49). Be aware that using the drip system can lead to restricted root growth because of the limited volume of soil wetted compared to the mini-sprinklers. Traditionally southern Queensland and NSW plantations used fixed overhead sprinklers but many have now adopted the more water efficient mini-sprinkler or drip (trickle) systems.

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 of nutrients and runoff. A well-designed plantation layout and irrigation system should align separate planting blocks (plants of the same age) and irrigation blocks with soil type. There should be at least one soil moisture monitoring device for each soil type in the area to be irrigated.

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, provided they are well sited and maintained, are a relatively cheap and effective way of monitoring soil moisture. They are probably the most commonly used system. Cheaper tensiometers without vacuum gauges can be used in conjunction with a Soilspec electronic vacuum gauge which can be connected to an electronic logger, giving greater precision. This is particularly economical if you want to use several tensiometers to cover a number of soil types.

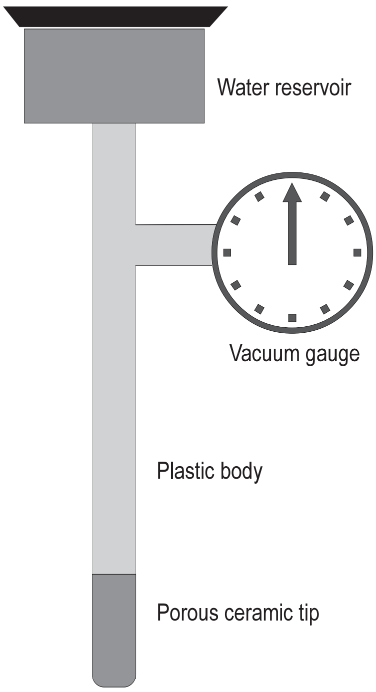


***Figure 50.** Parts of a standard tensiometer*

A conventional tensiometer consists of four basic parts: a hollow tube filled with water and algaecide, a ceramic tip, a water reservoir and a vacuum gauge which reads water tension on a scale of 0 to 100 centibars (cb) or kilopascals (kPa) (Figure 50). In saturated soil, the vacuum gauge displays 0 kPa. As the soil dries over several days, water moves from inside the instrument, through the porous ceramic tip, into the soil. The gauge reading steadily increases to a maximum of about 90 kPa. When the soil is re-wet after rain or irrigation, water moves from the soil back into the tensiometer and gauge readings fall.

Tensiometer monitoring sites

Two tensiometers are required at each site. Different sites are required where there are variations in soil type and crop development.

Place tensiometers in the active root zone of the crop, about 50cm from the base of plants in the row, and where they will receive an average amount of water from the irrigation.

Insert the shallow tensiometer (30 cm long) in the major root zone with its tip 15 to 20 cm deep and the deep tensiometer (60 cm long) with its tip 45 to 50 cm deep (Figure 51).

Installing tensiometers

Assemble tensiometers and fill with good quality water to which algaecide has been added. Adding a dye to the water also makes it easy to observe the water level. Leave them to stand in a bucket of water overnight, but preferably for one to two days. The water does not need to be pre-boiled. Tensiometers are more reliable if a vacuum pump is used to remove any air from the tensiometer body and gauge. Make sure the pump fits snugly over the fill point on top of the tensiometer.

Top up the tensiometers with more water if necessary and use the vacuum pump to remove any air bubbles. They are now ready to install. The two main principles when installing tensiometers are:

- good contact between the soil and ceramic tip;
- no easy pathways for water to flow directly from the soil surface to the tensiometer tip.

Carry tensiometers to the installation site with the tips either in water or wrapped in wet rags. Do not touch the porcelain tips with your fingers as finger grease can block the fine pores. To install tensiometers follow these instructions in conjunction with Figure 52.

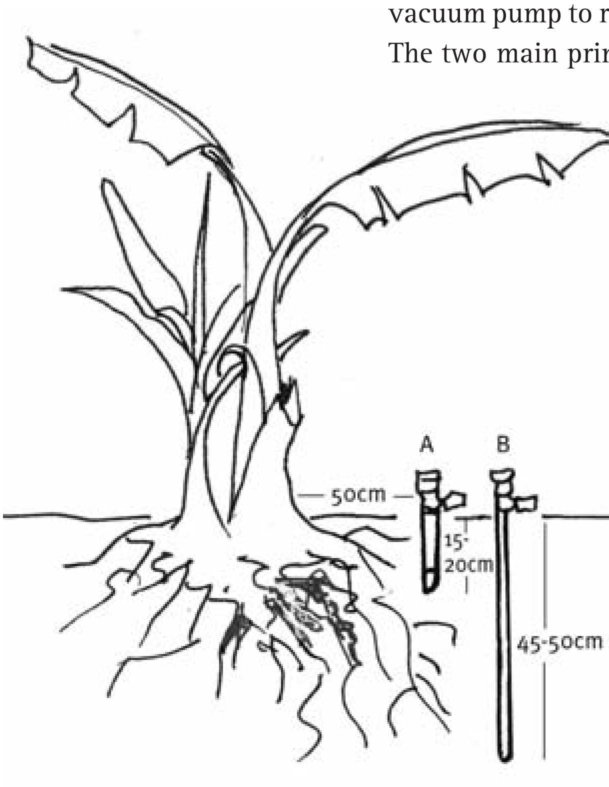


Figure 51. Tensiometers in place, (a) in major root zone and (b) below most roots

Dig a hole to the required depth and keep the excavated soil nearby in a pile—we have found a 50 mm auger the best tool to use. Place the tensiometer in the hole, over to one side. The next step is critical. Good contact between the ceramic tip and the surrounding soil is most important. Take the most crumbly, moist soil from the dirt pile and pack it around the tip at the base of the hole. A piece of 10 to 15 mm diameter dowel is useful for packing. Don't over-compact the soil but remove large air gaps. Continue replacing soil until the hole is filled. It doesn't matter which soil you use after you have packed the first 5 cm above the tip. Friable topsoil from a few metres away can be used to create a slight mound around the tensiometer. This minimises the risk of water draining down beside the tensiometer, leading to false readings.

Figure 52. Installing deep tensiometers

Covers made from silver/blue insulation foil can be placed over the tensiometers to minimise temperature fluctuations and algal growth. The gauge can be left exposed for easy reading.

The tensiometers are now ready to operate. Use the vacuum pump to remove air bubbles. Tensiometers may take a few irrigation cycles to settle down, so don't take too much notice of the readings for the first few days. During this period, air gaps may appear in the tensiometer. Simply refill with algaecide-treated water. Within a week of installation, readings should fall with irrigation or rainfall and rise during a dry spell.

Clearly mark tensiometer locations to avoid damage from tractors and other equipment.

Irrigating using tensiometers

Read the tensiometers each morning preferably at the same time. 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.

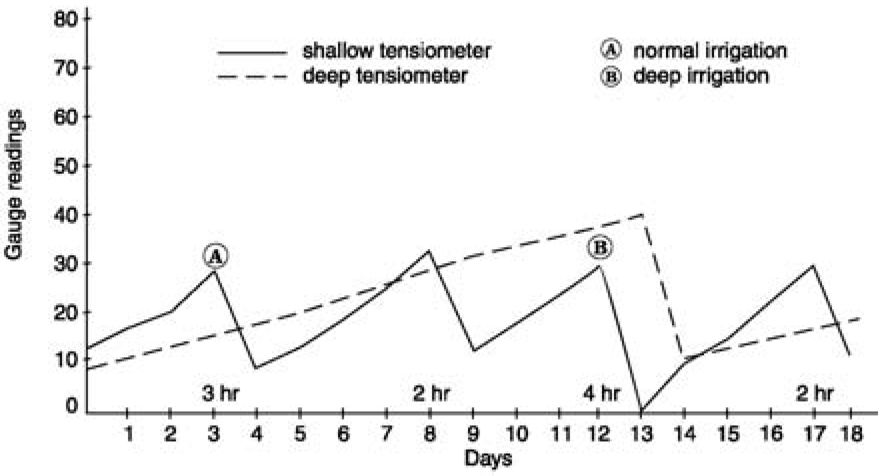


Figure 53. A sample chart showing tensiometer readings on a daily basis

Start watering when the shallow tensiometer reads 20 kPa (sandy soils) and 25 to 30 kPa (loam and clay loam soils). Stop watering when the reading falls to 10 kPa (Figure 53). If readings on the deep tensiometer continue to rise immediately after irrigation, not enough water has been added. If readings on the deep tensiometer fall to less than 10 kPa soon after irrigation, too much water has been added. Once a week, remove any accumulated air and check that gauges are working using the vacuum pump. Refill tensiometers with clean water.

Capacitance probes

Capacitive sensors measure the soil's ability to store electric charge which is proportional to the soil water content. The capacitance probe systems use multiple sensors installed in PVC access tubes to continually monitor soil water. Computer software 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.

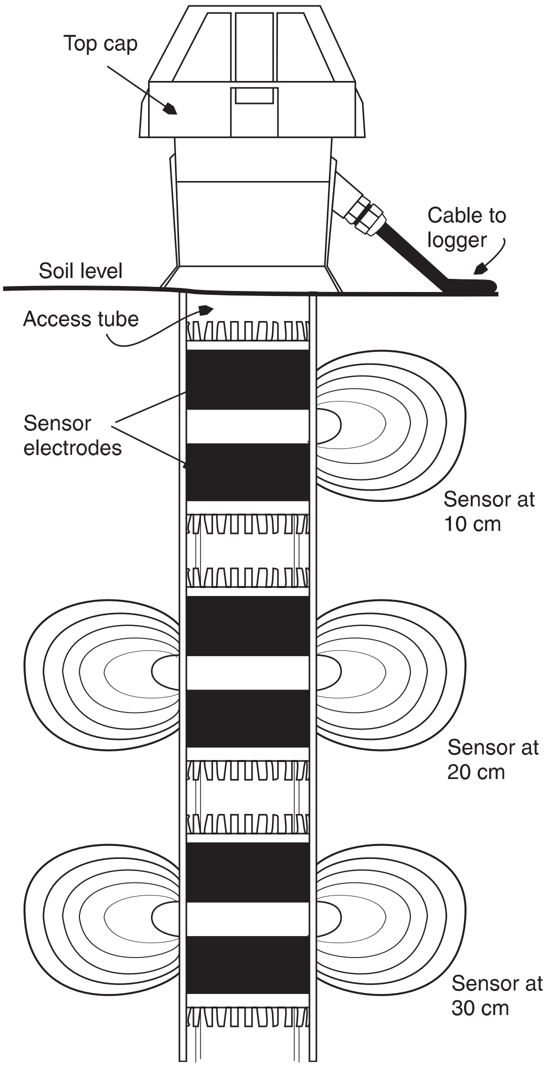


Figure 54. Diagrammatic representation of an Enviroscan probe

Probes are available in two forms, portable and non-portable. The portable version consists of a single sensor on the end of a probe lowered into a 50 mm diameter, vertical PVC access tube installed in the soil. A reading is taken at 100 mm intervals down the access tube and recorded by a hand held logger. Soil moisture readings can be measured on site or downloaded to a computer.

The non-portable version is a continuous moisture monitoring device consisting of multiple sensors mounted on a probe with slots every 100 mm to accommodate the snap-in sensors. The probes are placed within vertical PVC access tubes located semi-permanently in the plantation; they are normally left in place for the whole season. However, a probe can be moved from tube to tube to record readings as several different sites. Sensors are positioned in the probes to provide readings at specific depths. Measurements from the sensors are relayed at set times along a cable to a data logger for recording. Data from the logger are downloaded to show water use and provide recommendations for watering. Figure 54 is a diagrammatic representation of the EnviroSCAN capacitance probe.

The probes need to be correctly positioned in the active root zone and in an area that is being watered evenly by the irrigation emitters. Two access tubes and eight sensors are recommended per site. Irrigation consultants will install them for you and provide training.

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 capacitance probes.

Evaporation pan

The evaporation pan technique uses evaporation figures from a pan evaporimeter to calculate water requirements. Evaporation figures for your district are available from the Bureau of Meteorology, or for growers in northern New South Wales from offices of NSW Agriculture, local produce stores and local newspapers. Alternatively, you can install a pan evaporimeter and take regular readings. Evaporimeters are relatively cheap and simple to use.

The system is invaluable for calculating annual irrigation requirements and estimating peak demands. Annual irrigation requirements are used to assist in estimating storage requirements and peak demands for designing an irrigation system able to deliver enough water to satisfy crop demands.

Insect and mite management

Managing insects and mites is an important and complex aspect of growing bananas. There are several serious pests that can damage the plant and fruit with the potential to reduce fruit quality and yield, so knowledge of how to successfully manage these pests can save you a lot of wasted time, effort and money. Here are the important things you need to know.

- Traditional (past) approach to insect and mite control
- Integrated pest management (IPM)—the modern approach
- Pest monitoring
- The managed spray alternative

The traditional approach

Traditional approach to insect and mite control in many crops relied on the use of routine calendar sprays of registered chemical insecticides. This method of pest control had some problems:

- It was a waste of time, effort and money if the pests were absent.
- Even when pests were present, it disregarded the fact that plants can tolerate small numbers of pests without significantly affecting yield and quality. In this case, the cost of spraying is much greater than the benefit gained by controlling the pest.
- Unnecessary sprays increased the risk of chemical damage to the fruit.
- It was expensive.
- It relied heavily on new chemicals being developed to replace those for which insects developed resistance. This contradicts the modern reality where fewer new chemicals are being discovered and developed.
- It often killed beneficial insects and resulted in outbreaks of minor pests that were naturally well controlled.
- It exposed the farm family and employees to a range of toxic chemicals.
- It increased the amount of chemical residue in the crop and the environment. Chemical residues on fruit are creating growing consumer resistance to the use of chemicals, even where residues are within the permitted Maximum Residue Limit (MRL).

The modern approach—IPM

The modern approach involves less reliance on chemicals by using all or several complementary control measures in an integrated program known as Integrated Pest Management (IPM). These are some key elements of IPM:

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

Pest monitoring

Pest monitoring is the most critical component of IPM and is based on pest action or economic threshold levels. The action level is the point at which the damage is roughly equivalent to the cost of control. Monitoring then continues to allow pest populations to be managed at or below this action level. As well as the pests, the beneficial insects and mites which naturally attack the pests, are also monitored. This is because in many cases, they alone will be sufficient to keep the pest populations in check.

Monitoring also allows you to record pest hot spots for strategic spraying, instead of spraying the whole orchard.

Climatic conditions, insect mobility, duration of life cycle, potential crop damage and crop stage determine the frequency of monitoring. Insects are generally more active at higher temperatures and therefore require more frequent monitoring during spring and summer. The use of a x10 hand lens or small microscope is very useful for monitoring.

Monitoring requires skill in observing and identifying pests and beneficials requiring training and experience. Professional pest monitoring services are available in some areas.

The managed spray alternative

Use this book, *Bananas Insect and Mite Management* to find out more about identification, monitoring and action levels for spraying. Where to buy this book: Chapter 5 DPI Bookshop, page 186

If you are unable to employ the complete IPM system, you can still take advantage of the principal benefit offered—reduced chemical spraying, by using just some of the elements. This system uses the following strategy:

- targeted pesticide applications—bell injection for flower thrips and corm/pseudostem injection for banana weevil borer;
- broadly monitoring pest populations as outlined previously;
- using chemicals alone when action levels are reached;
- giving preference to chemicals that are not harmful to naturally-occurring beneficials;
- carefully applying chemicals with properly calibrated spray.

This strategy is called managed spraying and is the minimalist position we recommend for pest control in bananas.

Pesticide application and safety

There are two important aspects of responsible use of chemicals. The first is efficient application, so that the effect of each spray on the target is maximised, thereby reducing the number of sprays that may be necessary. The second is safety in use and application, so that any impacts of chemicals on operators, farm workers, the community and the environment are minimised.

Basic understanding of spray application

Spray application is a complex issue, but it essentially revolves around two important issues—knowing and understanding the target and getting the chemical to the target in such a way to achieve maximum effect.

Knowing and understanding the target

The first step is to clearly identify what you are targeting and understand what makes it easy or difficult to contact.

For example, mites, thrips and leaf spot diseases are essentially stationary organisms, and require very good coverage of the chemical to produce contact. On the other hand, caterpillars, beetles and fruitspotting bug move about on the plant and have a greater chance of coming into contact with the chemical.

Getting the chemical to the target

Once you have identified and understood the target, the next step is to ensure the pesticide reaches it and makes maximum contact. There are four important points.

Droplet size. Experience has shown that the best coverage and penetration is achieved with droplets ranging from 50 to 120 micrometres in diameter (1000 micrometres [μm] = 1 mm).

Spray volume. The machinery available allows a wide range of spray volumes to be delivered, from 50 L/ha for very low volume machines to over 2000 L/ha for high volume machines. To avoid wastage and run-off, the aim is to apply just enough volume to cover the target and, in some cases, wet it sufficiently to produce the pesticide effect. A good result is about 50 to 70 droplets of spray/square cm on both sides of the leaves and fruit.

Spray conditions. As sprays consist of water-based droplets, evaporation plays an important role in determining their fate. If the atmosphere is very dry and the droplets are small, the water carrier may evaporate before the pesticide has reached the target. Where small droplets are used (as is the case with most air blast and misting machines), sprays are best applied in the early morning, late evening or night, when evaporation rates are lowest.

Air movement. The main aim of pesticide spraying is to displace the air around the leaves and fruit and replace it with air laden with chemical droplets. This requires air movement; the larger the droplets, the larger and more turbulent the airstream required. For example, large droplets (more than about 150 micrometres in diameter) will drop to the ground fairly quickly unless carried in a large airstream. A combination of small droplets and airstream movement is most efficient way of achieving good distribution of the chemical.

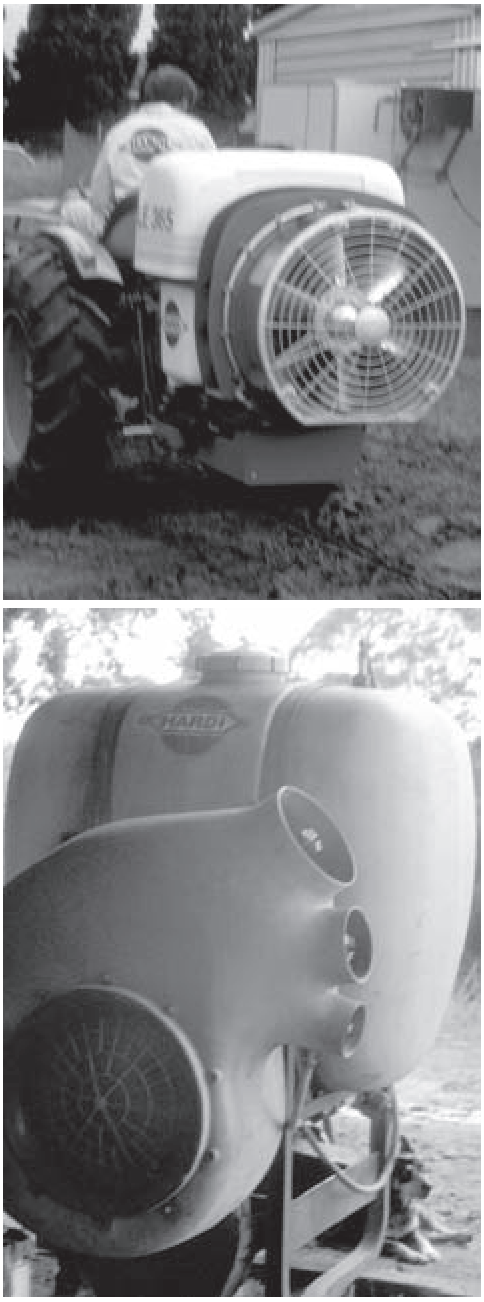


Figure 55. *A typical three-point linkage air blast sprayer (top) another type of air blast sprayer (lower)*

Spray equipment

Steep terrain on many subtropical banana plantations means that growers may be obliged to use helicopters or fixed wing aircraft to spray pesticides. However where it is possible to use wheeled spray equipment, there are two options.

Airblast machines

Air blast machines are designed to transport to the target small droplets produced by hydraulic nozzles in an airstream produced by a large axial flow or centrifugal fan, 800 to 900mm in diameter (Figure 55). These machines are very versatile and can be operated at low spray volumes (500 to 1000 L/ha), and also in high volume mode (2000L/ha).

Misting machines

Droplets are produced by feeding liquid into the path of a low volume, high speed air current (plus 250 km/hour). These sprayers are more suitable for low volume spray applications of 300 L/ha or less (Figure 56).

Figure 56. *Misting machine*

Calibration

To be sure that you are applying the chemical at the correct rate, the sprayer needs to be calibrated. A process for this is as follows:

1. Check that the pressure gauge is working properly.
2. Check spray nozzles and replace worn ones. Measure nozzle output for 30 seconds, replacing any nozzles that vary by more than 10% from the manufacturer's specifications.

3. Fill the tank with clean water, set the pressure and operate the sprayer for a minute or so in a stationary position to get all lines full.
4. Stop the sprayer and refill the tank to the top or to a pre-determined mark.
5. Operate the sprayer in a stationary position for one minute.
6. Measure the amount of water required to top-up the tank again to the top or the pre-determined mark. This is the sprayer output in L/min.
7. Check ground speed. Mark out a distance of 100 m. Select a gear to produce an operating speed of about 2 to 3 km/hr. With the sprayer operating, time the travel over the 100 m. From this, calculate the actual speed in km/hr from the following formula:

$$\frac{\text{distance (m) x 3.6}}{\text{time taken (sec)}}$$

8. Calculate spray volume in L/ha from the following formula:

$$\frac{\text{600* x sprayer output (L/min)}}{\text{row spacing** (m) x speed (km/hr)}}$$

   * 600 is a conversion constant used in the calculation, where sprayer output is measured in litres per minute, speed is measured in kilometres per hour and row spacings are measured in metres. It is therefore essential that these specific units be used in the calculation.

   ** Assumes both sides are being sprayed. For a single-sided sprayer, divide row spacing by 2.
9. Divide spray volume by the number of plants per hectare to calculate the volume applied per plant. If less than the desired amount, travel at a slower ground speed and re-calibrate. If more than the desired amount, increase ground speed and re-calibrate.
10. Regularly check nozzles, pressure gauge and spray volume to ensure desired spray volume continues to be applied.

Pesticide safety

Pesticides and the environment

Always consider the environment when you are applying pesticides. There are four main areas where pesticides can pose a threat to the environment.

Spray drift is generally the result of incorrect sprayer type, set-up or calibration, or spraying during inappropriate weather conditions. Calibrate your sprayer at least annually.

Excessive spray run-off is generally caused by similar factors to spray drift.

Inappropriate disposal of excess pesticide (both concentrate and dilute) and empty pesticide containers. There are documented methods for the safe disposal of these products. These can vary from state to state and some are covered by legislation. All growers should be aware of their local disposal regulations. Do not use empty pesticide containers for any other purpose.

Poor location of your pesticide storage shed, fill up and wash down areas. Pesticide users need to think about what would happen in a spillage. A common example of a potential hazard is where these facilities are located next to a water source. While convenient, the risk of contamination of the water source after a pesticide spillage is very high. If chemicals need be stored close to a water source, ensure precautions are in place to handle an accidental spillage.

How pesticides enter the body

Pesticides can enter the body in three ways:

Absorbed through the skin (dermally). Liquids are particularly hazardous and repeated skin exposure may lead to acute poisoning (short-term and severe), especially when handling the pesticide concentrate (for example, when mixing). Long-term exposure to drift from sprays or recently sprayed plants may also lead to chronic poisoning (continues over a long time). Dermal absorption occurs when inadequate protective clothing is worn.

Inhaled. This is a particular problem with dusts and fumigants. Inhalation may lead to both acute and chronic poisoning. Inhalation poisoning occurs when a suitable, properly maintained respirator is not worn.

Swallowed (ingestion). Children under the age of five are most at risk from swallowing pesticides. The danger results mainly from inadequate storage security or improper disposal of empty containers.

Chemical accreditation

Growers must be able to demonstrate that they are using pesticides safely and responsibly. One way is to obtain accreditation under the ChemCert Training system.

ChemCert is a special farm chemical-user training course available throughout Australia. Participants undergo the training, complete an assessment at the end of the course, and are issued with a statement of accreditation by their state ChemCert organisation (SMARTtrain in NSW). The accreditation is valid for five years.

Besides demonstrating responsible and safe use of chemicals, ChemCert accreditation offers other significant benefits. For example, throughout Australia, the pesticide endosulfan, can only be supplied to or used by an accredited person. In some states, some other pesticides cannot be bought without current accreditation. ChemCert accreditation will also assist in the documentation of a quality assurance program. TAFEs and other organisations offer training in chemical use, application and safety, some of these courses are accredited for ChemCert.

Safety requirements

All pesticides should be considered potentially hazardous. However, if simple safety precautions are taken, these hazards can be minimised or even eliminated. Here are the main precautions:

- **Always read the label before handling.** It provides advice on safe handling, storage and use. Use pesticides only as directed. The chemical's identity and toxicity are also given.
- Obtain and study the Material Safety Data Sheet (MSDS) for each chemical used (chemical suppliers should be able to supply copies). They provide detailed information on health hazard information, precautions for use and safe handling and chemical data. Information on storage and disposal procedures are included. File these in a safe place so they can be quickly referred to in emergencies.
- Follow all safety directions, including the use of safety equipment.
- Keep all chemicals in a secure location. A locked well-ventilated and well-lit room or a separate storage area that has impervious flooring and shelving.
- Store chemicals in original containers with labels intact. Relabel if label comes off.
- Never store chemicals in food or drink containers.
- Store away from foodstuffs, eating and packing facilities.
- Ensure a fresh water supply is available where chemicals are stored.
- Ensure a suitable fire extinguisher is available where chemicals are stored.
- Keep a spill kit, for example a bucket with a bag of lime and/or sawdust, where chemicals are stored or mixed. Chemical spills should not be diluted with water.
- Place a 'Danger Agrochemicals' sign on a chemical store.
- Keep a first aid kit on-farm and make sure it is easily accessible.
- Mix and measure in a well-ventilated area.

- Do not store personal protective clothing and equipment in a chemical store.
- Do not burn containers. Dispose of empty containers immediately in the correct way.
- Know the various ways pesticides can enter the body.
- Correct use, storage and disposal of chemicals will ensure your health and safety of that of others.

Key points

Before spraying:

- check that all equipment is in good working order
- make sure that all equipment is properly calibrated.

When applying pesticides and fungicides:

- spray with some air movement, between 3 and 8 km/h
- select the correct nozzle type
- use only sufficient water volume of an acceptable quality
- only spray under conditions that are NOT likely to cause spray drift
- use appropriate safety equipment.

If you are using a commercial operator, ensure that they are given full details of the job, including area to be sprayed. Make sure that chemicals are mixed and applied according to information on the label. Always take adequate safety precautions when handling and applying chemicals.

HINT
Spray records can provide good evidence of each operation should a dispute arise.

All users of agricultural chemicals should keep records that should include such details as:

- date and time of application
- chemical used and rate
- crop, pest and area sprayed
- weather conditions
- equipment and operating conditions.

There are additional requirements for endosulfan usage. See residue management on label and in particular, withholding period and re-entry period. This product is a restricted product and can only be supplied to or used by an authorised person. Observe mandatory and advisory requirements for use of this chemical.

In NSW under the NSW Pesticides Act 1999 there is an obligation on users of pesticides to keep written records of every application.

Managing thrips

Photos are found in the companion book, *PICTURE GUIDE: Subtropical banana problem solver.*

Thrips are serious and persistent pests of bananas. There are three types of thrips—flower thrips (Thrips hawaiiensis), rust thrips (Chaetanaphothrips signipennis) and silvering thrips (Hercinothrips bicinctus). Each produces different symptoms and has different control strategies.

Recognising different thrips species

Flower thrips

Ladyfinger flowers can be badly affected by flower thrips

Flower thrips affect the bunches causing dark spotting and in serious cases, a grey brown scab, slightly raised and corky, often confined to the cushion end of the fruit and to wing fingers. This symptom known as corky scab, is caused by a reaction to the feeding and egglaying activity of the thrips, particularly when plants are stressed.

Lesser thrips damage appears as raised ‘pimples’ on the skin of young fruit. Another type of damage known in NSW as Pacific scab sometimes occurs in Ladyfinger bananas after flower thrips damage. Pacific scab is more rounded in shape than corky scab and is easily removed without injuring the fruit skin.

Flower thrips is probably the most serious insect pest of Ladyfinger bananas. Copious pimpling will persist as the fruit matures constituting a blemish on marketed fruit. On Cavendish fruit, these pimples are not normally important as they fade when fruit matures.

Rust thrips

Cavendish bananas can be badly affected by rust thrips

The first symptom of rust thrips is dusty, watersoaked marks between the fingers in the area where two adjacent fingers touch, particularly closest to the cushion. This later develops into reddish-brown ‘rust’ areas. Severe damage can lead to skin cracking, both lengthwise and transverse, as the fruit develops.

Note that damage from rust thrips can be confused with maturity bronzing. This is caused by environmental and nutritional factors and mainly occurs on the exposed, outer curve of the fruit— it is not confined to areas where fingers are touching.

Silvering thrips

Silvering thrips produce irregular silvery areas on the fruit. Close examination of these areas reveals a black speckling from the thrips excrement. Some skin browning and cracking may result from severe infestation. Silvering thrips damage is rare in the subtropics.

Managing flower thrips

Chemicals registered for control of flower thrips
Chapter 6, Handy Guides

Cavendish and Ladyfinger bananas are affected differently by flower thrips so decision-making on thrips control will be different for Cavendish and Ladyfinger growers. The fruit damage starts with the fruit still in the throat of the plant. Treatments are only effective if applied at, or shortly after bell emergence so decisions must be made at or before bunch emergence. While the bell is new, the thrips can be easily seen by lifting the least opened bract of the male bell and checking the flowers—thrips are tiny, narrow bodied, and are either brown, black or pale cream coloured.

Not all fruit affected by flower thrips feeding develops the more serious corky scab condition or the similar condition, Pacific scab, in Ladyfinger. Flower thrips feeding damage is generally worse during dry conditions. Adequate moisture and fertiliser seem to be important in reducing the occurrence of corky scab.

The options for deciding how to manage flower thrips are:

Option 1: Cavendish—no previous corky scab problem

- **Action:** Treatment is unnecessary as the pimpling on young fruit fades as the fruit matures. Monitor for any sign of scab damage at harvest (do not confuse it with maturity bronzing damage).

Option 2: Cavendish—previous corky scab problem

- **Action:** Monitor flower thrips activity from October onwards and when pimpling on young fruit or thrips on emerging bells are detected, commence treatment. Usually treatments will be needed from November to March, but continue if thrips activity remains high.

Option 3: Ladyfinger

Because heavy pimpling persists on fruit consituting a blemish on marketed fruit, treatment for heavy pimples is warranted whether or not there has been a previous problem.

- **Action:** Monitor for pimpling damage on young fruit from spring onwards. As soon damage is seen, treat emerging bells once a week until April, or later if thrips activity remains high.

HINT
If bunch trimming, then this is a good time to check.

Pimpling

Count the number of pimples on the upper curve of the five central fingers on one of the lower hands of young fruit. Check at least ten bunches per hectare.

Lift the least opened bract (the bracts are just lifting) on the male bells and quickly look for small narrow-bodied insects, dark or light brown

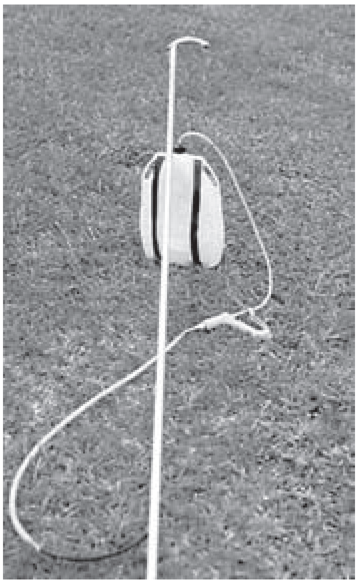


Figure 57. *Injection unit (upper), close-up of pointed hook used to pierce the bell (middle) and Sidewinder demonstration (lower). Noter that safety gear should be used*

in colour. Rather than count numbers, decide if there are none or some, on at least ten bells per hectare.

Treatment

Bell injections

Bell injection involves injecting a chemical into the emerging bunch while it is still upright. An inexpensive injection unit consists of a 3 to 4 m long lightweight aluminium tube, injector needle, metered hand pump and 5 L plastic container (Figure 57). Alternatively proprietary equipment such as the 'Sidewinder' injector can be used.

Depending on the chemical used, a single dose of 20 to 60 mL of solution is injected into the upper one-third of the emerging bunch while it is still upright (Figure 58). If injected above this point, it will be difficult to inject the required amount. If injected below this point, the lower hands can be damaged.

Advantages of this treatment are:

- highly effective if applied correctly
- will not harm beneficial insects on other parts of the plant.

Disadvantages are:

- requires routine checking of the plantation (at least once a week in warm weather) to find bells at the right stage of emergence
- equipment and application can be cumbersome to use on steep slopes
- young fruit can be damaged if the correct injection site in the bell is not used.

Throat sprays

Throat sprays are directed at the emerging or newly emerged bells. The advantages of this treatment are that it can be applied at weekly to fortnightly intervals and it needs less accuracy than bell injection but this method does not always give good control.

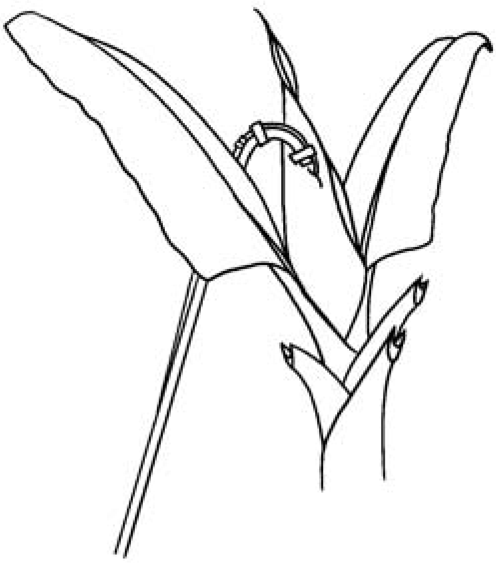


Figure 58. *Inject slightly above one third from the top of the bell*

Managing rust thrips

While the superficial damage from rust thrips does not reduce the eating quality of the fruit, 'rusty' fruit can be downgraded or rejected, depending on the severity of damage and the current market supply conditions.

Chemicals registered for control of rust thrips
Chapter 6, Handy Guides

Monitoring

Monitor fortnightly during spring to autumn. Check ten bunches per hectare and examine five central fingers from the top row of the top hand. If thrips are found and red discolouration is present on fruit examined, treatment should begin.

Treatment

NOTE
When establishing new plantations, make sure you use planting material that is free of rust thrips.

If treatment is required, apply insecticide (fipronil or chlorpyrifos) sprays in December to the base of the plants and surrounding soil. This method will kill the pupal stage in the ground. A number of bunch treatments can also be used to control adults on the fruit and are more reliable for quick control of rust thrips. Failure to control the pest in the bunch and on the ground will result in reinfestation.

suSCon RIBBON insecticide

NOTE
Sugarcane bud moth, a serious pest, is also controlled by chlorpyrifos bunch dusting/spray/ribbon treatment.

Proprietary ribbons impregnated with an insecticide, can be attached to the bunch stem at a specific stage of bunch development just prior to bunch covering, to protect the fruit against a number of pests including rust thrips. The ribbons are removed from bunch stems at harvest time and placed in a dedicated collection container for return to the manufacturer.

Managing silvering thrips

Monitoring

There is no specific monitoring program for silvering thrips. Watch for damage at the picking stage and if damage reaches unacceptable levels, take measures to reduce problems in spring and early summer.

Treatment

Chemical treatment is not generally required for this pest as it is sporadic and minor. The best treatment is to remove other host plants of silvering thrips from around the plantation in early spring. Other host plants include choko, passionfruit and weeds such as cobbler's pegs.

Managing spider mites

Banana spider mite (Tetranychus lambi) and two-spotted mite (Tetranychus urticae) are the two mite species most commonly found feeding on bananas. They feed on leaf tissue and also on the bunches.

Diagnose the problem

Photos are found in the companion book, *PICTURE GUIDE: Subtropical banana problem solver.*

Damage is mainly confined to the underside of the leaves appearing first as isolated bronzed rusty patches, which later coalesce along the leaf veins as the infestation increases. Eventually the whole leaf turns dark brown-grey and, in extreme cases, the leaves wilt, with partial or total collapse of the leaf blade. Leaf wilting and collapse result in sunburnt bunches and reduction in plant growth.

In severe outbreaks, the mites can move to the bunches and damage fruit—mainly on the cushion end of the fingers. Feeding in this area causes a red to purple-black discolouration of the fruit surface which may later dry out and crack.

Mites are most abundant during hot, dry periods—activity lessens during periods of wet weather or high humidity. Because mites can have a very short life cycle—as little as ten days in favourable conditions and high humidity, they can very quickly become a problem.

Options for control

Leaf damage is usually only important to the growth of young plants. Appropriate management and cultural techniques may help prevent mite problems.

- Reduce dust on roads—dusty conditions favour the build up of mites.
- Use irrigation if available—good water management especially during dry conditions will reduce stress to plants and help them withstand mite damage.
- Regular desuckering, leaf trimming and maintenance of plant densities will assist in achieving good spray coverage improving the level of insecticide control.

There are two options for control.

Use this book, *Bananas Insect and Mite Management* to find out more about identification, monitoring and action levels for spraying. Where to buy this book: Chapter 5 DPI Bookshop, page 186

Option 1: Wait for biological control

This involves doing nothing about the mites and allow biological control activity to reach useful levels. The predatory mite-eating ladybird (*Stethorous fenestralis)*, and predatory mites such as *Phytoseiulus persimilis*, are active most of the year and eventually overwhelm large mite populations. The advantage is no treatment cost and no potentially disruptive chemicals applied. The disadvantage is that in dry periods such as spring, some heavy leaf damage may occur briefly before the predators increase sufficiently to control the mites.

Option 2: Spray with a miticide

Mite control can be achieved with well-timed miticide treatments using correctly calibrated airblast sprayers or misting machines. This has the advantage of providing a rapid reduction in mite numbers, provided spray coverage is adequate. However, there are a number of disadvantages.

- Expense of insecticide and application.
- Thorough under-leaf coverage is needed for effective control—this can be very difficult to achieve. If possible, double spraying (in opposite directions) is recommended to improve spray coverage.
- A second treatment five days later is often needed to control mites hatching from eggs.
- Mites are able to develop resistance to chemicals; if repeated treatments are made, it is essential to rotate miticides from different insecticide groups.
- Mite damage to leaves can look much worse than growth response indicates, so the economic return from applied treatments can be marginal.

Managing banana weevil borer

Banana weevil borer (Cosmopolities sordidus) is a major insect pest of bananas. You need to decide if you have an infestation problem and how to treat it. This section provides a step-by-step approach from diagnosis and pest monitoring to the treatment options.

Avoiding weevil borer problems

Appropriate management and cultural techniques help prevent the weevil borer becoming a pest. These techniques include.

- Use clean weevil borer free planting material—tissue cultured plants are strongly recommended. Rhizomes (corms), bits or suckers used for planting must be carefully checked and trimmed to remove all traces of tunnels, eggs and larvae.
- When planting old banana land, allow at least six months of fallow after all the old banana material has rotted down to prevent a carryover of adult weevils.
- Cut up all fallen and harvested pseudostems to prevent weevil borer breeding. This is important in subtropical areas where drier, cooler conditions result in slow breakdown of plant material.

HINT
Avoid infestation by using tissue cultured plants for planting and destroying any infected plants as long as possible before planting. A fallow period is often necessary.

Diagnose the problem correctly

Nematodes can cause damage similar to that caused by banana weevil and you'll need to make careful observations to help you discriminate between the two problems. Some symptoms which can be help you diagnose banana weevil borer damage correctly include:

- Plants snapping at the base, leaving some rhizome (corm) in the ground, with weevil tunnels obvious. This is caused by weevils even if nematodes are also present (Figure 59).
- Old butts rotting quickly.
- Rhizome (corms) of plants heavily tunnelled and rotted.
- Plants apparently healthy but with tunnels in the base.
- Plants with residual butt rotting and weevil tunnels present.
- Young replant bananas severely stunted or dying, with tunnelling in the base.

Figure 59. Toppling of banana plant caused by banana weevil borer, the stem breaks and the rhizome (corm) remains in the ground.

Once you are sure you have a weevil borer infestation the next step is to monitor the population to see if it has reached a level that requires treatment.

Monitor weevil populations

Plantations can sustain a low population without suffering any economic damage. Excessive treatment for unimportant weevil populations is very expensive, time consuming and runs the risk of developing insecticide resistance. Weevil populations can be kept low simply through improved farm hygiene, so it is important to know when populations reach a critical level and require more expensive treatment.

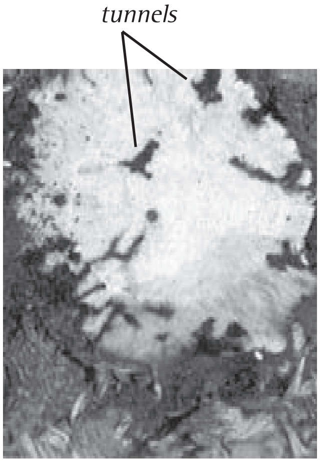


Figure 60. Typical tunnelling in the rhizome (corm) by banana weevil borer

Figure 61. Adult banana weevil borer and larva

The two most successful ways of monitoring weevil populations are tunnel rating and trapping.

Tunnel rating

The tunnel rating method involves cutting a thin slice off the side of the rhizome (corm) of spent stems, preferably less than a month after harvest. A quick estimate of the number of tunnels in the corm is made as follows:

- Less than 5 tunnels—low activity
- 6 to 9 tunnels—medium activity
- 10 or more tunnels—heavy activity

If rhizomes (corms) are old they will show damage that has occurred since harvest; this does not affect production. Monitoring 10 to 20 stools per hectare will give you a good idea of the weevil borer numbers in the plantation. **Treatment is necessary only if one in ten plants has a heavy activity rating.** If many plants are in the medium activity range in spring, be sure to do more ratings in early autumn. Tunnelling activity is shown in Figure 60 and the banana weevil and legless larva in Figure 61.

Trapping

Trapping with disc traps is another method that may be used for monitoring weevil population. It is probably the easiest way but is less accurate than tunnel rating for deciding the critical level.

Cut fresh, spent pseudostems (the lower portion of the stem on freshly harvested plants is ideal) into discs about 10 cm thick and place them at the base of stools in the plantation. Weevils will be attracted to the moist, newly exposed surfaces and remain under the discs while they remain moist. After five to seven days turn the traps over, count and record the weevil numbers. More than four weevils/trap indicates a critical level where treatment is needed.

HINT
The key to success in all control options is to keep the plants growing vigorously to compensate for any damage caused by banana weevil borer.

It is best to wait until after reasonable rainfall when laying traps in spring. About 50 traps per hectare are required to give a reliable assessment of weevil numbers.

Treat hot spots only

Whichever method is used, the monitoring will show which areas are hot spots and which have low weevil activity. There is no value in treating areas with low or medium weevil activity as these areas may not become a problem for years. Releases of adult weevils in trials have shown that the rate of natural spread is very slow, dispersal is primarily by the movement of infested suckers and bits at planting.

Decide on a control treatment

There are four options for controlling weevils.

Option 1: Hygiene

Figure 62. *A farm-made tool suitable for stem splitting*

Hygiene is a low cost, basic control method and is essential in all plantations. Toppled or broken plants provide ideal breeding sites for weevils especially during warm weather. Cut up these plants into about 30cm lengths within a month of them falling. It is important to split the rhizome (corm) and stem lengthwise to allow for rapid drying. Figure 62 shows a stem-splitting tool made on the farm. A good hygiene program may mean that you can avoid using insecticide control for many years.

Option 2: Injecting old harvested stems

This method has the following advantages over the old method of butt spraying (Option 4).

- 90% less insecticide is used.
- Trash is kept around the plant keeping the soil healthier.
- Less labour is needed and the work can be done in winter when there is less demand on labour.

A disadvantage is that it may be slow to reduce very high weevil populations.

How to do it

Small, targeted doses of insecticide are injected into the top of old, soft stems. Over about 4 to 6 weeks, the insecticide percolates down the stem to the rhizome (corm) killing the weevils on the way. Injections are most effective in winter and early spring when the majority of weevils are sheltering in old stems. There is some benefit in treating in summer months also but it is probably much less effective than winter as fewer weevils are sheltering.

There are a few important rules to obtain the best results.

- Only treat stems of old, decaying, harvested plants which are brown and soft.
- Do not inject hard green stems as the insecticide squirts back or dribbles out of the injection site and does not move freely down the stem. Fewer weevils shelter in these harder stems.
- Inject in July through August to give weevils time to settle into the rhizomes (corms) for the winter, and to have 4 to 6 weeks for a kill before they move out in mid-spring. Two rounds of injections give the best results, one in mid-winter and one during late winter to early spring.
- Inject at least 60 cm above the corms as weevils can move up through the centre of the stems to about this height.
- Allow 4 to 6 weeks for the treatment to reach the old corm before the butt is knocked over.
- Use a tree injector with a needle long enough to reach the centre of the stem.
- Inject with the needle angled downwards towards the centre of the stem to ensure the solution does not run out of the injection site (Figure 63).
- Do not wriggle the needle when inserting or it may snap.
- Use Tokuthion mixed at a rate of 25 mL/L water. Inject 8 mL of this solution into each stem.

Figure 63. *Injecting old harvested stems*

HINT
Treat only if monitoring reveals infestation levels which are unacceptably high.

Option 3: Baiting

This method has similar advantages and disadvantages as the injection method, compared to butt spraying (Option 4). Baiting attracts weevils to cuts in old rhizomes (corms), where they are killed by small doses of insecticide. Weevils are most active from spring to late autumn. Use Tokuthion mixed at the rate of 330 mL/100 L water. Spray cut surface with 20 mL of this solution.

Any cut into the corm of a recently harvested plant will attract weevils. Deep narrow cuts that stay moist for a long time are most attractive to weevils.

There are a number of ways to make these cuts.

Gouge baits. These are made with a desuckering gouge. Push the gouge into the old butt, parallel to the ground to reduce the risk of water entering the hole. Turn the gouge around to cut out a cone shape. Remove the cone, treat the hole with insecticide and replace the cone loosely to encourage weevils to hide in the dark crevices. Two such holes per rhizome (corm) are recommended . The series of drawings and the photo in Figure 64 illustrate how to do this.

Axe baits. A small axe or hatchet is the best tool for this job, and will work even better if an extra piece of metal is welded onto the blade. Make at least two deep cuts near the base and parallel to the ground and treat with insecticide. These slots cannot shelter as many weevils as the gouge traps but can be made much faster.

Wedge baits. Wedges of rhizome (corm) are cut horizontally out of the butt with a cane knife. The cut is treated with insecticide and the wedge loosely replaced. These traps dry out more quickly than other traps, making them less effective.

Option 4: Butt spraying

The main advantage of butt spraying is that it is highly effective against very large banana weevil borer populations. However, it has the following disadvantages:

- it is labour intensive, uses much more insecticide and therefore more costly;
- the environment is more exposed to insecticide;
- expensive equipment is needed;
- necessary removal of trash prior to treatment with some chemicals exposes the soil to erosion, high temperatures and weeds;
- work has to be carried out during periods when labour requirements are greatest for other tasks.

How to do it

Butt sprays are applied in mid October, when weevils become active after the winter, and/or in mid-autumn when activity is also high. Before treating the plantation, remove all the trash from a 30 cm area around base of the plants (not necessary for some chemicals).

Using the recommended rates, spray the cleared area and about 30cm up the plant stem. The two rates indicated on the labels are for once yearly or twice yearly applications. Once yearly applications are best applied in spring after rain stimulates borer activity.

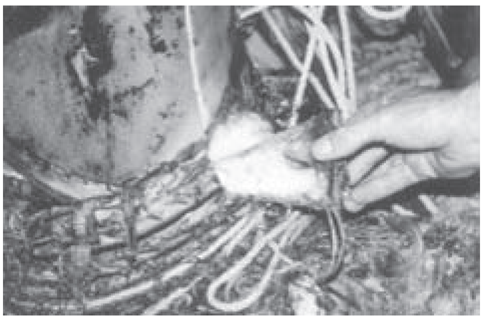


Figure 64. *How to apply gouge baits*

Managing nematodes

Photos are found in the companion book, *PICTURE GUIDE: Subtropical banana problem solver.*

Nematodes can be a major problem in bananas. Because damage occurs below the ground, it can reach high levels before the grower becomes aware of the problem. First decide whether you have a problem and then work out how to treat it. This is a step-by-step approach starting with diagnosis, then monitoring and finally the treatment strategies.

What are nematodes?

Nematodes are microscopic worm-like organisms. There are a wide variety of nematodes found in the soil of subtropical bananas. Some nematodes feed on other microbes such as fungi and bacteria, helping to recycle nutrients; others feed on plant roots. A problem occurs when there is a large number of plant feeding nematodes.

The most destructive nematodes in the subtropics are the burrowing nematode (*Radopholus similis*) and the lesion nematode (*Pratylenchus goodeyi*). These nematodes reduce plant growth by damaging the root system causing the plant to topple. Lesion nematodes prefer cooler temperatures and are regarded as being more prevalent in some subtropical areas. Both nematodes cause characteristic red-black lesions in the root cortex (outer section of the root) and only by actually extracting them from the damaged roots and examining them under a microscope is it possible to identify which one is present. Monitoring for damage and treatment methods are the same for both species (Figure 65).

Other nematode species such as root-knot nematode (*Meloidogyne* spp.) and spiral nematode attack the root system, but only root knot nematode occasionally causes economic losses in subtropical banana production.

Figure 65. *Life cycle of lesion and burrowing nematode and damage on banana roots*

Diagnose the problem

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 or plants begin to topple. Nematode-infested plants grow slowly, their bunches are smaller and their bunching cycle is longer.

Symptoms that are generally present with severe nematode damage are:

- Plants toppling (whole rhizome (corm) comes out) and roots exposed above the ground are very poor (Figure 66). This is caused by nematodes, *regardless* of whether or not weevil tunnels are present.
- Roots rotting and with red-stained tissue. You will need to slice along the root to determine this problem.
- Stunted plants with poor vigour, despite adequate watering and fertiliser.

Figure 66. *Toppling of plants caused by burrowing nematode. Note that the whole rhizome (corm) is lifted out of the ground and some of the roots are exposed.*

Monitoring for nematodes

If you suspect that nematodes are present, you need to monitor to decide how severe the problem is.

Estimate the nematode condition of the crop. From each banana block take 20 root samples to give a good estimate of the damage. The best time to sample plants is at bagging. Use a spade to dig a block of soil (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 100 roots). Place the roots in a bucket and rinse them with water to remove any loose dirt.

HINT
Disease index rating for lesions caused by burrowing nematode is best done immediately after sampling.

Cut each root lengthwise and use the rating scale in Table 24 to estimate the proportion of the root cortex which is occupied by reddish-black lesions.

Table 24. Rating scale for lesions caused by burrowing nematode in banana roots

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

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

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

The disease index can then be compared with the action threshold to help you make decisions on nematode management (Table 25). Once the disease index of a block is above 20, nematodes are causing economic damage.

Table 25. Disease index action levels

Disease index	Action
0–20	No action required Sample again in 3 to 6 months
20–40	Some yield loss may occur Nematicide may be applied
>40	Yield loss is occurring Fallow should be considered

These action levels apply to plants that have the potential to grow well. Treating nematodes in plantations that are too dry or have poor nutrition will not necessarily be beneficial. Good responses to nematicides occur where plants are otherwise growing well.

If the disease index has reached 40, 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.

Nematode reduction strategies

Strategy 1: Improve the general vigour of the plantation

Generally, healthy and vigorous plants can sustain a higher nematode load without serious loss. However, once plants are stressed, nematode damage compounds the problem. The rate of nematode build-up in bananas appears to vary widely between plantations.

To avoid stressed plants, review your fertiliser program.

- Consider the benefits of irrigation to reduce stress and promote vigorous root growth.
- Retain trash as a mulch around the base of plants to assist root growth and encourage beneficial anti-nematode organisms in the soil.
- Maintain a well-balanced fertiliser program to encourage good root growth and help compensate for nematode damage. When damage reaches unacceptable levels (with numerous plants toppling), replanting the badly affected sections may help rejuvenate the plot.

Strategy 2: Fallows and rotations

A method of cultural control recommended for nematodes is a fallow period which is commonly used to reduce nematode populations. Fallows begin with removing the old crop and destroying as much of the existing corm as possible by tillage where slopes permit the use of machinery. Rizome residues which host nematodes, can take as long as six months to break down; therefore, a fallow should be at least one year to ensure that no volunteer bananas and few nematodes survive. Many growers in the subtropics feel that a two-year fallow gives much better results for reinvigorating the plantation.

Grow a non-host in the fallow to prevent nematodes from reproducing. Some crops have been tested for their ability to allow burrowing nematode reproduction or host status. Table 26 shows the resistance to burrowing nematodes as a percentage level to allow the crops to be compared for their effectiveness as a fallow crop. Crops with a resistance level higher than 95% are suitable for use in a banana fallow. The planting of green manure crops during this fallow period slowly assists in improving soil structure, aeration and water holding capacity of the soil. In some subtropical plantations, especially on podzolic soils where burrowing nematodes are rare or absent, molasses grass has been used very successfully as a green manure crop.

Table 26. Fallow crops and resistance to burrowing nematode reproduction

Species/variety	Resistance %	Species/variety	Resistance %
Bonar rape	100	Oats cv. Algerian	82
Mustard	100	Oats cv. Riel	80
Canola	100	Brachiaria humidicola	78
Highlander swede	100	Velvet Bean (ex Florida)	77
Brassica cv. MPT swede	100	White French Millet	75
Brassica cv. Hyola 42	100	Gatton panic	68
Paspalum wettsteinii	100	Oats cv, Algerian	65
Rye grass cv. Roberta	99	Sorghum cv. Hunnicut	64
Jarra grass	97	Sorghum cv. Lush	55
Oats cv. Saia	97	Sorghum cv. Super Dan	47
Rhodes grass cv. Callide	96	Sorghum cv. Asgrow	47
Ryegrass cv. Dargle	95	Vetiver cv. Grafton	43
Rhodes grass cv. Nemkat	92	Sorghum cv. Betta Dan	38
Oats cv. Panarama	92	Sorghum cv. G93A010	35
Velvet Bean (CSIRO-81006)	92	Sorghum cv. YSG33	31
Vetiver cv. Monto	91	Molasses grass	25
Panorama millet	90	Sorghum cv. LB905	0
Green panic	90	Sorghum cv. 27900	0
Pearl millet cv. Supermill 2	89	Canary Grass	0
Argentine bahia	89	Banana cv. Williams	0
Pearl millet cv. Nutrifeed	82		

High resistance of a fallow crop to burrowing nematodes does not necessarily infer a similar resistance to lesion nematodes, and in areas where this species is a problem, this method of control may not be successful.

Strategy 3: Clean planting material

Clean planting material is important to stop the spread of nematodes from one field to another or between farms. Nematodes are able to burrow into the rhizome and are easily spread with rhizome material. Tissue cultured bananas are the preferred type of planting material in new ground or ground that has been fallowed with a non-host. This is the only type of planting material that can guarantee nematode-free status.

Heat treatment of rhizomes or hot nematicide dips can be used to disinfest vegetative planting material. However, it is not possible to completely disinfest planting material using these methods and they are not recommended. There is also a risk of transmitting Panama disease to clean sites when using inadequately sterilised hot water treatment equipment and there is a high risk to operators when using extremely toxic nematicide mixes in hot dips.

Strategy 4: Biological control

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

Biological control organisms are being developed that can be introduced onto tissue culture plants in the nursery. These organisms are able to give the young, developing banana plants some protection (usually only about two months) as they become established in the field.

Strategy 5: Varieties

Ladyfinger bananas are more resistant to burrowing nematode than Cavendish varieties such as Williams and Grande Naine. Goldfinger has been found to be as susceptible as Cavendish varieties to burrowing nematode damage.

There is currently significant global research to develop new varieties resistant to burrowing nematode. The varieties being developed acquire their nematode resistance from a banana variety called Pisang jari buaya. Some isolates of burrowing nematode found in Queensland are able to overcome the resistance of Pisang jari buaya. However, it is hoped that new varieties will show more resistance to burrowing nematode in the future.

Strategy 6: Pre-plant amendments

Soil characteristics can be improved by the addition of amendments to the soil before planting though large quantities (tonnes/ha) are required to have any effect on soil characteristics. Young plants grown in compost have been found to have greater resistance to nematodes than plants grown in potting mix. Beneficial microbes present in the compost are able to protect the roots and slow nematode damage. This is an option for increasing the resistance of potted suckers to nematodes.

NOTE
Enhanced biodegradation occurs when the micro-organisms in the soil develop to use the nematicide as a food source.

The ash residue from sugarcane mills has been found to suppress nematodes and enhance the growth of bananas by improving soil and root relations, thus reducing the stress on plants.

Strategy 7: Control with chemical nematicides

Chemical control consists of applications of nematicides two to three times per year to suppress nematode populations. The economic damage level for nematodes in the subtropics (20) is much higher than in the tropics (10). The main advantages of nematicide control is that it has the capacity to suppress nematode damage in roots if applied routinely.

Nematicides have been able to demonstrate only a slight increase in banana production and therefore may not be able to justify the cost of application.

The disadvantages are expense, high toxicity, some treatments require removal of trash from the base of plants before application (this causes the soil to heat, dry, degrade) and it is a laborious and time consuming application.

There are currently four nematicide active ingredients that are registered to be used on bananas in subtropical Queensland:

- Cadusafos—Rugby 100 G
- Fenamiphos—Nemacur 400, Nemacur 100 G
- Oxamyl—Vydate 240 L
- Terbufos—Counter 150 G, Terbuforce, Hunter

Continual use of the same nematicide active ingredient will lead to enhanced bio-degradation of the nematicides. Repeated applications are broken down faster, with each application leaving the nematicide ineffectively reducing nematode numbers. The speed at which enhanced biodegradation occurs depends on the number and frequency of applications, soil pH, soil temperature and microbial activity. Nematicides are applied in early spring, summer and autumn.

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. A quarantine strategy should also be put in place to prevent the movement of soil and water from potentially nematode infested areas.

Leaf and fruit diseases

Diseases are difficult to monitor. The causes are microscopic and in most cases, by the time you see symptoms the disease is well established and difficult to control. We therefore rely on preventive sprays to control most disease problems. Monitoring is still useful for detecting obvious problem areas and for evaluating how well your disease prevention program is working.

Leaf spot diseases

Yellow Sigatoka (*Mycosphaerella musicola*) fungus produces two types of spores—sexual ascospores and asexual conidia.

Ascospores are produced within the leaf tissue and are forcibly ejected into the air where 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. In 1998, two trials found that infected leaves hanging in the canopy can continue to eject ascospores for at least 20 weeks. After deleafing, the leaf tissue on the ground can only eject ascospores for 4 to 8 weeks. This highlights the importance of a regular deleafing program. Deleafing can be expected to reduce the quantity of ascospore production by 85%.

HINT
A regular deleafing programis vital for disease control.

Conidia are produced on the leaf surface and disperse 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.

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 stages are shown in Figure 67.

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 and is shown in Figure 68a and 68b.

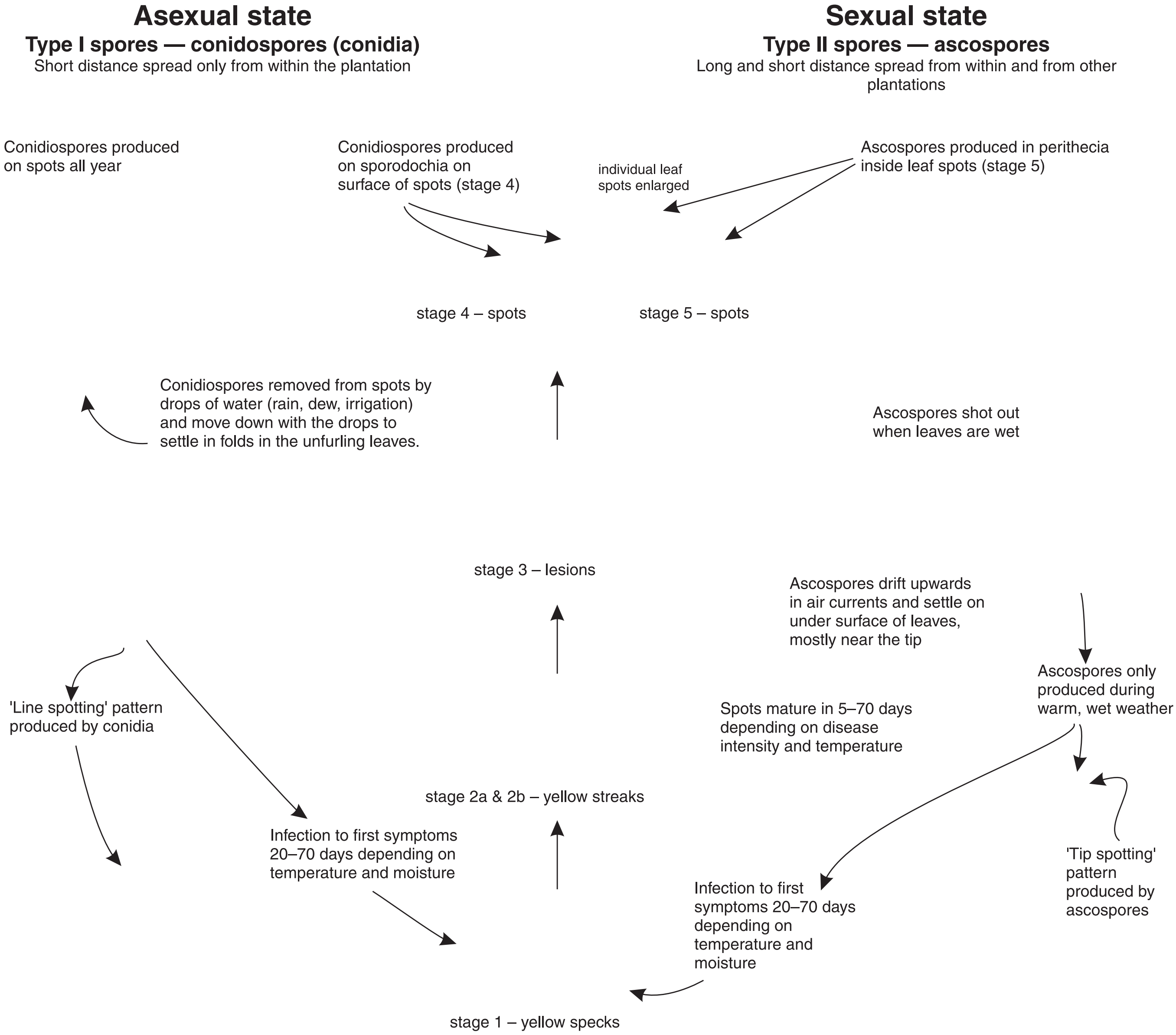


Figure 67. Life cycle of leaf spot fungus—5 stages to leaf spot development. Drawings: R. Peterson and C. Kroger

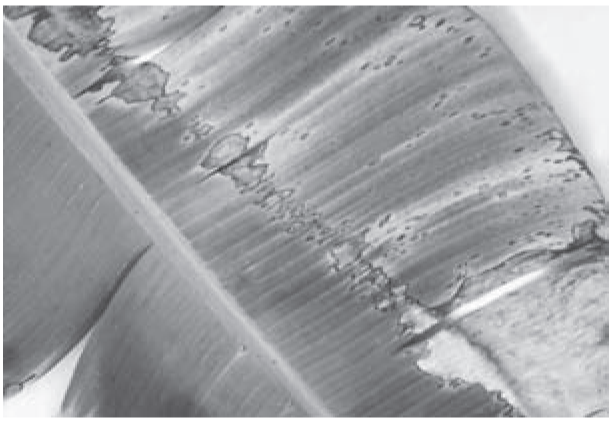


Figure 68a. *Line spotting pattern caused by conidial infection*

Figure 68b. *Tip spotting pattern caused by ascospore infection*

Controlling leaf spot

HINT
The yellow Sigatoka poster from DPI Queensland will tell you more about this disease.
See *Articles, brochures* Chapter 5 page 190

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

HINT
Deleafing regularly is critical for effective control of leaf diseases.

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. 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. Regular desuckering is important to maintain good airflow. 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

HINT
The poster, *Anti-resistance strategies for systemic fungicides in north Queensland* will help with your disease management.
See *Articles, brochures* Chapter 5 page 190.

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. Table 27 shows the three fungicide groups used on bananas.

Table 27. 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

Application frequency

Application frequency can be based on disease development monitored by consultants, on weather conditions or by the calendar on a regular schedule. Monitoring systems have been developed and various forms are used by consultants. NSW has a disease prediction service for leaf spot diseases that allows growers to schedule treatments according to expected levels of disease pressure.

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

HINT
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, 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.

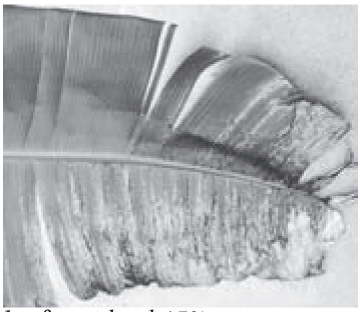
Preventing chemical resistance

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.

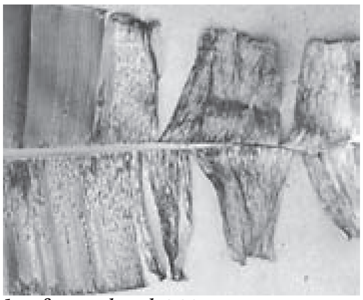
Strategies to reduce this resistance have been developed and presented in a DPI poster. The key points include:

- not using a chemical-only program—cultural practices such as deleafing is critical;
- 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.

Legislation for leaf spot



Leaf spot level 15%



Leaf spot level 30%

Figure 69. *Action levels 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 and 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 (Figure 69) and Table 28.

Table 28. Leaf spot levels (%) and relevant control actions (DPI)

Leaf spot level	Action	
	Summer—autumn wet/warm	**Winter—spring cool/dry**
15%	Control **order** given	No action
30%	Control **order** given	Control **order** given

Black Sigatoka

Black Sigatoka, caused by the fungus *Mycosphaerella fijiensis*, is a more virulent, devastating disease than yellow Sigatoka. It is a major threat to the Australian banana 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*.

Quarantine and black Sigatoka
This chapter page 68

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.

QUARANTINE ALERT

If black Sigatoka is suspected, contact the DPI immediately.

Fruit diseases

Sooty blotch

Sooty blotch (*Chaetochyrena musarum*) causes the fruit skin to blotch when surface cells are penetrated and causing diffuse symptoms. The disease is more common in Ladyfinger bananas, but also occurs in Cavendish and Goldfinger bananas.

The disease is common when the relative humidity in the bunch bags is high, particularly during cloudy and overcast or drizzly conditions and when double bagging is used. Symptoms can be difficult to see, especially on unripe fruit.

No chemicals are registered for control of this disease.

Sooty mould

Sooty mould is non-invasive and growth occurs on the fruit surface, particularly between the fingers where they connect to the cushion. Presence of banana aphid favours sooty mould build-up under the bunch covers. Monitoring and control of the aphid during bagging is the best method of control. Washing, brushing and rubbing fruit can remove mould but it is probably uneconomic to carry out this remedial control.

Fruit speckling—Deightoniella or salt and pepper spot

Fruit speckling, known as Deightoniella or salt and pepper spot in New South Wales is caused by the fungus, *Deightoniella torulosa*. Deightoniella can be particularly damaging on Ladyfinger bunches. The fungus infects green tissue on the fruit surface resulting in small water soaked lesions. In ripe fruit these appear as rounded, smooth brown spots on the skin. The presence of dead leaves on the plant allows the disease to increase. Regular deleafing is therefore an important practice to help control this disease.

Speckling of fruit can also be caused by insecticide damage, flower thrips and sooty blotch.

Mechanisation

Due to high labour costs, the tropical banana industry in Australia is perhaps more mechanised than in any other banana producing country. This level of mechanisation has yet to be achieved in the subtropical industry due to the difficulties of mechanising operations on sloping land and the smaller production units. Other factors, including workplace health and safety and the availability of reliable labour, are also driving increased mechanisation in the industry. Some aspects of mechanisation of possible interest to subtropical growers are given in this section.

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 70).

Figure 70. *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 can be 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.

Figure 71. *Bagging and spraying bunches from a 4WD bagging machine*

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.

Figure 72. Using a cherrypicker for bagging bunches

Bagging and bunch support

Purpose-built 4WD bagging machines are widely used in the industry where plantation scale permits (Figure 71). 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 tiresome work associated with carrying and climbing ladders.

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 larger than 10 ha may benefit from their use.

Alternatively an ordinary cherrypicker may be used to make bagging and other bunch work a lot easier and quicker on suitable terrain (Figure 72).

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 up to about 40 to 50 bunches. Self-propelled versions are sometimes used. Bunches are loaded straight from the shoulder onto the trailer. 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. Whether or not a plantation is highly mechanised, a well padded A-frame trailer is essential for the production of quality bananas (Figure 73).

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

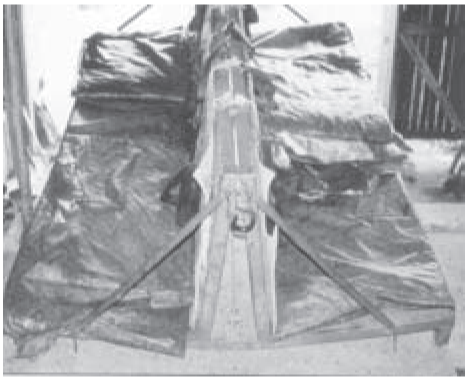


Figure 73. A 'home-made' padded trailer suitable for use in transporting bunches from field to shed (upper) and a loaded trailer below a butcher's rail gantry ready for unloading (lower)

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.
- **Staff amenities.**
- **Storage.** Especially for bunch covers; empty cartons; chemicals and fertilisers; machinery
- **Workshop** / office space.
- **Shed structure.** Especially the position of posts.
- **Parking.**
- **Quality assurance** protocols.

Centralised packing

The emergence of contract packing services is a recent development and some growers are also considering cooperative packing sheds (typically with near neighbours), which is also option for sub-tropical producers. There are also some difficulties and disadvantages with centralised packing including:

- 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.

The main advantages of centralised packing are:
- uniform standards;
- economies of scale should lead to lower packing costs.

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

Handling fruit in the packing shed

General

Shed capacity determines the handling system and degree of mechanisation implemented. 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.

HINT
In any shed, productivity is limited by bottlenecks in the system rather than the number of people working.

Bunch unloading and washing

With most bunch trailers used in the industry, 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

Figure 74. *Hanging bunches on a bunchline using a pneumatic bunch lifter in a large packing shed (upper). A simple butchers rail gantry system in a smaller shed (centre). Batches of bunches hanging from a gantry before being washed and dehanded (lower).*

manually. More commonly, bunches are hung on a moveable gantry or continuous bunchline before dehanding. There are many variations of each system (Figure 74).

Gantries are favoured in smaller sheds where either the trailer or gantry can be 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.

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 Ladyfinger). Use of straight or curved bladed knives depends on the preference of the dehander (Figure 75).

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 and there is a much lower risk of bruising occurring during dehanding.

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.

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 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.

Figure 75. *Dehanding Ladyfinger bananas with a pneumatically operated knife*

Packing wheel systems

Packing wheels are preferred by smaller sheds employing two or more 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 dehanders 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 (Figure 76). 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 dehander 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.

Figure 76. *Dehanding bunches on bunchlines into a trough*

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 at sorting and packing;
- can be more compact than full belt or trough systems.

Packing

Packing is a manual and somewhat specialised operation. Although productivity will depend largely on the skill of the packer, it can be enhanced significantly by considering the ergonomics of the packing station (Figure 77). In even the smallest sheds, packing is usually a continuous operation. The packing station should be as close as comfortable to the wheel for easy access to fruit. A ready supply of cartons should be within easy reach. 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 77. *Packing station for a wheel system*

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

Carton handling

The efficiency of carton handling before and after packing can significantly influence shed productivity. Good layout is important, 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 cost and space, but will require additional labour. 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 the following 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.

Pallet handling

Pallets loaded with packed fruit or packing material need to be moved throughout the shed. In smaller sheds, manually operated pallet jacks are used. A fork-lift is highly desirable for sheds packing more than 50 000 cartons/year (about 1000 pallets). Common shed layout for a gantry and wheel system, is shown in Figure 78.

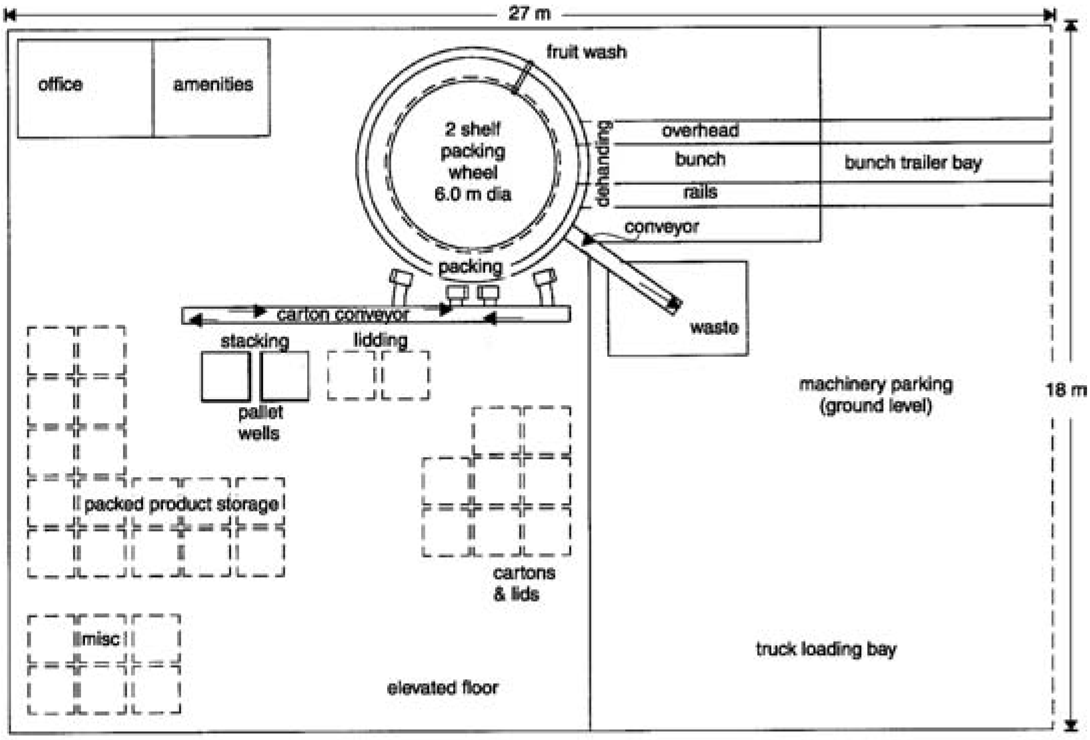


Figure 78. Common packing shed layout using a gantry and wheel system—up to 1250 cartons per day

Environmental considerations

The growth and development of the banana plant is governed to a great extent by the environment that it is grown in. This section will help you understand the most critical aspects of the interaction between the environment and the plant

Select a suitable site

When selecting areas for plantation crops, important points to remember are:

Temperature

Where water is not limiting, the rate of banana growth and development is determined by temperature. The optimum temperature is about 27°C. New leaf emergence (plant development) ceases below mean daily temperatures of 16°C, while growth stops below 14°C. Leaf yellowing occurs at mean temperatures of 6°C while 0°C is lethal—one night below freezing is sufficient to ruin a plantation. After bunch emergence, fruit take from 3 to 4 months to mature in summer, and 6 to 8 months during colder months.

Detailed information on selecting the best sites is contained in the booklets: *Buying the Farm for Horticulture—site it right* and *Self-help Landcare for New Farmers*. *Buying the Farm for Horticulture—site it right* is complemented by a video of the same name. All of these products are available from Department of Primary Industries Queensland.

A north-east to north-west slope aspect is desirable to increase sun incidence and temperatures in the winter months, to provide protection from colder winds and to avoid any frost prone sites in low lying areas.

Very cold weather (less than 6°C) at the time of bunch initiation can lead to what is known as November dump fruit (the time of bunch emergence). These fruit are characterised by:

- reduced number of hands of fruit/bunch
- irregular size of fruit
- cracked and twisted fruit
- one or two locules (fruit cavity) instead of the usual three so that fruit are thinner
- deformed flower ends
- abnormal flowers.

Fruit which fills during the cooler months often ripens to a dull yellow colour, unlike its bright yellow appearance at other times of the year. This poor colour development is due to underpeel discolouration caused by chilling. The classic internal symptoms are reddish-brown streaking of the vascular tissue just below the fruit skin. Chilling damage can occur once temperatures drop below about 13°C. The more the hours of exposure and the lower the temperature the greater will be the degree of damage.

Rainfall

The water requirements of the banana are high and in a closed canopy at optimum temperatures they reflect pan evaporation rates (between 5 to 10 mm/day in hot dry weather). However, banana plants are able to withstand moisture deficiencies well in comparison with many other species but supplementary irrigation does greatly benefit yield and fruit quality.

Wind

Winds probably represent the largest source of loss suffered in banana production. Windspeeds in excess of 60 km/hr from storms cause considerable losses where plants have already bunched. Wind can severely damage leaves and fruit reducing the quality and blow plants down; it also increases evapotranspiration making irrigation less efficient and may cause soil erosion.

Protection from damaging south-easterly and westerly winds is essential for banana plantations. Natural stands of timber left during land clearing can provide wind protection but planting of windbreaks is recommended on all farms. Windbreaks help to reduce leaf breakage at the petiole and minimise leaf tearing.

Aspect/frost

Choose frost-free sites as bananas are very susceptible to frost damage. In the subtropics, this generally means siting plantation crops on elevated land which can be steep. Slopes facing north, north-east and north-west are preferred as these are better protected from the strong south-easterly and westerly winds. Planting on cooler, more exposed slopes generally results in slower growth, poorer fruit set, reduced fruit quality, dull fruit and plant tissue damage.

Slope/topography

Select level areas wherever possible. Sloping land will require some erosion control measures.

Slopes 15% or less are preferred as they are safer for machinery and allow a wider range of options for farm layout and soil erosion control. They also enable the easier provision of all weather access to the crop, which is vital for harvesting and pest and disease control.

Slopes of more than 15% make it more difficult to operate machinery safely and carry a high risk of erosion damage. Erosion removes valuable topsoil and nutrients reducing plant vigour and productivity, in addition erosion of access tracks resulting in post-harvest fruit damage during transport is often a problem on these steep slopes. Consequently, these slopes require more substantial and costly erosion control measures and the high cost of developing and managing a plantation on land that is steeper than 15% would normally render this type of land uneconomic for banana growing.

Soils

Bananas require a well-drained soil and ideally with a minimum depth of 0.5m. A soil pH of 4.8 to 5.5 is suitable for bananas. Heavy clay soils with good drainage properties are ideal because they provide better conditions for root anchorage and better water holding capacity. Heavier soils are less likely to have plant nutrients leached out. Sandy, loamy or gravely soils are less suitable.

Soil type has a major effect on the amount of soil loss. For example, sandy surface soils are generally more prone to erosion than clay soils. Soil which has been cultivated to a fine tilth when preparing planting sites is more susceptible to erosion damage than undisturbed soil. Soils least likely to erode are those which are cultivated as little as possible and protected by a mulch or standing cover crop. Problem soils are:

- light sandy soils because they have low water holding capacity and poor retention of nutrients and are more susceptible to erosion
- poorly drained soils restrict crop growth may cause crop failure and limit nutrient uptake and may contribute to blow down (plants falling over in wind).

Detailed information on selecting the best sites is contained in the booklet: *Buying the Farm for Horticulture—site it right* The book is complimented by a video of the same name. These products are available from the Department of Primary Industries Queensland.

Access to irrigation water

If you are planning to irrigate your bananas, check that you have access to sufficient quantities of suitable quality irrigation water. As a rule of thumb, a two year supply is regarded as the minimum level for maintaining a crop throughout periods of drought. Around 10 ML of water per year are required for one hectare of cultivated bananas.

Crops vary in sensitivity to the amount of salts in irrigation water. The tolerance of the plant also depends on the stage of growth, soil type, climate and leaching conditions. Bananas do not tolerate irrigation water with a salinity (electrical conductivity) of more than 0.65 decisiemens.

Water harvesting, storage, drainage and irrigation systems

A good farm layout should incorporate water harvesting where possible. This means that runoff is removed from the plantation and directed into a dam for later irrigation use. It may be possible to drain wet areas by laying PVC pipes or gravel drains and should be designed to integrate with the other aspects of farm layout. When planning irrigation, seek specialist advice from a qualified irrigation designer.

Advice on water harvesting, dam siting, construction and drainage is available from DPI Queensland Water Resources advisory officers Chapter 5 page 186.

Previous plantation history

The presence of Panama disease will severely restrict the production of Panama susceptible cultivars. Residual fungal spores in the soil will quickly infect any replant of susceptible cultivars reducing yields and eventually killing the plant. These spores live for 30 to 40 years.

Cost of clearing

Heavily timbered or steep sites are expensive to clear. Location of the site may also be an issue in clearing costs.

Legislation (NSW)

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Land conservation extension officers Chapter 5 page 185

In NSW, clearing of land for banana plantations requires a permit—contact the local LAWC office. There are limitations on land clearing that exclude areas with a high conservation value (vegetation or inappropriate soil types).

Manage fertilising, irrigation and pest control

Fertilising

Applying fertiliser routinely rather than on a needs basis is not recommended because it is wasteful, costly and may cause pollution. Monitor the nutrient status of your crop by soil and leaf analyses—sampling kits are available from agricultural suppliers. Sap testing services are available from some consultants. Fertilise according to the results of your analysis.

Irrigation

Irrigation should be managed by monitoring soil moisture levels in the root zone with tensiometers, neutron probe moisture meters or soil moisture capacitance probes. This allows the most efficient use of water with the minimum amount of leaching of plant nutrients which prevents the increase in water table levels. Irrigation helps to achieve optimum crop growth thereby reducing soil erosion. Periodically check the quality of your irrigation water and if there are problems, seek professional advice on its continued suitability for your crop.

Pest and disease control

Pesticide use should be minimised for environmental and health reasons. Misuse of pesticides can result in pollution of soil or ground and surface water and current legislation makes growers responsible for the health and safety of their farm workers and adjacent landholders. The use of integrated pest management is the best way to minimise pesticide use. IPM involves monitoring pest levels, using natural and introduced predator species and the strategic use of less disruptive (low toxicity) chemicals.

In addition, growers are urged to use extreme caution in the storage, mixing, application and disposal of all chemicals and used containers. Always read and follow the directions on the product's label regarding application storage and disposal of any chemicals.

Planting and managing ground covers

Heavy rainfall on bare exposed soil has the potential to wash away valuable plant nutrients and organic matter. The use of ground covers provides protection to the soil surface and greatly reduces these losses. Ideal species for use as a ground cover should be permanent, low growing (prostrate), non-competitive, shade-tolerant, dense enough to smother weeds and have a degree of herbicide tolerance. In trials, *Arachis pintoi*, a variety of peanut, has shown promise as a good ground cover for plantations. Climbing or sprawling legumes such as siratro or glycine are more difficult to control. Unprotected soil is easily eroded especially on sloping ground (Figure 79). Ground covers help prevent this erosion (Figure 80).

Management of fallow

The use of a fallow period between crops reduces nematode numbers and disease build-up. The longer the period of fallow the better—a minimum of 12 months is recommended, and 24 months is preferred. Plant green manure crops during this fallow period to assist in improving soil structure, aeration and water-holding capacity of the soil.

The big picture

Following the planning principles outlined in this section will provide benefits to you and your farm as well as your whole catchment and community. Joint government and community initiatives encourage people to cooperate and work together on a catchment basis to reduce the offsite effects of land degradation. Adoption of the recommended planning principles will lead to a reduction in the impact of community problems such as:

- poor water quality due to nutrients contained in runoff water
- siltation of rivers, streams and harbours
- algal blooms in water storage
- loss of production caused by soil erosion.

For further information on how you can be more involved at a community level, contact the DPI Landcare and Catchment Management coordinator for the catchment in which you live or your local Landcare group.

Figure 79. *Unprotected soils can be easily eroded in wet weather*

Figure 80. *Ground covers help prevent soil erosion between planting rows (top left) and stabilise roadside banks (top right) and drainage lines (left)*

Organic production

Bananas are generally grown by conventional methods, using many 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. This section outlines the things you need to know if you want to grow bananas organically.

Why the interest in organic growing?

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

- Markets are prepared to pay a premium for this produce.
- Health concerns 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 in southern Queensland and northern NSW have demonstrated that it is possible. The extension of organic production systems to larger commercial farms is difficult however, with the existing technology. Fruit yields are often lower than in conventionally grown crops where organic growing methods of production are practised. There are several important problems to consider, which can contribute to yield loss.

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 deleafing and the use of natural chemicals such as copper and sulphur, but significant leaf loss in susceptible varieties should be expected during prolonged wet weather. Plant damage from these natural chemicals is also much more likely. In addition, fruit will often be damaged by rust thrips, flower thrips and sugarcane bud moth, all of which are very difficult to control organically.

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 or manual weed control 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 sold 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 and banana flower thrips are two common pests with no highly effective bio-control methods available.

Before you start growing organically

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—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 and try to work with a grower 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

The key to successful organic production is to keep the soil 'alive' by 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 (manure can contain Fusarium wilt fungus). 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 disease control

Use 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.

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 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 inoculum that causes leaf and fruit diseases;
- under-tree irrigation systems to reduce humidity;
- 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.

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. 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 and its high sugar content can assist with nematode control.

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.

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.

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Organic organisations
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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.

You are then subject to annual re-inspection and there may be significant costs associated with this ongoing process.