Banana Best Management Practices

Environmental Guidelines

for the Australian Banana Industry

Horticulture Innovation Australia

Australian Banana Growers' Council Inc.

Queensland Government

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FOREWORD

This Guideline is a resource that has been greatly anticipated by our industry.

It was the banana industry's strategic planning process which first identified the need for a Best Management Practices (BMP) Environmental Guideline specific to banana production.

Action was taken to develop a Guideline as a joint initiative of the banana industry's peak body – the Australian Banana Growers' Council (ABGC), and the Queensland government's Department of Agriculture and Fisheries, Queensland (DAF Qld). A major contributor was the Queensland government's Reefocus extension project, which strives to improve water quality in reef catchments.

While the water quality of our reef catchments has been central to the Guideline's development it is a key resource for all banana production regions throughout Australia. Importantly, growers from across these regions have contributed to its development.

Banana-growing communities are located in many regions that are ecologically significant. Many farms are multi-generational family businesses and their continuing sustainable production is essential.

This Guideline has been designed as a valuable resource for all banana farming businesses whether they already have Environmental Management Systems (EMS) or are assessing their environmental performance for the first time. The Guideline reflects the structure of the Freshcare Environmental Code, which is administered by Freshcare, of which ABGC is a stakeholder.

Key features are comprehensive information, intuitive layout and ease of use, and access to additional resources that are only a mouse click away in the online version. Businesses audited under other systems will also find it highly valuable.

The Guideline demonstrates our industry's commitment to the responsible management of natural resources. I commend it to all growers.

Doug Phillips
Chairman
Australian Banana Growers' Council

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SELF-ASSESSMENT CHECKLIST

Completing the self-assessment questionnaire will help to determine which farming practices you are doing well and where improvements may be possible. By completing the checklist, you are provided with an overview of farming practices as they relate to the industry benchmark. This will identify where improvements are required and help prioritise and direct the business to the most appropriate information. Use this as a guide only; the self-assessment will never replace expert advice.

The format follows a simple question and answer approach. Consider what you do most of the time. There are a number of possible answers, please choose the answer that best suits your situation. If the question is not relevant to your particular situation please select N/A for 'not applicable'.

Most questions require a single answer, but for some questions, more than one answer may be possible. These questions are identified by '*tick all that apply*' in brackets next to the question topic. In these cases, an overall practice rating is determined by the number of practices you select from the list.

There are three practice ratings:

- *Best* – demonstrates a practice that has a high level of sustainability
- *Okay* – demonstrates a practice that is acceptable to industry standards
- *Improve* – demonstrates a practice that is below the industry benchmark and improvements are required

Most questions will have all three of these practice ratings as possible answers. However, there are some questions that will only have two possible practice ratings.

Any practices checked as '*Improve*' should be made a priority practice for the business to address and improve. If the checklist is completed electronically, any answers in the '*Improve*' category will automatically be added to the management plan. If you choose to print this checklist and complete it as a hardcopy, all practices in the improve category rating should be added manually to the business management plan.

Land and Soil

Soil structure

1. Crop rotation

❍	Either a volunteer grass fallow or a fallow crop is planted between banana crop cycles.	[Best]
❍	A weedy fallow grows between banana crop cycles or the block is rotated with another crop.	[Okay]
❍	There is no fallow period between banana crop cycles or bare fallow is left between crop cycles.	[Improve]
❍	N/A	

2. Which of these practices do you use to increase organic matter levels?
(tick all that apply)

❑	Fallow crops are grown between banana crops.
❑	Harvested heads and leaves are left on the row.
❑	Products are applied to increase organic matter such as manures/mulch/compost/mill mud.
❑	High nitrogen rates are avoided.
❑	Cultivation is reduced.
❑	A side-throw slasher or similar is used to put mulch back on the row.
❑	Banana waste scraps are spread back onto the rows.
❑	Non-competitive companion crops are encouraged around banana plants.

[Best = 6+] [Okay = 4+] [Improve = 3 or less]

3. Cultivation method and timing land preparation

❍	The **row** only is cultivated at the times of year when the risk of erosion is low.	[Best]
❍	The **whole block** is cultivated at the times of year when the risk of erosion is low.	[Okay]
❍	The whole block is cultivated at any time of year.	[Improve]
❍	N/A	

4. Cultivation method and timing – crop destruction

❍	The banana crop is removed by treating with herbicide and plants are left to break down before cultivation.	[Best]
❍	Practices are implemented to breakdown plants while minimising soil disturbance, for example, using a mulcher or lightly with the discs.	[Okay]
❍	The banana crop is removed by discing green plant material repeatedly.	[Improve]
❍	N/A	

Soil erosion

1. Ground cover

❍	Living ground cover is encouraged in areas such as the inter-row space and headlands, excluding major roadways.	[Best]
❍	Living or dead, at least 60% ground cover is encouraged in areas such as the inter-row space and headlands. This includes mulching banana plant material in the inter-row space. Major roadways are excluded.	[Okay]
❍	Areas such as inter-rows and headlands are sprayed bare.	[Improve]
❍	N/A	

2. The plant crop stage has the highest erosion risk because it was cultivated recently and there is a large area of bare soil. Which of the practices listed below do you use to reduce the risk of erosion in plant crops? *(tick all that apply)*

❑	Planting is confined to low-rainfall times of the year when the risk of erosion is low.
❑	Grasses/plants are encouraged as inter-row ground cover in the plant crop.
❑	Permanent beds are used, allowing cultivation to be restricted to the row only.
❑	If plant blocks are established outside of low-risk rainfall periods, rows are formed early and grass is encouraged as ground cover, and only the row or furrow is disturbed at planting.
	[Best = 3+] [Okay = 2] [Improve = 1 or less] [N/A]
❑	N/A

3. Wind erosion (Western Australia only)

❍	Structures or trees are placed on the southern side of banana blocks to help minimise wind damage and erosion.	[Best]
❍	No wind breaks of any kind.	[Improve]
❍	N/A	

4. Controlling run-off water – slowing water

❍	The farm and blocks have been designed to slow surface water and direct it to an appropriate waterway capable of carrying high velocity water. Blocks are laser-levelled where required to prevent water from collecting in the paddock and creating wet areas.	[Best]
❍	**Most** blocks have been designed to slow surface water and direct it to an appropriate waterway, although some corrective work is still required.	[Okay]
❍	Little or no attention is currently given to slowing surface water or directing it to a suitable waterway.	[Improve]
❍	N/A	

5. Controlling run-off water – contouring

❍	If the farm has areas under banana production with a gradient of 3% or more, **all** blocks in these areas have been planted along the contour and designed to include diversion banks and constructed waterways. Advice has been sought for placing these structures correctly. Annual maintenance is carried out to ensure these structures are operating correctly. Blocks are left undeveloped if erosion cannot be managed.	[Best]
❍	If the farm has areas under banana production with a gradient of 3% or more, **most** blocks in these areas have been planted along the contour and designed to include diversion banks and constructed waterways. Advice has been sought for placing these structures correctly. Annual maintenance is carried out to ensure these structures are operating correctly. Blocks are left undeveloped if erosion cannot be managed.	[Okay]
❍	The farm has areas under banana production with a gradient of 3% or more, but there are no control structures in place.	[Improve]
❍	N/A – no land with a gradient over 3%	

6. Controlling run-off water – silt traps

❍	Silt traps have been designed, constructed and located **with** expert advice.	[Best]
❍	Silt traps have been designed, constructed and located **without** expert advice.	[Improve]
❍	N/A	

7. Controlling run-off water – drains

❍	All constructed drains on-farm are vegetated-shallow-spoon drains.	[Best]
❍	Most constructed drains on-farm are vegetated-shallow-spoon drains and any box drains have a batter suited to the soil type, so they do not erode.	[Okay]
❍	Constructed drains on-farm are mostly box drains with straight sides.	[Improve]
❍	N/A	

8. Controlling run-off water – roads

❍	**All** main roadways are either concreted or stabilised with sand or rock. Unless specifically designed the road is not used to direct and carry water. Suitable batters and culverts are used.	[Best]
❍	**Most** main roadways are either concreted or stabilised with sand or rock, but some roads still require improvements.	[Okay]
❍	Main roadways are not stabilised and water is able to travel along roads that are not designed for this purpose.	[Improve]
❍	N/A	

9. Controlling run-off water – maintenance

❍	All maintenance of drains, roads and inter-row spaces is carried out **during the time of the year when the risk of erosion is low**. Maintenance is carried out annually or as required to ensure these structures are working adequately.	[Best]
❍	Maintenance of drains, roads and inter-row spaces is carried out **at any time of the year regardless of rainfall activity** or no maintenance is carried out and structures may not be working adequately.	[Improve]
❍	N/A	

Soil acidity and alkalinity

1. Soil acidity and alkalinity

❍	Soil pH is monitored at least annually and pH amending products are applied as required.	[Best]
❍	Soil pH is **not** monitored at least annually or pH amending products are applied without testing pH levels.	[Improve]
❍	N/A	

Biosecurity

On-farm biosecurity

1. Property Access

❍	Access to the property is limited to authorised people only and their footwear is **effectively** managed (e.g. footwear exchange and disinfected). Vehicle access to the property is limited and any necessary vehicle movements undergo decontamination prior to entry and upon exit.	[Best]
❍	Access to the property is limited to authorised people only and their footwear managed (e.g. footwear exchange and disinfected). Vehicle access to the property is limited however there are no decontamination facilities.	[Okay]
❍	Access to the property is not limited and there are no decontamination procedures in place.	[Improve]

2. Planting

❍	Planting material is ALWAYS sourced from a certified clean planting material supplier	[Best]
❍	Planting material is sourced from own property	[Okay]
❍	Planting material is sourced from other properties	[Improve]

3. Suspect Plants

❍	Property owners and staff members are able to identify plants with unusual symptoms and are aware of how and who to report them to. Any suspect plants are reported to Biosecurity Queensland 13 25 23.	[Best]
❍	ONLY property owners are able to identify plants with unusual symptoms and are aware of how and who to report them to. Any suspect plants are reported to Biosecurity Queensland 13 25 23.	[Okay]
❍	Little attention is given to plants with unusual symptoms and they are not reported.	[Improve]

Pesticides

Integrated pest and disease management

1. Integrated pest and disease management

❍	Methods to manage **all** pests and diseases on-farm include physical (mechanical), biological, cultural and chemical control options. They do not rely only on chemical options.	[Best]
❍	Methods to manage **most** pests and diseases on-farm include physical (mechanical), biological, cultural and chemical control options. They do not rely only on chemical options.	[Okay]
❍	Pests and diseases are predominately managed using chemicals and little thought is given to other forms of control.	[Improve]
❍	N/A	

Chemical treatments

1. Monitoring

❍	Pest and disease levels are monitored on a regular and consistent basis by trained staff or service providers. Records are retained and treatments are applied using monitoring information and relevant threshold levels for each pest/disease.	[Best]
❍	Pest and disease levels are monitored by general observations when doing other activities and control methods applied accordingly.	[Okay]
❍	Spray treatments are applied on a calendar basis or in response to severe outbreaks.	[Improve]
❍	N/A	

2. Chemical rotations

❍	A rotation program is in place to ensure products are applied correctly and rotated according to label instructions, to prevent resistance from developing.	[Best]
❍	Attempts are made to rotate between chemical groups according to label instructions, but there is no rotation program in place.	[Okay]
❍	Chemicals are not rotated to avoid resistance.	[Improve]
❍	N/A	

3. Chemical registrations

❍ Key personnel know how to find which products are registered and permitted for use and only these products are used on-farm.	[Best]
❍ Rely on reseller or consultant advice for product registrations and only registered and permitted products are used on-farm.	[Okay]
❍ Not sure if the products used are registered or permitted for use.	[Improve]
❍ N/A	

Obtaining, storing, handling, applying and disposing of chemicals

1. Obtaining

❍ Chemicals are sourced from an Agsafe-accredited supplier or similar.	[Best]
❍ Not sure if suppliers are accredited by Agsafe or similar.	[Improve]
❍ N/A	

2. Storing

❍ The chemical storage area is locked, bunded, ventilated and is either located in an area where spills will not affect waterways, or measures are in place to ensure potential spills will not affect waterways.	[Best]
❍ The chemical storage area is not bunded and spills could not be contained.	[Improve]
❍ N/A	

3. Handling and applying

❍ Only appropriately-trained staff, handle and apply chemicals. Other staff cannot access or use chemicals.	[Best]
❍ Measures are not in place that prevent unqualified staff from accessing chemicals.	[Improve]
❍ N/A	

4. Disposal

❍ Empty chemical drums and unwanted or out-of-date chemicals are disposed of through DrumMUSTER® and ChemClear® programs respectively.	[Best]
❍ The DrumMUSTER® program for empty drum disposal is not utilised, neither is ChemClear® for the disposal of unwanted or out-of-date chemicals.	[Improve]
❍ N/A	

Spray drift

1. Chemical treatments

❍	Aerial and ground applications are only made during suitable weather conditions and care is taken to prevent off-target spraying. **Vegetative buffer zones** are in place around the farm to minimise the risk of drift.	[Best]
❍	Aerial and ground applications are only made during suitable weather conditions and care is taken to prevent off-target spraying.	[Okay]
❍	Measures are in place to minimise off-target movement of chemicals but improvements are still required.	[Improve]
❍	N/A	

Maintain and calibrate equipment

1. Maintain and calibrate equipment

❍	Spray equipment is maintained and calibrated regularly to ensure it is working effectively, leaks are avoided and the product is distributed evenly.	[Best]
❍	Maintenance and calibration of spray equipment could be improved or you need information about calibrating spray equipment.	[Improve]
❍	N/A	

Banana Integrated Pest and Disease Management

Nematodes

1. **Which of the practices listed below do you use to manage plant-parasitic nematodes?** *(tick all that apply)*

❑	Only tissue culture or clean (and dipped) plant material is used.
❑	At the end of the crop cycle, banana plants are removed with glyphosate to eradicate all living plant material that could harbour plant-parasitic nematodes between crops.
❑	A fallow crop identified as a non-host for a particular plant-parasitic nematode is planted in the fallow period.
❑	Plant-parasitic nematode levels are monitored using the Root Disease Index (RDI) to determine when economic thresholds are met.
❑	N/A

[Best = 3+] [Okay = 2+] [Improve = 1 or less] [N/A]

Banana weevil borer

1. **Which of the practices listed below do you use to manage banana weevil borer?** *(tick all that apply)*

❑	Only tissue culture or clean plant material is used.
❑	At the end of the crop cycle, banana plants are removed using glyphosate to eradicate all living plant material that could harbour banana weevil borer between crops.
❑	Banana weevil borer levels are monitored to determine when economic thresholds are met.
❑	Desuckering practices that produce broken or cut corm material or excessive stem shatter are avoided.
❑	In the subtropics where decay rates are slower, the pseudostems are cut in half lengthwise to accelerate the rate of stem decay.
❑	N/A

[Best = 3+] [Okay = 2] [Improve = 1 or less] [N/A]

Spider mites

1. **Which of the practices listed below do you use to manage spider mites?**
   (tick all that apply)

❑	Using chemicals that disrupt predators is avoided.
❑	Spider mite populations are monitored to determine when thresholds are met.
❑	Appropriate irrigation management is used to ensure the plants are not water stressed.
❑	Excessive applications of nitrogen fertiliser are avoided.
❑	Sufficient volume and coverage is applied if spray treatments are used.
❑	Predatory mites are released to manage pest mite species.
❑	N/A

[Best = 5+] [Okay = 4] [Improve = 3 or less] [N/A]

Leaf diseases

1. **Which of the practices listed below do you use to manage yellow Sigatoka?**
   (tick all that apply)

❑	A deleafing program is followed and infected leaf material removed. The deleafing program removes all inoculum before the peak infection period.
❑	Potential sources of infection are removed by eradicating old crops and feral plants.
❑	Leaf disease levels are monitored to determine when disease is present.
❑	Plant and soil nutritional status is monitored and maintained at desired levels.
❑	N/A

[Best = 3+] [Okay = 2] [Improve = 1 or less] [N/A]

2. **Which of the practices listed below do you use to manage leaf speckle and leaf rust?**
   (tick all that apply)

❑	A deleafing program is followed and infected leaf material removed.
❑	Leaf disease levels are monitored to determine when disease is present.
❑	Ground applications are made of the spray treatment to target the organism.
❑	N/A

[Best = 3] [Okay = 2] [Improve = 1 or less] [N/A]

Fertiliser and Soil Additives

Soil and plant tissue testing

1. Soil testing pre-plant

❍ 100% of blocks are soil tested before planting.	[Best]
❍ Soil testing before planting is infrequent or not done at all.	[Improve]
❍ N/A	

2. Soil testing

❍ Soil tests are taken on all blocks more than once a year.	[Best]
❍ Soil tests are taken on all blocks once a year.	[Okay]
❍ Soil tests are taken less than once a year or on fewer than all blocks.	[Improve]
❍ N/A	

3. Leaf testing

❍ Paired leaf and soil tests are taken on all blocks at least annually.	[Best]
❍ Paired leaf and soil tests are taken at indicator sites at least annually or tissue tests taken throughout the year but not paired with soil tests.	[Okay]
❍ Leaf tests are taken less than annually or not at all.	[Improve]
❍ N/A	

Selecting nutrient types and amounts

1. Fertiliser program

❍ The fertiliser program is supported by soil and leaf testing and yield monitoring. The program is revised annually and checked to ensure targets are actually applied.	[Best]
❍ The fertiliser program is supported by soil and leaf testing and yield monitoring.	[Okay]
❍ There is no fertiliser program and/or the rates applied are not based on soil and leaf test results.	[Improve]
❍ N/A	

Nutrient budgeting

1. Fertiliser program

❍	The fertiliser program **is** based on recommended rates for nitrogen and phosphorus.	[Best]
❍	The fertiliser program **is not** based on recommended rates for nitrogen and phosphorus.	[Improve]
❍	N/A	

2. Nutrient Target – *indicate average nitrogen application rate*

❍	100 – 150 kg/ha/year
❍	151 – 200 kg/ha/year
❍	201 – 250 kg/ha/year
❍	251 – 300 kg/ha/year
❍	301 – 350 kg/ha/year
❍	> 350 kg/ha/year

Applying fertiliser and soil additives

1. Pre-plant pH adjustments and fertiliser applications

❍	If pH adjustments, calcium, magnesium, potassium and phosphorus applications are required pre-plant, they are applied and **incorporated into the soil**.	[Best]
❍	If pH adjustments, calcium, magnesium, potassium and phosphorus are required pre-plant, they are applied **to the soil surface**.	[Improve]
❍	N/A	

2. Fertiliser application frequency

❍	The aim is to apply fortnightly applications of fertiliser during high growth periods such as summer, and potentially reduce this during low growth periods such as winter. Weather conditions may mean that this is not always possible.	[Best]
❍	The aim is to apply monthly fertiliser applications all year round.	[Okay]
❍	Fertiliser is applied less frequently than monthly.	[Improve]
❍	N/A	

3. Fertiliser application method

❍	All fertigation or combination of fertigation and banded surface fertiliser applications depending on the weather conditions.	[Best]
❍	Banded surface fertiliser applications to rows or in non-mechanised production systems the fertiliser is broadcast by hand to entire root zone.	[Okay]
❍	Fertiliser broadcast over rows and inter-row spaces or in non-mechanised production systems the application is more concentrated by placing it primarily at the base of the plant.	[Improve]
❍	N/A	

4. Calibration and maintenance of fertiliser application equipment

❍	All spreaders are calibrated on a regular basis and fertigation systems are checked regularly for uniformity. If applicable - ensure hand application is calibrated (NSW).	[Best]
❍	Improvements are required in the current systems and/or regular calibration of spreaders (including hand application). Fertigation systems are not checked regularly for uniformity.	[Improve]
❍	N/A	

Storing fertilisers

1. Storing fertilisers

❍	The fertiliser storage area is located in an area where spills will not affect waterways, or measures are in place to ensure potential spills will not affect waterways. This includes manures, compost and liquid fertilisers.	[Best]
❍	Spills could not be contained and/or surface water is not diverted away from the site.	[Improve]
❍	N/A	

Fertiliser application records

1. Fertiliser application records

❍	Records of all fertiliser applications are kept in a manner that allows the user to easily monitor progress and, if required, easily retrieve information such as total nutrients applied to date and soil and tissue test trends (e.g. electronic).	[Best]
❍	Records of all fertiliser applications are kept although retrieving information would be time-consuming (e.g. hardcopy).	[Okay]
❍	Not all fertiliser applications are recorded.	[Improve]
❍	N/A	

Water

Efficient irrigation

1. Emitter type

❍ 100% under-tree sprinklers or drip and an **automated** system.	[Best]
❍ 100% under-tree sprinklers or drip and a **manual** system.	[Okay]
❍ Some overhead irrigation.	[Improve]
❍ N/A	

2. Soil moisture monitoring

❍ Irrigation schedules are based on capacitance probes and weather stations and are **fully automated**.	[Best]
❍ Irrigation schedules are based on capacitance probes or tensiometers and use a **manual system**.	[Okay]
❍ No scheduling equipment is used to develop an irrigation schedule.	[Improve]
❍ N/A	

3. Manage salinity

❍ Underground water is tested to monitor salinity levels especially after periods of heavy rain. Where possible water sources are combined to reduce salinity levels or irrigation from tidal reaches is only taken at low tide and tests have been taken to ensure this water is safe for use.	[Best]
❍ Water sources are not tested to monitor salinity levels.	[Improve]
❍ N/A	

4. Check irrigation system performance

❍ Water uniformity and distribution is tested and above 90%.	[Best]
❍ Water uniformity and distribution is tested and above 80% but below 90%.	[Okay]
❍ Water uniformity and distribution is tested and below 80% or not tested and is therefore unknown.	[Improve]
❍ N/A	

Managing water quality to minimise environmental harm

1. Protect water quality

❍	Applications of fertiliser and pesticides **are** timed for suitable weather conditions and **all** run-off water is filtered through grassed headlands or vegetation before reaching waterways.	[Best]
❍	Applications of fertiliser and pesticides **are** timed for suitable weather conditions and **most** run-off water is filtered through grassed headlands or vegetation before reaching waterways.	[Okay]
❍	Applications of fertiliser and pesticides **are not** timed for suitable weather conditions **and/or run-off** water is not filtered through grassed headlands or vegetation before reaching waterways.	[Improve]
❍	N/A	

2. Packing shed waste water quality

❍	Filtration removes fine particles and larger debris before releasing water into local drains or waterways.	[Best]
❍	Grates in the shed remove large debris before water is released into local drains or waterways.	[Okay]
❍	There is no filtration of any sort in place and water from the packing shed is disposed of into adjacent drainage lines or waterways.	[Improve]
❍	N/A	

Biodiversity

1. Regional biodiversity priorities

❍ Management **is aware** of regional biodiversity priorities and how to source this information if required.	[Best]
❍ Management **is not aware** of regional biodiversity priorities or how to source this information if required.	[Improve]
❍ N/A	

2. Riparian vegetation

❍ Native riparian vegetation is present **for 100% of the length** of all creeks and rivers.	[Best]
❍ Native riparian vegetation is present **for at least 70% of the length** of all creeks and rivers.	[Okay]
❍ Native riparian vegetation is present **for less than 70% of the length** of all creeks and rivers.	[Improve]
❍ N/A	

3. Native vegetation

❍ Stands of native trees are maintained and protected, and **additional native vegetation** is established through tree plantings.	[Best]
❍ Stands of native trees are maintained and protected.	[Okay]
❍ Stands of native trees are not maintained and protected.	[Improve]
❍ N/A	

4. Native birds and animals

❍ Native birds and animals are identified and their habitats preserved. Farming practices that minimise impact on native wildlife are selected.	[Best]
❍ Little thought or consideration of native birds and animals.	[Improve]
❍ N/A	

5. Feral animals

❍	Feral animals are managed through suitable methods to minimise their populations and impact on the environment.	[Best]
❍	Attempts are made to manage feral animals to minimise their populations and impact on the environment.	[Okay]
❍	Feral animals are not managed.	[Improve]
❍	N/A	

6. Environmental weeds

❍	Weeds on the property are identified and managed according to relevant legislation.	[Best]
❍	Weeds are not managed according to relevant legislation.	[Improve]
❍	N/A	

Disease management

1. Disease management

❍	The business has reviewed the major pest and disease threats to their business and a biosecurity plan is in place. Visitors have a designated parking area and **all machinery and vehicles are excluded** from entering the farm. **Only designated farm machinery is used on site**. A perimeter fence is in place to prevent unauthorised access.	[Best]
❍	The business has reviewed the major pest and disease threats to their business and a biosecurity plan is in place. Visitors have a designated parking area and **any personnel, machinery or vehicles entering** the farm must be free of soil before entry is allowed.	[Okay]
❍	Threats from potential pests and diseases are not considered and there is no set policy for dealing with visitors to the farm. Vehicles and machinery are not forced to be free of soil before entering the farm.	[Improve]

Waste

Minimise, re-use and recycle

1. General waste

❍	Products that allow packaging to be minimised, re-used or recycled are used in preference to those that require disposal, where possible. **A formal waste plan is in place.**	[Best]
❍	Products that allow packaging to be minimised, re-used or recycled are used in preference to those that require disposal, where possible, but **there is no formal waste plan**.	[Okay]
❍	Little thought or consideration is given to waste management and no formal waste plan exists.	[Improve]
❍	N/A	

2. Banana bunch covers – number of uses

❍	Bunch covers are re-used as many times as possible.	[Best]
❍	Bunch covers are single use.	[Improve]
❍	N/A	

3. Banana bunch covers – disposal method

❍	**Recycled or biodegradable bunch covers** are used.	[Best]
❍	Bunch covers are **disposed of at the local dump or** through a **waste contractor**.	[Okay]
❍	There is no formal disposal method for bunch covers.	[Improve]
❍	N/A	

4. Banana bunch covers – farm collection

❍	All bunch covers are removed from the paddock and staff are aware that any bags laying around the farm should be collected and returned to an appropriate collection point.	[Best]
❍	Bunch covers are often left in the paddock or not collected when seen laying around the farm.	[Improve]
❍	N/A	

5. Waste bananas

❍	Waste bananas and stalks are mulched and spread back onto the banana paddock OR waste bananas are dumped in a single pile where water does not directly flow into waterways.	[Best]
❍	Waste bananas and stalks are dumped in a single pile where surface water flows directly into waterways.	[Improve]
❍	N/A	

Disposal

1. Removing irrigation

❍	All irrigation pipes are removed from the block before cultivating.	[Best]
❍	No attempt is made to remove irrigation before cultivating.	[Improve]
❍	N/A	

2. Disposing of irrigation

❍	If accepted by the local council, irrigation pipes are taken to the designated waste station.	[Best]
❍	Local council does not currently accept irrigation pipes, so they are stockpiled at the farm until a solution is found.	[Okay]
❍	No formal disposal method exists.	[Improve]
❍	N/A	

3. Disposing of string

❍	String **is removed** from the paddock and stockpiled in an appropriate manner pending waste collection.	[Best]
❍	String **is not removed** from the paddock or **string is removed from the paddock but** no formal disposal method is in place.	[Improve]
❍	N/A	

4. Chemical containers and chemical

❍	All chemical containers are triple-rinsed and collected through the DrumMUSTER® scheme. All chemical that is out of date or no longer required is collected through the ChemClear® scheme	[Best]
❍	DrumMUSTER® and ChemClear® type schemes are not used.	[Improve]
❍	N/A	

5. Disposing of general waste

❍	All waste material that cannot be re-used (e.g. some plastic) is **separated** from waste that can be **recycled** (e.g. paper). Waste is either collected by a local waste contractor or taken to the local waste station.	[Best]
❍	All waste material that cannot be re-used is either collected by a local waste contractor or taken to the local waste station.	[Okay]
❍	There is no waste management plan in place and not all the waste for disposal is taken by a waste contractor or taken to the local waste station.	[Improve]
❍	N/A	

Air

1. Neighbouring properties

❍	Immediate neighbours are known and contactable at short notice. The impacts of business operations have been discussed with the neighbour/s and reasonable practices to minimise disturbance have been adopted.	[Best]
❍	Reasonable practices to minimise disturbance to neighbouring properties have been adopted.	[Okay]
❍	Neighbouring properties aren't considered when undertaking farming activities.	[Improve]
❍	N/A	

2. Odour management

❍	Raw manures, waste bananas and chemicals are stored and applied in a way that **minimises their odour potential**. The prevailing wind determines where these products are stored and when they are applied, to minimise disturbance to neighbours and staff.	[Best]
❍	Raw manures, waste bananas and chemicals are stored and applied with **little consideration for reducing** their **odour potential**.	[Improve]
❍	N/A	

3. Dust management

❍	Disturbance to neighbours and staff **is minimised with action taken** to reduce the impact of dust from activities such as liming, cultivation and peak traffic periods along dirt roads.	[Best]
❍	**No action is taken** to minimise disturbance to neighbours or staff by reducing the impact of dust from activities such as liming, cultivation and peak traffic periods along dirt roads.	[Improve]
❍	N/A	

4. Smoke management

❍	The use of fire is minimal and the prevailing wind is considered when burning to reduce disturbance to neighbouring properties and staff.	[Best]
❍	No action is taken to minimise the impact of smoke on neighbouring properties and staff.	[Improve]
❍	N/A	

5. Noise management

❍	The noise level generated from activities has been considered and, where possible, practices have been altered and improved, or measures are in place to reduce the amount of noise produced.	[Best]
❍	No action is taken to minimise the impact of noise on neighbouring properties and staff.	[Improve]
❍	N/A	

6. Artificial light management

❍	Night activities that require lights have been reviewed and all required practices are implemented to minimise disturbance to neighbouring properties and wildlife.	[Best]
❍	No action is taken to minimise the impact of light on neighbouring properties and wildlife.	[Improve]
❍	N/A	

Energy

Conserving energy

1. Machinery

❍	Only machinery with the right capacity for the job is chosen. Machinery that lacks the capacity or has excess capacity is not used.	[Best]
❍	No consideration is given for the capacity of the machinery.	[Improve]
❍	N/A	

2. Machinery – crop destruction

❍	**Practices that minimise the number of passes** required to remove the banana crop are incorporated. For example, the banana crop is removed by treating with herbicide and plants are left to break down before cultivation.	[Best]
❍	**Little consideration is given to minimising the number of passes** required to remove the banana crop. For example the banana crop is removed by cultivating green plant material repeatedly.	[Improve]
❍	N/A	

3. Pump

❍	The pump's most efficient operating zone in terms of head pressure and volume of output is **understood and adhered to**.	[Best]
❍	The pump's most efficient operating zone in terms of head pressure and volume of output is **not understood or adhered to**.	[Improve]
❍	N/A	

4. Irrigation efficiency

❍	All irrigation is under-tree, rather than overhead, so that less water needs to be pumped.	[Best]
❍	There is still some overhead irrigation used on farm, which requires more water to be pumped.	[Improve]
❍	N/A	

5. Cold rooms

❍	Cold rooms are well insulated and protected from direct sunlight. All seals are checked on a regular basis to ensure they are not losing air.	[Best]
❍	Cold room efficiency could be improved through better insulation, protection from direct sunlight or more regular checks for air loss.	[Improve]
❍	N/A	

6. Management practices

❍	Where possible, management practices are implemented that reduce the amount of energy used, and energy consumption is monitored.	[Best]
❍	Little consideration given to the business's energy use and consumption is not monitored.	[Improve]
❍	N/A	

7. Maintenance

❍	All machinery, cold rooms, pumps and other equipment are serviced following the service book instructions to ensure they are operating efficiently.	[Best]
❍	Servicing is not always done on time and there are no systems in place to identify when services are due.	[Improve]
❍	N/A	

Greenhouse gas

1. Nitrous oxide

❍	The loss of nitrates to nitrous oxide is minimised by limiting nitrogen fertiliser applications when soils are at field capacity or saturated, and by having good drainage in blocks.	[Best]
❍	There is no awareness of nitrous oxides or how these are formed.	[Improve]
❍	N/A	

2. Carbon farming initiative

❍	Management **is aware of** the types of projects that can be funded under the carbon farming initiative and where to source this information.	[Best]
❍	Management **is unaware of** the types of projects that can be funded under the carbon farming initiative or where to source this information	[Improve]
❍	N/A	

Fuel

1. Storage location

❍	Fuel tanks are stored in an area where spills will not affect waterways, or measures are in place to ensure potential spills will not affect waterways. This includes mobile fuel tanks. **Bunding is provided on all petrol tanks and diesel tanks**.	[Best]
❍	Fuel tanks are stored in an area where spills will not affect waterways, or measures are in place to ensure potential spills will not affect waterways. This includes mobile fuel tanks. **Bunding is not in place on all fuel tanks** because tank capacity is less than that requiring bunding (minor storage) and a risk assessment has been performed.	[Okay]
❍	Spills from the current fuel tank location could not be contained and prevented from reaching waterways.	[Improve]
❍	N/A	

2. Storage and maintenance

❍	Fuel is only stored in tanks specifically designed for this purpose. Tanks are located in easy-to-reach locations, where filling is easy and access to fuel machinery is easy. **All tanks are locked when not in use** and **systems are in place to reduce** the chance of **accidental spills and leakage**.	[Best]
❍	Fuel is only stored in tanks specifically designed for this purpose. **Tank location could be improved** to allow improved access or there are no systems in place to reduce the risk of accidental spills and leakage.	[Improve]
❍	N/A	

MANAGEMENT PLAN

Priority Rating	Module/ Submodule	Item for Improvement	Action Required	Person Responsible	Budget ($)	Due Date	% Completed	Completed Date

Bananas are best suited to free-draining soils with good internal structure that can be cultivated.

LAND AND SOIL

Farm businesses should always implement management practices that maintain or improve soil condition. The priorities for soil management vary depending on soil types, topography of the land, surrounding environment, previous land use and climate. So the priority given to the soil management practices discussed in this section will vary from farm to farm and between production regions.

Soil structure

Soils are classified into a range of soil classes. Bananas grown in better class soils have higher yields and are more profitable. Bananas prefer soils that are not prone to water logging. They should be free-draining, have good internal structure and be suitable for cultivation. It is important to understand the soil types on your farm, their characteristics and the best way to manage them. Select farming practices that will maintain or improve soil structure to ensure optimal productivity.

Crop rotation

Planting a fallow crop in between each banana crop rotation helps to maintain or improve the soil structure. In any fallow period, it is important to kill volunteer bananas as they can harbour pests and diseases from one crop rotation to the next. The longer the block can be left fallow, the better for soil health. Ideally, blocks should be left with a fallow crop for a minimum of 12 months.

Volunteer bananas can harbour pests and disease from one crop rotation to the next.

A break in production, by introducing a fallow crop, is important for:

- Banana pest control – introducing a crop that is not a host banana for pests such as banana weevil borer or plant-parasitic nematodes, breaks the pest life cycle, effectively removing them from the block.
- Soil biology – introducing a new crop encourages a diversity of microorganisms and maintains an environment that is conducive to growth, as an active root system is required for a healthy food web.
- Organic matter – incorporating fallow crops into the crop rotation helps to improve soil organic matter levels.
- Erosion protection – a fallow crop provides soil cover and protection against the impacts of rainfall and surface water runoff.

Fallow crops provide a number of benefits to the soil.

Canola is a non-host crop for burrowing nematodes.

Selecting the fallow crop in a banana rotation depends largely on two factors:

- the presence or absence of plant-parasitic nematodes
- the length of time the block will be left fallow

If plant-parasitic nematodes are present, it is important to identify which nematodes cause the main economic problem. There may be more than one type of nematode present, but the nematode likely to have the largest economic impact is the highest priority. For more information on managing nematodes, refer to the module on banana pest and disease management.

If plant-parasitic nematodes are not present, select the fallow crop by simply choosing a crop that suits the climatic conditions and will provide maximum organic matter. In the tropics, suitable crops are sorghum and rhodes grasses. In the east coast subtropics, molasses grass, lotononis and broadleaf paspalum are suitable, while in the west coast subtropics, crops such as sorghum are also suitable but they will need to be irrigated.

If a fallow crop cannot be planted, volunteer grass or a weedy fallow is preferable to a bare fallow as it will still protect the soil from erosion and provide an active root zone for microorganisms. Bear in mind, however, that it could continue to host plant-parasitic nematodes, if they are present.

If a fallow crop cannot be planted, volunteer grass or a weedy fallow is preferable to a bare fallow.

Increasing organic matter

Organic matter is an essential component of a healthy soil because it increases the soil's nutrient and water holding capacity, improves the soil structure and provides a food source for soil organisms. It can be difficult to increase the amount or organic matter because it decomposes rapidly in the warm climate in most banana production areas.

Organic matter can be increased with practices such as:

- growing fallow crops in between banana crop rotations
- applying compost and manures
- applying sugar cane by-products such as mill mud **NOTE:** Mill mud has the potential to introduce pests, diseases and weeds
- returning harvested stems and leaves to the row
- using a side-throw slasher to put the vegetation slashed from the inter-row onto the rows
- applying mulch
- reducing cultivation
- avoiding high rates of nitrogen fertiliser
- encouraging earthworm activity, which incorporates organic material deeper into the soil

Mulching the row, with the aid of a side-throw slasher, will increase organic matter in the soil.

Too much cultivation or poor cultivation techniques can be detrimental to the soil structure.

The soil profile on the left is from a compacted inter-row space that has poor soil structure, which is evident from the large soil clods. The soil profile on the right is from a less compacted row and has better soil structure.

Permanent beds minimise the amount of cultivation required.

Cultivation method and timing

For most of the banana industry in Australia, mechanical cultivation is essential. However, some banana farmers in the east coast subtropics region do not use any mechanical cultivation due to the topography of the land they farm.

While cultivation prepares the bed for planting and removes any potential compaction zones, it leaves the soil exposed to erosion. Too much cultivation or poor cultivation techniques can be detrimental to the soil structure. This can lead to surface crusting and loss of air spaces preventing water, air and root access. Fertility may be reduced if less fertile subsoil is being brought to the surface.

Several things should be considered to improve cultivation outcomes –

Cultivation timing. Cultivate at times of the year when there is a lower risk of rainfall to minimise the chance of erosion

Minimal tillage. Reduce the impact of cultivation by minimising the number of passes, which will conserve the soil structure. Fortunately the perennial nature of the banana system means that cultivation is not required very often. For more information on tillage implements, their benefits and potential impacts, refer to the New South Wales Department of Primary Industries' website, and follow the links to agriculture, natural resource management, soil health and fertility, soil types, structure and condition, how cultivation affects soil or follow this link http://www.dpi.nsw.gov.au/content/agriculture/resources/soils/structure/cultivation.

Cultivate at the correct moisture level. Soil should not be worked when too wet or too dry. If the soil is too wet it can cause large clods and compaction below the cultivation zone. Too dry and the soil can be pulverised into a fine dust, losing structure and potentially causing surface crusting.

Maintain the same row location (permanent beds). If the irrigation system does not need to be moved, plant successive crops back into the same row. The frequency of mechanical operations such as bagging, picking and spraying in a banana plantation means that a lot of traffic travels each banana row. Over time this soil becomes very compacted. Marking the rows on a GPS provides the opportunity to plant back into the original row configuration. This avoids planting into the compacted inter-row regions.

Permanent beds. Consider switching to a permanent bed system. As long as drainage is adequate, there is no real need to work up the inter-row space. This effectively means only half the block is being cultivated. The benefits of this system include:

- less soil is exposed to erosion when a smaller area is cultivated
- soil preparation is faster and cheaper

Pre-formed beds can be planted with a cover crop and left until the crop is planted.

- soil in the rows is uncompacted, encouraging better crop growth
- inter-row spaces are already consolidated and hard for improved traffic access

Pre-forming beds. Form beds at the time of year when heavy rainfall is least likely, and sow with a cover crop. The benefits of this approach include good soil cover during wet periods and mounded rows dry the bed out more quickly. This gives more flexibility in planting times, as minimal cultivation is then required to prepare for planting.

Crop removal. Consider eradicating the old banana crop by injecting with glyphosate rather than cultivating. Also control volunteer bananas with herbicide rather than cultivation. The permit for glyphosate use in the banana industry is available at the Australian Pesticides and Veterinary Medicines Authority website by searching the permit database for permit 11733 or by following this link http://permits.apvma.gov.au/PER14850.PDF.

Some growers have successfully used a forest mulcher (hammer mulcher) to remove a banana crop quickly. It doesn't disturb the soil and the banana plants can break down rapidly.

More information can be found in the Banana root and soil health user's manual which can be accessed through the Queensland Department of Agriculture Fisheries web and Forestry website or by following this link http://era.daf.qld.gov.au/3498/.

Injecting bananas with glyphosate reduces the number of passes required with the off-sets.

SUBTROPICS EAST COAST – If planting furrows are created with a ripper tine, avoid ripping up and down the hill as this increases the chance of erosion along the furrow.

Soil erosion

Research done in the tropics of north Queensland has shown it takes a million years to produce 30 cm of soil. Soil production rates will vary across the regions, however it highlights why it is essential that we conserve the soil that we have. Managing soil erosion is especially important in the subtropics on the east coast, where bananas are grown on relatively steep gradients, and in the tropics of far north Queensland, where significant, high intensity rainfall is received. The west coast subtropics are also vulnerable to wind erosion and water erosion during flooding events.

It takes a million years to produce 30 cm of soil.

There are two main principles for managing soil erosion:

- maintaining ground cover
- controlling runoff water

An example of pedestal erosion. Some ground cover (in this case a rock) has protected the soil, which remains at its original height while the adjacent soil has eroded.

During a rainfall event more soil is lost from bare ground compared with areas having ground cover.

Slashing headlands and inter-row spaces maintains ground cover, which limits the potential for erosion.

Ground cover

There is enough energy from raindrops in a large thunderstorm to splash more than 150 tonnes of unprotected soil per hectare into the air. Therefore good ground cover is essential for managing soil erosion and is critical on any gradients greater than 3%. Ground cover:

- intercepts rainfall, reducing the surface impact of raindrops
- slows the velocity of surface water
- increases water infiltration
- stabilises the soil

Other benefits associated with maintaining soil cover include limiting the spread of pests and diseases. Pests such as plant-parasitic nematodes and diseases such as Panama disease can be spread when moving soil. The more soil that is moved around the farm on machinery and in surface water, the quicker these problems can spread across the farm and elsewhere.

A suitable ground cover is:

- shade tolerant
- not invasive or too competitive
- perennial
- tolerant of traffic (tropical production or row configuration plantings)
- short growing and has a spreading habit
- a non-host for the main plant-parasitic nematodes if they are present

In the subtropics it may be possible to introduce ground cover species that will grow successfully. However, where planting arrangements are based on row configurations, such as in the tropics, most introduced species do not tolerate the traffic, so native grasses and vegetation often suit this role best.

For more information on cover crop selections in the east coast subtropics, refer to pages 11 and 12 of the Soil and water best management practices for NSW banana growers manual, which is available at the New South Wales Department of Primary Industries website or by following this link http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0007/242359/soil-and-water-best-management-practices-for-nsw-banana-growers.pdf.

There are several ways to maintain and promote ground cover in the plantation –

Promote vegetation around the farm. Maintain vegetation and slash rather than spraying it out, especially during periods when there is a

Encourage ground cover in the inter-row space.

In drier climates, mulched banana trash provides an effective ground cover.

Pinto peanut planted as a companion crop.

high risk of erosion. If it isn't possible to maintain slashed inter-rows and headlands, across the farm all year round, ground cover should be a priority:

- in plant blocks
- during the wet/storm season
- on steeper slopes
- on lighter soils that are prone to erosion

Minimum 60% ground cover. While a living ground cover is preferable, a dead cover can also provide protection from erosion. If spraying the inter-row cannot be avoided, allow the vegetation to grow and then spray with a knock-down herbicide. This will preserve the root system and provide a mulch layer to protect the soil. Regardless of whether it is living or dead, a minimum of 60% ground cover is required.

Mulching the inter-row space. In drier climates, where organic matter decays more slowly, mulching trash material in the inter-row space provides an effective ground cover.

Mulching on the row. Where cultivation is limited, establish a fallow grass crop and then spray this out before planting, leaving a mulch layer over the ground. Other, low-growing cover crops may only require spraying in the immediate row area where the banana is to be planted. In the tropics, use a side-throw slasher to put mulch on the row.

Companion crops. Planting a quick establishing companion crop is recommended for plant crops or bare ground, especially during high risk rainfall periods. In the east coast subtropics, white clover and summer grass are suitable.

Place leaves and harvested heads on the row. This provides soil cover and prevents the inter-row grasses from being smothered.

Plan the timing of crop removal and cultivation. Plan banana crop removal and general cultivation activities for the time of year when there is the lowest risk of rainfall. Time the inter-row maintenance for the dry times of the year.

Eradicate the old banana crop by injecting. Remove the old banana crop by injecting with glyphosate rather than cultivating. Also, control volunteer bananas with herbicide rather than cultivation. The permit for glyphosate use in the banana industry is available at the Australian Pesticides and Veterinary Medicines Authority website by searching the permit database for permit 11733 or by following this link http://permits.apvma.gov.au/PER14850.PDF.

Constructed wind breaks are used to prevent wind erosion in Carnarvon.

Ensure ground cover is maintained during other farming activities. For example, maintain the ground cover when installing a pump near a creek bank.

Maintain ground cover on buffers/headlands between the blocks and creeks or drains.

SUBTROPICS EAST COAST – For more information on cover crop selections refer to relevant sections of the New South Wales Department of Primary Industries resource, Soil and water best management practices for NSW banana growers available at the following link http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0007/242359/soil-and-water-best-management-practices-for-nsw-banana-growers.pdf.

Even with ground cover, erosion can be difficult to control if the speed and direction of runoff water is not managed.

SUBTROPICS WEST COAST – Wind breaks are useful to prevent winds from eroding the soil or damaging the banana leaves. They should be placed on the southern side of the banana paddock.

Controlling runoff water

Controlling the speed and direction of runoff water is critical for minimising erosion. Measures and structures should be introduced to slow water where slopes are likely to produce high velocity water flows. Surface water should be directed to suitable waterways that are capable of carrying high velocity water. Seek professional advice where the topography makes the soil more prone to erosion.

Farm design. Use farm maps and topographical maps to design or improve the farm layout, to provide permanent, all-weather access and good drainage. These plans need to take into account soil types, current and future land use, gradients, existing waterways and irrigation layouts.

Block selection. Avoid growing bananas in low-lying areas that may be prone to flooding, especially where high velocity flooding occurs and on steep slopes where erosion cannot be managed.

Block design. Use structures such as diversion banks, contour banks and constructed waterways to manage the direction and velocity of surface water. Engage a consultant to help plan where to place these structures.

Slopes greater than 3% should be contoured.

- *Contouring.* As a general rule, any land with a gradient greater than 3% (a 3 metre fall in 100 metres) should be contoured. Contouring stops water running off slopes too fast and subsequently eroding soil. GPS systems help to simplify the contour design process. The block can be travelled in a tractor

Contours are required on slopes greater than 3%.

fitted with a GPS to gauge gradients. Depending on the GPS used, this information can then be sent to a consulting firm to calculate exactly where the contour rows should be placed, the row length and where waterways should be created. This reduces the need to use a survey stave. Seek professional advice before developing contours. Unless major modifications are required, maintain these rows as permanent beds.

- *Diversion banks.* These are often used to catch surface water from above a paddock, diverting it away from the block and into a suitable waterway.
- *Constructed waterways.* These are wide, vegetated, flat-bottomed structures designed to collect runoff and slow the water before conveying it at a safe velocity to a drainage line. They differ from constructed wetlands, which are planted with vegetation to capture and hold runoff water (for at least two days), allowing time for fine sediments and nutrients to be removed from the water.
- *Silt traps.* These are a last line of defence against sediment leaving your farm and are not effective on their own. Excess sediment in the silt trap demonstrates that the farming system is failing elsewhere. Professional advice on the design and positioning of silt traps will save time and money, while ensuring the desired impact.
- *Laser levelling.* On farms with little gradient, blocks should be laser levelled, where practical and affordable, to ensure a constant fall and prevent water from collecting in the paddock and creating wet areas. Afterwards leave blocks to consolidate as long as possible before planting and consider forming beds early, then planting with a cover crop.
- *Vegetative ground cover.* Maintaining grass or vegetation cover wherever possible on the farm helps to stabilise the soil, reduce the velocity of surface water and provides filtration before the water leaves the farm.
- *Land clearing.* Do not clear vegetation from steep land where soil conservation practices cannot manage potential erosion problems. Each state has different land clearing legislation. Contact your state natural resource department to get the necessary permits before clearing land.

GPS technology has simplified the contouring process significantly.

Placing harvested heads perpendicular to the fall of the block will help slow the runoff water.

Plant crop

The plant crop stage is the most susceptible to erosion and should receive the most care and attention because:

- the soil has not yet consolidated following recent cultivation

The plant crop stage is very susceptible to erosion because recent cultivation has loosened the soil and removed the ground cover.

- there is limited ground cover as it has not yet established
- there is limited plant root mass to hold the soil together
- there is limited plant canopy to intercept rainfall before it hits the ground
- there is limited banana 'trash' to provide ground cover

Planting a rapidly establishing companion crop is recommended for plant crops or bare ground, especially during high risk rainfall periods.

In a system where cultivation is not required before planting, (such as a pre-formed bed system or in plantations established by hand-planting), an effective management strategy is to establish a fallow crop and spray this out before planting. This will provide a thick mulch layer that will cover the soil. Care is needed because this mulch layer may harbour plant diseases such as bacterial corm rot (*Erwinia*).

Drains

Grassed, shallow spoon drains have the least chance of eroding.

- Use pipes and culverts to reduce the need for machinery to drive across drains and put rocks on those where access cannot be avoided.
- Natural gullies and waterways should not be disturbed or redirected.
- Consider installing a diversion drain at the top of a sloping block to keep the water out of the block altogether.
- Broad, shallow drains are most suitable as they are less susceptible to erosion and allow vegetation to be easily maintained with slashing. This is particularly important on lighter soils.
- Use 'drop structures' in drains where there is a significant fall to reduce water velocity and therefore subsequent erosion.
- Maintain living vegetation on drains during the wettest periods of the year.
- Slash rather than spray drains or, if spraying, let the grass at the side of the drain get tall before spraying with a knock-down herbicide. This will preserve the root structure of the plants and protect the bank with a mulch layer.
- Inspect drains regularly, especially during heavy rainfall, to ensure they are working effectively.
- Carry out drain maintenance during the low risk rainfall periods.
- Stabilise drains with stones/ballast where necessary.

Rock helps to stabilise drains where traffic crosses.

Roads

The roadway should never be used as a drain unless it has been specifically constructed and stabilised for this purpose. The road and

All weather access roadways are essential in banana production systems.

batter may be used to help direct water to an appropriate drainage line as long as they were constructed for this purpose.

- Stabilise main headlands with sand and rock, as they pack hard. Remove wheel ruts and repair roadways as necessary.
- Put a suitable batter on 'built up' roads to prevent erosion from the sides of the road, and maintain vegetation beside the road batter.
- In steeper areas, for example on the subtropics east coast, concrete the roads that receive a lot of traffic and the corners where vehicles are constantly turning and disturbing the soil.
- Use pipes/culverts under the road, where necessary, to prevent water from damming. This ensures good drainage so that water does not pond in traffic areas.
- Build roads on the contour or build whoa-boys or inverts to allow water to cross the road.

Concrete roadways provide all weather access in steeper areas, for example on the subtropics east coast.

SUBTROPICS EAST COAST – While most farms on steeper gradients already have well-established roadways, regular maintenance of these structures is essential to prevent erosion in immediately adjacent ground.

Inter-rows

- Encourage traffic to stay on the roadways/headlands instead of taking short-cuts through paddocks.
- Make the main picking rows wider to allow extra sunlight and air flow, which enables them to dry out more quickly and makes conditions more conducive for vegetative ground cover to grow. It will also mean that less damage is caused to the fruit hanging in the picking row during harvest.
- Maintain grass in the inter-row space. Vegetation will reduce the raindrop impact (splash erosion), increase water infiltration, decrease the speed of surface-water runoff, reduce soil movement with machinery and improve the soil structure.
- Where necessary, use a 'V' blade to make the centre of the inter-row the lowest point, rather than the wheel tracks.
- Repair wet areas in inter-row spaces as soon as possible either with ballast or by improving the drainage. Once ruts are established in a block, they are hard to manage and can potentially cause sediment loss in surface runoff water.

Ground cover in the inter-row stabilises the soil and reduces erosion.

Permanent beds have a number of benefits.

- Consider switching to a permanent bed system. This maintains the rows in the same place, preferably with the aid of a GPS, so that only the row is cultivated at planting. The inter-row space remains uncultivated, and this provides a hard driving surface, limiting the amount of compacted soil that is mixed into the row.

TROPICS – Pay close attention to stabilising inter-row spaces (especially the picking rows), and ensuring the inter-rows remain well drained. This will prevent sediment movement from within the paddock. It should be a high priority due to year-round machinery travel in each row and the intensive rainfall received in the region.

Creeks

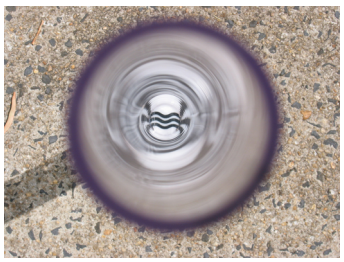
- Contact your local, state-based natural resource department and seek professional advice before conducting any work on waterways, including works to prevent stream bank erosion.
- Leave riparian vegetation along the creek/river banks.
- Revegetate and/or stabilise eroding creek banks where significant erosion is evident. Contact your relevant state natural resource department before starting any work.
- For information relating to revegetation refer to the Stream bank planting guidelines and hints available at the Department of Natural Resources and Mines website or by following this link http://www.qld.gov.au/dsiti/assets/soil/stream-bank-planting-guidelines.pdf.
- General information on erosion management is available at the Department of Natural Resources and Mines website or by following this link http://www.qld.gov.au/environment/land/soil/erosion/management/.
- Avoid constructing roads or tracks through creeks that would affect hydrology and fish passage and can lead to erosion.

Maintain riparian vegetation along creeks and rivers.

Packing shed runoff water

Manage all shed waste water to ensure it does not cause erosion by creating a wet area that is filtered before reaching waterways. This is primarily an issue for producers in far north Queensland, Northern Territory and the packing houses in Western Australia, where high volumes of water are used in the packing process.

This is covered in more detail in the module on water.



Looking down a turbidity tube. These tubes are useful for measuring suspended solids in runoff water.

Monitoring soil erosion

Monitoring soil erosion can be useful to businesses that use an audited Environmental Management System (e.g. Freshcare Environmental) to demonstrate that their practices are managing and improving areas prone to soil erosion. Three possible methods for monitoring soil erosion include:

Turbidity tube. Make a dark mark (e.g. an 'X') on the bottom of a clear-plastic tube that has millilitres marked on the outside. Fill the tube with runoff water until the mark can no longer be seen. The less sediment in the water, the more water the tube will hold before the mark is no longer visible. This is a relative measure, since different soils will have different dispersion properties. This means it can be used to compare different practices on the same soil type or the same spot over consecutive wet/storm seasons, but it cannot be used to compare different soil types.

Erosion peg. Hammer a piece of threaded rod into the ground, away from traffic areas. Put a washer at ground level and a nut above this. If there is any erosion the washer will fall to the new ground level but the nut will remain at the previous level. The distance between the two is a measure of the amount of soil lost. If the nut is buried it indicates soil has moved in from elsewhere. **NOTE:** For OH&S consideration, mark the rod or its position so that staff can see it easily and are not injured by standing on it.

Photographs. This is an easy way to demonstrate change over time. Include land features for size comparison or to demonstrate the exact photo location. A GPS location or permanent marker can also be linked to a photo to obtain an exact position.

An erosion peg shows soil erosion that has occurred since the washer was placed at the original soil level.

Salinity

Most of Australia's banana production areas are free of salinity problems. However as the industry seeks new production regions for geographical diversification, this may become a greater issue in the future.

Some regions or particular farms within a region may experience salinity problems related to irrigation water.

Growers irrigating from underground water sources should test their water source and manage accordingly. To reduce the salinity of irrigation water, it may be possible to mix it with a better quality water supply.

Growers irrigating out of tidal reaches should avoid irrigating at high tide to ensure they are only using fresh water. It is also recommended that the water between high tides is tested to ensure the salinity levels are acceptable.

Use pH-amending products when necessary to maintain an appropriate soil pH.

Soil acidity and alkalinity

A pH (water) within the range of 6 – 7 is ideal for bananas. Depending on the farming location, this could be higher or lower without intervention. For example, at Carnarvon soils are naturally more alkaline (high pH), whereas in the Tropics soils are naturally more acidic (low pH). Bananas will grow outside of this range, although the closer the pH is to neutral, the better for production.

- Monitor your soil pH and test it at least annually. Continuity in a declining pH at lower levels in the soil profile may indicate that nitrate from ammonium based fertilisers is being lost in deep drainage or leaching.
- Apply soil amendments based on your soil test results to maintain an optimal pH. This will vary depending on your location (refer to the fertiliser section for more information).
- Incorporate pH amending products into the soil before planting.
- In low pH (acidic) conditions, lime and dolomite will help to increase the pH. In higher pH (alkaline) conditions, sulphur and ammonium products will help to reduce the pH level. Professional advice should be sought to test for and correct pH.
- In dry periods when spider mites are causing a problem, the extra dust from lime may provide conditions that increase mite populations. More frequent pest monitoring may be necessary in this case.
- Some fertilisers reduce pH, so the fertiliser program needs to be managed accordingly.
- pH conditions outside the optimum range (too acid or too alkaline) can restrict the availability of micro and macro-nutrients as well as influencing soil microbiology.

Lime and dolomite products will help to increase the pH.

Acid sulphate soils

Acid sulphate soils can harm banana production and can have a major impact on farm infrastructure. When exposed to the air, due to drainage or disturbance, acid sulphate soils release sulphuric acid and iron, aluminium and heavy metals. Acid sulphate soils are commonly found in areas that are less than 5 m above sea level. Mangroves, salt marshes, floodplains, swamps, wetlands, estuaries and brackish or tidal lakes are ideal areas for acid sulphate soil formation. The presence of acid sulphate soil may not be obvious on the soil surface and it is harmless unless disturbed. Therefore these areas should not be drained, cleared or exposed.

Source: Freshcare Environmental Resource

Sodic soils are dispersive when wet, which is visible as 'cloudy' water.

Sodicity

Sodic soils are generally not very suitable for banana production and unlikely to be used unless there is no other soil type available. Sodic soils have poor soil structure, which means they are prone to surface crusting or sealing, can have poor water infiltration and low water holding capacity. They are dispersive when wet, which is visible as 'cloudy' water, rather than the soil particles staying together. Drains will be susceptible to erosion if constructed on these dispersive soil types.

Gypsum, deep rooted plants and improving soil organic matter can help to improve the soil structure.

SUBTROPICS WEST COAST – Sodic soils are present in Carnarvon and therefore should be managed accordingly.

Soil contamination

Soil contamination occurs from persistent chemicals, old dips, dumps, heavy metals, fuels, oils or hydraulic fluid.

- On a farm map, identify areas that have been contaminated and ensure measures are in place to prevent soil from moving from these sites. Avoid these areas, maintain vegetation to prevent soil movement and if necessary fence or bund the contaminated area.
- Provide bunding or a containment method where products that could cause contamination are used.
- Control erosion on the site to help contain contaminated soil.
- Do not plant bananas in contaminated areas.

Avoid planting bananas in contaminated soil.

BIOSECURITY

Maintaining good farm quarantine practices is essential for managing many banana pests and diseases.

Managing disease

A number of pathogens and insects can cause damage in bananas. It is important to understand the pest or disease epidemiology and the risk pathways so you can manage potential points of entry.

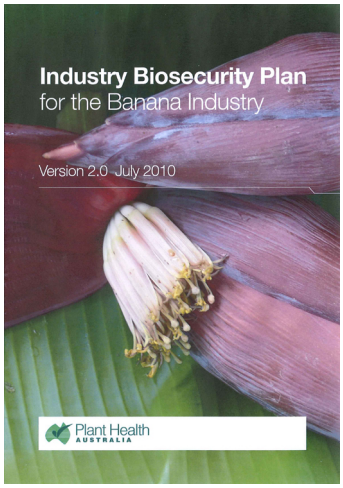
Adopt a quarantine-type approach to all farm practices –

- Do not allow visitors onto your farm without knowing where they've been.
- Install biosecurity signage at all farm entry points and critical points along the farm boundary. These signs should be easily visible and provide clear instructions for visitors.
- Provide a visitor car park and access point to limit contact with farm vehicles and machinery.
- Ensure equipment and vehicles are thoroughly decontaminated before entering and exiting your property. The link to the decontamination guide is https://publications.qld.gov.au/dataset/panama-disease-tropical-race-4-grower-kit/resource/566b02f0-eff4-4966-8da7-976c5e64dad6.
- Provide a wash-down pad to ensure machinery and vehicles are clean before leaving your property.
- Teach staff to identify disease symptoms and understand infection pathways, so they can be effective in helping to control the spread of disease.
- Only source plant material from trusted suppliers. Tissue cultured material is the safest form of planting material.
- Maintain records of the sources of all planting material. This enables trace-back for potential outbreaks.
- Inputs including organic green waste and soil amendments may contain disease. Source these only from a trusted supplier.

Decontaminating vehicles and machinery is critical for managing movement of soil and plant material.

The Banana Farm Biosecurity Manual is available at http://www.planthealthaustralia.com.au/wp-content/uploads/2015/03/Farm-Biosecurity-Manual-for-the-Banana-Industry.pdf.

Information about high priority exotic pests and diseases is available from Plant Health Australia. Follow the link below and scroll down to



The Banana Industry Biosecurity Plan provides information about exotic pests and diseases.

select the Pest Information Document Database link http://www.planthealthaustralia.com.au/industries/bananas/

The following link provides a "Risk Assessment Tool" allowing banana businesses to assess their preparedness to prevent and manage the spread of disease. The checklist can help businesses to identify potential pathways for disease infection, particularly Panama disease, and assess how prepared the business is to deal with these risks. The risk assessment tool is available from the Australian Banana Growers Council website http://abgc.org.au/projects-resources/industry-projects/best-management-practice-project/.

IPDM includes physical, biological, cultural and chemical control options.

PESTICIDES

Disclaimer: Chemical registration and permits vary between states. Always check the label or permit to ensure that a product is registered in your location for the intended use. This document should not be considered an authority to use a particular product.

Integrated pest and disease management

Banana growers should use an integrated approach to pest and disease management. Integrated pest and disease management (IPDM) includes the use of physical, biological, cultural and chemical control options.

Monitoring for pests and diseases enables timely and better informed decisions.

Regular monitoring of pests and diseases is essential. It enables better informed decisions to be made in a timely manner. In most instances, it also negates the need for calendar sprays and provides opportunities to consider control options other than chemical use, before the pest pressure gets too high.

Inappropriate use of chemicals can encourage some pest species, be harmful to personnel, the environment and, potentially, could reduce the product life if pest resistance occurs.

The banana industry has made significant advances in reducing chemical use by targeting applications and finding alternative methods for controlling pests. Some growing regions, such as Carnarvon, are virtually chemical-free as they exist in an environment that has very few pest and disease problems.

The next module is devoted to specific examples of IPDM that are used in the banana industry for our main pests and diseases.

Physical control

These include physical barriers and measures that are used either to eliminate completely or to make conditions less suitable for a particular pest or disease. Examples include:

- cultivating to control weeds
- regular deleafing and desuckering for leaf diseases
- applying bunch covers to protect the bunch from birds and bats, and to enhance the length of bunch treatment
- barring or gouging suckers

Regular desuckering is important for crop hygiene and disease management.

Biological control

Some pests and diseases have natural predators that help to control their populations. An obvious example in bananas is the use of *Stethorus* and *Halmus* for controlling spider mites. The Good Bugs


The adult lacewing is a predator of some banana pests.

website (www.goodbugs.org.au) is hosted by the Association of Beneficial Arthropod Producers Incorporated and provides information on commercially available predatory insects available in Australia and their suppliers. Care is needed when using natural predators because chemicals that are used to control pests and diseases are often also harmful to these insects and organisms.

Other organisms such as fungi and bacteria have demonstrated some level of control for certain banana pests, although they are not registered in the banana industry. Examples include *Beauveria bassiana* and *Metarhizium anisopliae* for banana weevil borer and *Paecilomyces lilacinus* for nematodes.


Good crop hygiene helps pest and disease management.

Cultural control

Cultural practices facilitate control by creating better growing conditions, encouraging indigenous organisms and generally making conditions less favourable for pests and diseases. Cultural practices include:

- rotating crops or using fallow crops to encourage a diverse range of organisms and break the life cycle of pests
- selecting banana varieties resistant to Race 1 Panama disease (Fusarium Wilt)
- maintaining good crop and farm hygiene
- limiting plant stresses, such as water and nutritional stress
- farm quarantine measures to keep pest and disease pressure low

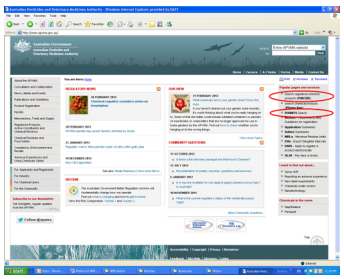

Use targeted application of chemical products when they are registered or permitted for this use.

Chemical control

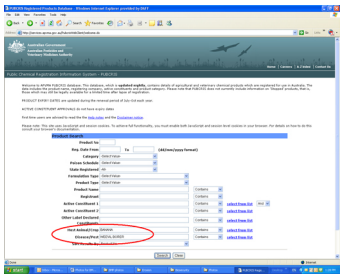
Despite concern over their use, pesticides are still important in many programs. Problems arise when people rely too much on pesticides or use them incorrectly. By being aware of possible benefits and risks of using pesticides, you can select, wisely, when, where, and how to use pesticides to your best advantage.

The Agricultural Chemical Users' Manual provides a wealth of information on topics such as product formulations, modes of action, resistance strategies, calibration and legislation. The manual is available at https://www.daf.qld.gov.au/__data/assets/pdf_file/0009/54738/AgChem-UsersManual.pdf.

Chemical activity tables for fungicides, insecticides and herbicides are available at Crop Life Australia's website www.croplifeaustralia.org.au These tables help to identify which chemical group a product belongs to, assisting in developing a resistance management program. Furthermore under the Resistance Management (RM) menu, there are some useful fungicide strategies for RM of Yellow Sigatoka in



The APVMA webpage enables searches for registered products and products with a minor use permit.



The APVMA's PUBCRIS webpage provides information about registered products for bananas.

Rotate chemical groups to avoid pest and disease resistance.

FNQLD and elsewhere, as well as a non-region specific RM strategy for insecticides and other integrated controls on Banana Weevil Borer and Rust Thrips.

Chemical treatments

When chemicals are used care should be taken to avoid environmental damage both on and off-farm. The potential impact that a chemical could have depends on the toxicity of the chemical used, the method of application, the potential movement of soil and the length of any buffer/filtration zone that surface water passes through.

Use permitted chemicals according to the label or permit directions. Only chemicals that are registered for use in the banana industry should be used. Registrations vary from state to state, so it is important to confirm where a particular product and its use are allowed. The product label or permit will provide information on how the product should be used. Always read the label and follow all instructions the company provides. To find which chemicals are registered or have minor use permits for bananas, visit the Australian Pesticides and Veterinary Medicines Authority (APVMA) webpage http://apvma.gov.au/.

For registered chemicals search the PUBCRIS database https://portal.apvma.gov.au/pubcris.

For minor use permits search the PERMITS database https://portal.apvma.gov.au/permits.

Tips for searching the PUBCRIS database. If you want to know if a particular product is registered enter 'banana' rather than 'bananas', as the latter search will ignore any products registered for banana without the 's' while the first will include both spelling options. Either enter the product name/active constituent or the pest.

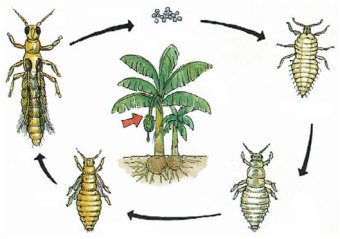
Searching tips for PERMITS. Enter any information that is known, such as the crop, pest, product/active ingredient and also the permit number if it is known. Be careful when searching for permits as they may be for specific states only, so be sure to read the permit carefully.

Rotate chemicals to avoid resistance. Rotate chemical groups to avoid pest and disease resistance. Within every population, some individuals will have resistance or increased tolerance to a particular product due to genetic variability. With repeated use of this product, the tolerant population will become dominant. Some chemicals are registered for a number of pests and application methods. Relying on the same chemical to treat a number of pests may also lead to resistance.

Understand the chemical groups. Although two chemicals may have different 'active' ingredients they may still be from the same 'chemical group'. Be aware which group each chemical you use is

Biodegradation occurs when microorganisms use the chemical as a food source, reducing its effectiveness.

The correct volume of spray is essential for good coverage.



The pest can only be effectively controlled if the lifecycle is understood.

categorised under to avoid overuse. For information on herbicide, insecticide and fungicide modes of action and classification refer to the Crop Life Australia website at http://www.croplife.org.au/.

Rotate soil-applied pesticides to avoid biodegradation. Biodegradation occurs when microorganisms use the chemical as a food source, prematurely denaturing the product and reducing its effectiveness. Biodegradation is associated with repeatedly using the same chemical or closely related chemicals.

Record the chemical being used and application dates. While it is a requirement that producers record their chemical applications under their quality assurance schemes and in some cases legislation, keeping records also helps to ensure that chemicals are not overused. Review your spray records and consider whether improvements could be made in terms of rotating chemicals, timing applications, method of application and the number of applications.

Chemical coverage. It is important to get pesticides to the target insect or disease. Insufficient coverage can result in poor control and the development of resistance. Check the spray equipment is well calibrated and that the correct nozzles are used and working efficiently before application. Ensure the product is applied at the correct rate and concentration, following all recommendations on the label.

Target treatment. Some products are registered for targeted application. Where registration allows, target chemical applications to reduce the impact on beneficial organisms and the environment. Bell injection is an example of how the banana industry has targeted the application of a product and greatly reduced the total amount of chemical used.

Monitor pests and diseases. This will ensure chemical treatments are only applied as required and the effectiveness of treatments can also be assessed. Monitoring should be carried out by a trained person, either a contractor or trained staff member. The prevalence of pests and disease and the season will determine how often this is required. Monitoring also helps to identify hot spots, which enables pests and diseases to be detected early on. Over time, monitoring will allow you to build an understanding of the environmental conditions and times when pests and diseases occur and concentrate your monitoring efforts accordingly.

Thresholds. Understand the principle of treating at threshold as sometimes the chemical cost may be greater than the damage caused by the pest. It is important to maintain a monitoring program to determine when these thresholds are met.

Life cycle and epidemiology. Understand the pest life cycle or the disease epidemiology (*the way the disease and pest interacts with the host and surrounding environment*). If you understand how the pest or disease functions, you can control the problem more effectively.

Chemicals should be stored in a specifically-designed and designated area.

Chemical toxicity to beneficial organisms. Many indigenous organisms provide some level of control against pests and diseases. Therefore we need to be mindful of these populations when applying chemicals and performing certain practices that may be detrimental to their survival. More information on the toxicity of certain chemicals to beneficial insects is available from the Australasian Biological Control Inc. at http://www.goodbugs.org.au./.

Obtaining, storing, handling, applying and disposing of chemicals

Obtaining chemicals

- Source chemicals only from an Agsafe accredited supplier, or similar.
- Do not accept chemicals if the seal or container is broken.
- Do not accept chemicals if the label is missing or illegible.

Storing chemicals

Ensure the chemical storage area is located away from waterways and flood-prone areas.

- Ensure the chemical storage area is located away from waterways and flood-prone areas.
- The chemical storage area should be ventilated, structurally sound and segregated, by some means, from other activities.
- The chemical storage area should be bunded and the floor impervious, to prevent spills from contaminating adjacent land and waterways.
- Segregate flammables from non-flammables, keep chemicals out of direct sunlight and away from materials that burn readily like oils, hay, straw and tall dry grass
- The storage area should be locked when not in use to prevent access to those not trained in the correct use of chemicals.
- All chemicals should be stored in their original container, with the label intact.

There is a phase out of the term MSDS and they are soon to be referred to as SDS.

- Safety Data Sheets (SDS) should be obtained for all chemicals stored and used on the property. These are available online or from the chemical supplier. SDS's should be kept in an easily accessible location in case of an emergency. Do not store them in the chemical storage area in case there is a fire.
- Have a chemical spill kit near the chemical storage area. You can purchase the kits or, if you make them up, they should include:
  - clearly labelled water proof container
  - sand, vermiculite or hydrated lime

Only appropriately trained staff should handle and apply pesticides.

- shovel
- broom
- bucket
- gloves
- respirator

Handling and applying chemicals

- Only allow the staff trained in the safe use and handling of chemicals to have access to chemicals.
- Read the product label and SDS before using and apply the chemicals following the directions on the product label and/or minor use permit.
- Ensure the appropriate protective equipment is used for safe handling.
- Consider using equipment and tools that make mixing safer and easier. A platform next to the tank provides easier access during filling and mixing, and will help to prevent accidental spills.
- Ensure chemicals are mixed or decanted away from waterways or flood-prone areas.
- Do not leave tanks unattended while they are filling, to avoid accidental spills.
- Be aware of any withholding periods (WHP) for the products you use to ensure that the maximum residue limits (MRL) are not exceeded.
- Prepare only enough chemical for anticipated use. This is not such an issue in the subtropics, where chemicals are often applied from knapsacks, or on the west coast, where very little chemical is used.
- Calibrate and maintain the equipment regularly to ensure that the application rates are correct and to prevent leaks.

Only appropriately trained staff should apply spray treatments.

Chemical training

- Train the staff responsible for chemical application to handle, store, mix and apply chemicals correctly, and under the correct weather conditions. Ensure they have completed the appropriate recognised training.
- A number of organisations can provide this training, including Chemcert® http://www.chemcert.com.au/. and SMARTtrain http://www.smarttrain.com.au./.

Triple rinse and store drums in a suitable location until collected using the DrumMUSTER® scheme.

- Check your state's specific requirements: some states require all personnel who use chemicals to have recognised training, for example, New South Wales.
- Freshcare requires that these competencies are included in all farm chemical user training qualifications:
  - AQF Level 3 – AHCCHM304A – Transport, handle and store chemicals
  - AQF Level 3 – AHCCHM303A – Prepare and apply chemicals

Disposing of chemicals and containers

- Refer to relevant SDS and product labels for disposal information.
- Add hydrated lime to waste pesticides, and dispose of them on the banana plantation floor, well away from waterways, drains or low lying areas.
- Triple rinse chemical containers, pouring the rinsate into the spray tank and store in a suitable location until delivery to your local waste facility or drumMuster receival depot. Cleaned caps or lids can also be disposed of through drumMUSTER®, see www.drummuster.com.au
- Book any unwanted or no longer registered chemicals into the ChemClear® program at www.chemclear.com.au. There is no charge for currently registered chemicals (or chemicals within 2 years of deregistration) in drums that carry the drumMuster logo but there is a fee for deregistered chemicals like endosulfan etc.
- Service providers can design a waste minimisation plan that is tailored to your business.

The finer the droplet size, the greater the potential for drift.

For more information about the responsible use of chemicals, refer to the Agricultural Chemical Users' Manual, pages 35 to 45 at the link below https://www.daf.qld.gov.au/__data/assets/pdf_file/0009/54738/AgChem-UsersManual.pdf.

For legislation about chemical use relevant to each state:

- Queensland - http://www.legislation.qld.gov.au/OQPChome.htm.
- New South Wales – http://www.legislation.nsw.gov.au
- Western Australia – http://www.legislation.wa.gov.au
- Northern Territory – http://www.legislation.nt.gov.au

Search the databases under 'A' for Agriculture and Veterinary Chemicals.

Aerial application is common in the tropical regions of the banana industry.

Spray drift

Spray drift can occur from either ground or aerial application. The recommended practices are:

- Ensure that the weather conditions are suitable before spraying and be prepared to stop spraying if conditions change.
- Record wind speed and direction when spraying and keep these records for a number of years in case claims are made against a particular spray activity in the future.
- Consider where rows begin/end at the planting stage to prevent over-spraying onto sensitive areas such as environmentally sensitive areas, roads and buildings.
- Ensure appropriate droplet size for the target. Coarser droplet size reduces the potential for off target drift.
- Do not spray beside roads when traffic is present, whenever possible.
- When ground-spraying, ensure that the spray is turned off at the end of each row and while the tractor is turning. This will prevent spraying off-target.

For more information on spray drift, refer to the Agricultural Chemical Users' Manual, pages 88 to 99 at the link below https://www.daf.qld.gov.au/__data/assets/pdf_file/0009/54738/AgChem-UsersManual.pdf.

Aerial application

Aerial operators are often faced with difficult spray situations to ensure that the crop is evenly covered while also avoiding spray drift. These situations or 'obstacles' include:

Understand what is achievable for the aerial operator.

- environmentally sensitive areas
- power lines
- tall structures such as communication towers, aerials, wind turbines
- houses and buildings
- neighbouring crops
- tree lines
- public roadways and people stopping in vehicles to watch
- people or vehicles within crops that are being treated
- changing weather conditions

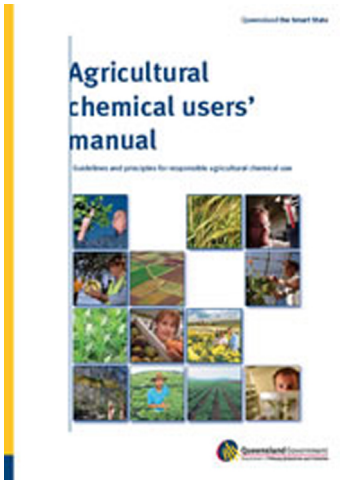
Work with your neighbours to arrange suitable times for aerial application.

- Talk with your aerial operator, find out what issues may be present at your property and discuss measures to address them before application commences.
- Complete a spray request order form. Preferably, the Aerial Operator will supply you with their standard form, which lists the appropriate questions that they need to ask you to ensure a safe and accurate application.
- Supply the aerial operator with a current, detailed map, clearly showing the target area and the location of any obstacles that are listed above.
- Ensure that all the chemicals requested are registered not only for bananas but also for aerial application.
- Understand what is achievable for the aerial operator in geographical terms as well as the set time frames.
- If you have identified some obstacles from the list above, you may need more than one wind direction to achieve an even coverage. This means the operator will have to come back at a later time.
- If residences or buildings neighbour your property, where possible, spray at times that will minimise disturbance.
- By law, aircraft are not allowed to operate within 100 m of a residence. This distance can be breached if there is a signed agreement between the aerial operator and the person in residence.
- In New South Wales, this buffer increases to within 150 m of a residence with respect to **spraying**, not just general flying.

Ensure that all staff are notified of an imminent aerial application.

- Work with your neighbours as much as possible to arrange suitable times for aerial applications.
- Particular attention should be given to public areas near the treatment area. This includes schools and community gathering areas.
- Ensure that all staff are notified of an imminent aerial application and that a time is set for all staff to be away from the treatment area.
- Be aware that in some instances it may be preferable for the aerial operator to turn the spray off early and tidy up the block edges with a separate run in a different direction.
- Aerial operators have a number of tools to assist them manage spray drift. Talk to your operator so you understand how they manage spray drift. Possible tools they can use include:
  - smoke generators to check the wind direction

Trees provide a 'buffer' zone that filters spray droplets.



Agricultural chemical users' manual.

- GPS facilitates flying in relation to the wind, rather than row direction
- flow regulators that give a more uniform coverage
- droplet regulators for more uniform droplet size

- Remain contactable to your aerial operator beforehand and throughout the application. If this is not possible, advise the aerial operator of an alternative contact.
- Ask your aerial operator to confirm when the job has been completed.
- Only use reputable contractors for aerial spraying.

The Aerial Agricultural Association of Australia (AAAA) maintains its own industry accreditations. Check with your chosen aerial operator that they are appropriately licensed to complete the application.

If the operator does not hold the minimum standard of AAAA Spraysafe Accreditation, then consider, carefully, which standards the operator is working to. It is advisable to check that your chosen aerial operator has at least one of the following AAAA industry accreditations:

- *Spraysafe Accreditation.* This is the minimum standard set by industry for aerial operators. It is based on a self-audit and overseen by the AAAA.
- *Aerial Improvement Management System (AIMs) Accreditation.* This is the highest standard set by industry for aerial operators. It is based on a stringent and complex BMP and is independently audited. Operators who are accredited with AIMs are required to display a high professional standard and a sound knowledge of all aspects of aerial applications, and are benchmarked to the highest industry standards.

Maintain and calibrate equipment

- Ensure equipment is maintained and calibrated regularly, and record when this occurs.
- Ensure the nozzles used are appropriate for the type of product being applied.

For more information on how to calibrate spray tanks refer to the Agricultural Chemical Users' Manual, pages 74 to 87, at the link below https://www.daf.qld.gov.au/__data/assets/pdf_file/0009/54738/AgChem-UsersManual.pdf.

An IPDM program details how pests and diseases will be managed.

Buffer zones

A buffer of trees along the paddock edge helps to filter out spray droplets. Air should be able to move through the buffer as the plant foliage captures the droplets. If planting buffers, always allow extra room along the edge of the treatment area for aircraft to fly safely.

- Solid or very dense buffers are not effective because the wind cannot pass through, so it rises up and over the buffer instead.
- She-oaks (*Casuarina* species) are suitable as buffers because they have a large surface area to capture the droplets, while air passes through them.

More information on design and plant selection for buffer zones is available in the agriculture note "Using buffer zones and vegetative barriers to reduce spray drift," located on the Victorian Department of Primary Industries website, or by following the link http://agriculture.vic.gov.au/agriculture/farm-management/chemical-use/agricultural-chemical-use/spraying-spray-drift-and-off-target-damage/using-buffer-zones-and-vegetative-barriers-to-reduce-spray-drift.

Monitoring and recording

Integrated Pest and Disease Management. An Integrated Pest and Disease Management (IPDM) program for all major pests and diseases should be developed. It should give details about how pests and diseases will be managed on the property.

Monitoring records. Keep all pest and disease records to monitor any trends over time, and to provide a record of spray recommendations.

Chemical records. Record all chemical activities, including post-harvest chemical applications.

Chemical storage inspection. Inspect the chemical storage area annually and keep the records.

Authorised personnel. Keep a record of personnel authorised to store, handle, apply and dispose of chemicals. Keep a copy of this record at the chemical storage area.

Cut banana roots showing typical symptoms of burrowing nematode damage.

BANANA INTEGRATED PEST AND DISEASE MANAGEMENT

This section provides examples of different IPDM management options for the main pests and diseases in bananas.

Nematodes

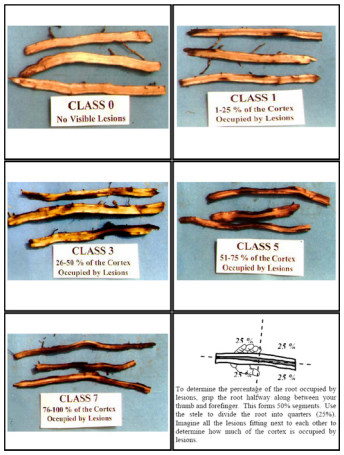
A number of different plant-parasitic nematodes affect bananas. The predominant nematode species varies from farm to farm and across production regions. Therefore it is essential growers identify which nematodes are present before selecting a control option. The table shows the main and secondary nematode problems in each production region.

Much of the nematode population in the soil is actually beneficial.

Nematodes present in each region (✖ main; ✕ secondary)

	Burrowing	Root knot	Spiral	Lesion	Reniform
Tropics Qld	✖	✕	✕		✕
Tropics NT		✕	✕		
Subtropics East	✖		✕	✖	
Subtropics West		✖	✕		

✖ main – potential to have major impact on production; ✕ secondary – present.



Root Disease Index for calculating the level of impact burrowing nematodes are having.

Not all nematodes are plant parasites. Much of the nematode population in the soil is actually beneficial. This means it is important to minimise the impact of farming practices on these beneficial nematodes.

Monitoring burrowing nematode damage using the Root Disease Index (RDI). Assessing the level of nematode damage present in a banana crop is a useful way to determine if treatment is required, and which treatment best suits the conditions. A RDI greater than 10 means the nematodes are having an economic effect, while an index greater than 35 means the impact is so significant the bananas should be knocked out and replanted. The Burrowing nematode management booklet provides information on how to calculate a RDI and can be accessed at http://abgc.org.au/wp-content/uploads/2013/04/Managing-banana-nematodes_edited-version.pdf.

Physical control

Limit cultivation. Plant-parasitic nematodes colonise more quickly than some beneficial nematodes. Therefore, if the soil is continually being disturbed the number of beneficial nematodes will decrease, allowing the plant-parasitic nematodes to increase rapidly when bananas are re-planted.

Injecting the banana crop with glyphosate removes the food source for plant-parasitic nematodes.

Completely eradicate all banana material from the fallow crop. Nematodes can continue to live on small corm pieces, small volunteer plants and some broad leaved weeds. Previous trials have demonstrated plant-parasitic nematodes can survive for more than 6 months when corm and root material is buried and there is no plant material above the surface. Stem injection with glyphosate for crop removal is effective. Plant-parasitic nematodes need to feed on live plant material, so this practice removes their food source. All volunteer banana plants should also be treated to prevent 'hot spots' from developing. **WARNING** – Suckers have been known to translocate glyphosate back into the mother plant, so care is needed if hanging bunches remain in the paddock. When the plants have softened sufficiently, run over them with discs to prevent problems with banana weevil borer or rats. The permit for glyphosate use in the banana industry is available at the Australian Pesticides and Veterinary Medicines Authority website by searching the permit database for permit 11733 or by following this link http://permits.apvma.gov.au/PER14850.PDF.

Plant parasitic nematodes can survive for more than six months on small pieces of disced corm material.

Biological control

Encourage a diversity of microorganisms. Parasitic nematodes have a lot of natural enemies, including nematode-trapping fungi and predatory nematodes. Increasing organic matter inputs to the soil (such as green manures in fallows and leaf and stem trash on the row) encourages a diversity of microorganisms, some of which will prey on plant-parasitic nematodes. Limiting cultivation and nitrogen applications will also help the beneficial nematode populations.

Cultural control

Clean plant material. This is especially important when cultivating new ground. Tissue cultured plants from a QBAN accredited nursery is the only way to be certain the material is free of nematodes. If using bits or suckers remove the attached soil, trim the material well and treat with a chemical or hot water if necessary. If the preference is to use bits, consider using tissue cultured plants to establish a nursery plot.

Using tissue cultured plants is the only way to be certain the material is free of nematodes.

Encourage organic matter. A healthy soil encourages a diverse range of soil organisms capable of managing low populations of plant-parasitic nematode.

Non-host fallow crops. This is the most effective control measure as it removes the food source for the plant-parasitic nematodes and subsequently breaks the life cycle. It is critical that all volunteer bananas are removed otherwise hot spots will remain in the plant crop. Non-host crops will only affect the plant-parasitic nematodes, because other beneficial nematodes feed on soil organisms and will continue to survive.

Rhodes grass is an ideal fallow crop.

Non-host fallow crops – burrowing nematodes

- Callide and Katambora Rhodes grass are suitable fallow crops for burrowing nematodes and they also make good green manure crops, adding organic matter to the soil. Rhodes grass requires a minimum fallow period of 6 months, although the longer the period, the better the result. Rhodes grass can be planted all year round.
- Brassica crops such as BQ Mulch and canola provide a short-term fallow crop option. However, they can only be planted in the cooler months and they do not provide much organic matter. BQ Mulch is best planted from April to June in the tropics and canola can be planted up until the end of July. Later plantings will result in a very short crop cycle as the plants prefer cooler conditions.
- Other brassica crops such as oilseed rape are also good non-host crops although they may be more difficult to source.
- It is commonly believed that brassica crops such as BQ mulch and canola control plant-parasitic nematodes through biofumigation. Biofumigation is the production of isothiocyantes from the break-down of plant tissue. However, this effect is only secondary, compared with the roots' resistance to burrowing nematodes.

Non-host fallow crops – other nematodes

- Less work has been carried out on determining non-host crops for other plant-parasitic nematodes in bananas. Based on work to date, Jumbo sorghum and Katambora Rhodes grass are the best fallow crop options for root knot nematodes. Avoid Biofumigator sorghum, as pot trials demonstrated it was in fact a host of burrowing and root knot nematodes.

Burrowing nematodes can be managed by growing a non-host fallow crop like canola in the fallow period.

Chemical control

An integrated approach is the best control option for plant-parasitic nematodes by:

- eradicating the banana crop with glyphosate
- controlling volunteer bananas
- planting a non-host fallow crop
- sourcing clean planting material (tissue culture is best)
- managing soil movement across the farm

First use an integrated system. Best results are achieved by using an integrated system with the practices mentioned above. However, where nematode problems are inherited, or it is not feasible to knock out the block, nematicides will provide some level of control.

Nematicides are harmful to the entire nematode population, which includes the beneficial nematodes.

A high RDI score. If nematodes are present in a ratoon block and a Root Disease Index (RDI) shows a score of above 35, consider knocking out the block and planting a non-host fallow crop, rather than treating with chemicals.

Nematicide application. Extreme care is needed when using nematicides due to their high toxicity and application method. Rotate between registered products to avoid building up nematode resistance or enhancing biodegradation issues.

Nematicide efficacy. Nematicides are harmful to the entire nematode population, which includes the beneficial nematodes. Calculations carried out by Queensland Government researchers showed nematicides are not always cost-effective when chemical and application costs are considered against the level of control they provide.

Banana weevil borer

Banana weevil borer damage to corm of banana plant.

Activity peaks for banana weevil borer occurs from September to October and from March to April. During the cooler weather, weevil borers are less active and retreat into the plant. Banana weevil borers prefer to feed on decaying material, so they will be at a higher pressure level after weather events causing serious plant damage (storms and cyclones), and in blocks where farm practices have broken stems or damaged corms (e.g. 2-4,D and mechanical desuckering).

Physical control

Completely eradicate all banana material from the fallow crop. As with nematodes, Banana weevil borers can continue to live on small pieces of plant material and small volunteer plants. Stem injection with glyphosate for crop removal is effective as it completely destroys the banana plant. All volunteer banana plants should also be treated to prevent 'hot spots' from developing. **WARNING** – Suckers have been known to translocate glyphosate back into the mother plant so care is needed if hanging bunches remain in the paddock. When the plants have softened sufficiently, from the glyphosate, go over them with the discs to remove material that may be a potential harbouring ground for banana weevil borer. This is critical as decaying material can potentially attract more banana weevil borers. The permit for glyphosate use in the banana industry is available at the Australian Pesticides and Veterinary Medicines Authority website by searching the permit database for permit 11733 or by following this link http://permits.apvma.gov.au/PER14850.PDF.

Banana corm material can harbour pests from one banana crop to the next, so it is better to remove the crop with glyphosate.

Biological control

General predators. The large range of general predators includes ants and earwigs. However, they are not often in sufficient numbers to provide control on their own.

Using tissue cultured plants ensures pests are not introduced with the planting material.

Pheromone baits can be used to lure banana weevil borer.

Rapid decay of the harvested stool is a sign of banana weevil borer activity.

Cultural control

Fallow period. Leave a sufficient fallow period to allow all plant material from the previous crop to decay before replanting. Best practice would include a fallow crop.

Fallow crop. Incorporating a fallow crop in the crop cycle helps provide ground cover and organic matter, while providing sufficient time to ensure all banana material is broken down. It also eliminates volunteer bananas that could carry banana weevil borer from one crop to the next plant crop.

Clean planting material. This is especially important when cultivating new ground. Tissue cultured plants are guaranteed to be free of banana weevil borer. If using bits or suckers trim the material well, making sure material with any evidence of banana weevil borer damage is not used. Remove any attached soil and treat with chemical if necessary.

Baits. Consider using stem baits or pheromone baits to monitor banana weevil borer populations. Baiting is most effective in autumn and spring when the banana weevil borer is most active. Banana weevil borer pheromone lures and traps are available from Bugs for Bugs. Trials are underway to determine the best strategy to use these in Australian production systems https://bugsforbugs.com.au/product/banana-weevil-borer-trap-pheromone/.

Stem decay. Rapid decay in harvested stool stems is also a sign of banana weevil borer activity. If the harvested stool is completely broken down before harvesting the following bunch, then banana weevil borer activity is likely.

Desuckering. Banana weevil borers are attracted to the volatiles in corms and stems and consequently, desuckering with 2,4-D and also gouging will attract banana weevil borer. If using these methods for desuckering, time the banana weevil borer control to coincide with desuckering.

In the subtropics east coast. Some growers cut the harvested pseudostems down the centre lengthways, so they break down more rapidly, and also lure the banana weevil borers away from the plants.

Chemical control

Targeted treatment. Stem injection is a more targeted treatment for banana weevil borer. Clothianidin (e.g. Shield®) and imidacloprid (e.g. Confidor® Guard) are registered for stem injection. However, it is important to rotate chemicals to prevent potential resistance in banana weevil borers. Both products belong to Group 4A (neo-nicotinoids), which means they are not suitable substitutes for each other in a rotation program.

Banana weevil borers are more active in warmer weather. During cool weather they shelter inside the plant. Choose an application method to suit.

Mite flare-ups. Some chemicals used for managing banana weevil borer have been known to cause mite flare-ups, so use these products in periods of low mite pressure, supported by a regular mite monitoring program.

Injecting the harvested/spent stem. During cooler weather, banana weevil borers shelter inside the banana plant. This is an ideal time for targeted stem injection into previously harvested stems, before the banana weevil borers move out over spring. This targeted application is restricted to New South Wales and allowed under approval number 33087 as per the Tokuthion® label. This label can be found on the Australian Pesticides and Veterinary Medicines Authority (APVMA) website, by searching the PUBCRIS database for product number 33087, and selecting view label https://portal.apvma.gov.au/pubcris. **Targeted injection into the harvested plant is only registered for use in New South Wales.**

Band spray applications. Applying insecticides adjacent to the plant aims to kill banana weevil borers as they move around the corms to feed and lay eggs. Therefore this treatment works best in spring or autumn when the banana weevil borers are more active. Most products are absorbed into the soil more efficiently if applied to moist soil, so application after light rainfall or irrigation is often recommended. Read the label carefully before applying, to ensure the spray is used correctly.

Toxicity. Some products are very toxic. Follow all label instructions carefully, and ensure appropriate personnel are trained and aware of the correct application method. This includes any products that need to be applied at least 24 or 48 hours before rainfall. Avoid soil applications in periods of high risk rainfall to avoid the product moving into the surrounding environment and watercourses.

Applying bunch covers early on protects bunches and lengthens the life of spray treatments.

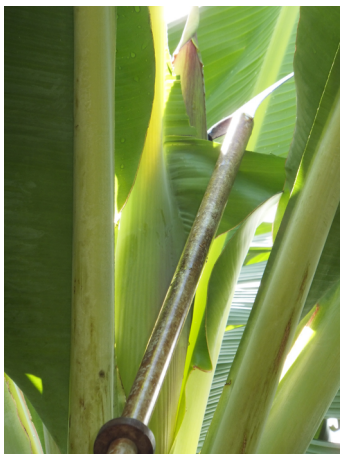
Bunch pests – flower thrips, rust thrips, scab moth, sugarcane bud moth

Physical control

Bagging. Bagging the banana bunch enhances the longevity of bunch treatments against rust thrips and other minor bunch pests, and provides some control as a physical barrier.

Biological control

General predators. Several general predators (ants, earwigs and lacewings) can provide some level of control. These alone are not considered sufficient to control bunch pests during high pest pressure in the tropical production regions. However, they may provide acceptable levels of control in the subtropics.



Targeted application using bell injection has significantly reduced the amount of chemical used in the banana industry.

Trimming leaves away from emerging bunches can prevent easy access of rust thrips

Softer chemicals are now registered for control of rust thrips as a bunch spray.

Obtaining beneficial insects. A number of companies supply beneficial insects. The Good Bugs website (http://www.goodbugs.org.au./) is hosted by the Association of Beneficial Arthropod Producers Incorporated and provides information on commercially available predatory insects available in Australia and their suppliers.

Products. The spinosad (e.g. Success®) and spinetoram (e.g. Success Neo®) chemicals are derived from a soil bacterium, and they are registered for bunch spraying in bananas. A resistance strategy needs to be in place and both products belong to Group 5, so they are not suitable substitutes for each other.

Cultural control

Trimming leaves. Keep leaves trimmed and away from emerging bunches to prevent easy access for rust thrips.

Timing activities. Increase the frequency of bell injection, bunch treatments and bagging during warmer weather so these activities are carried out at appropriate times. In the tropics, weekly bell injection and bagging is recommended. However, during warmer weather, this may need to increase to every 4 or 5 days, depending on growth rates. This ensures the bell is treated when it is still upright.

Monitoring. The presence of rust thrips can easily be identified by inspecting the banana pseudostem. Fresh feeding marks appear as a reddish colour, while older feeding marks have a dark brown appearance. To inspect for the presence of live rust thrips, look for fresh feeding marks and pull the petiole back, as the thrips shelter in these areas.

Chemical control

Targeted treatment. The banana industry has reduced, significantly, the amount of insecticides used by introducing bell injection, which allows targeted treatment of bunch pests such as flower thrips, scab moth and rust thrips.

Softer chemicals. Products such as spinosad (e.g. Success®) and spinetoram (e.g. Success Neo®) are now registered for the control of rust thrips as a bunch spray. Both chemicals exist as Group 5 (spinosyns), so they cannot be substituted for each other in a rotation program. Products containing Bacillus thuringiensis (e.g. DiPel®) are also available to control caterpillars and the label indicates general use conditions for fruit crops.

Emulsified concentrations (EC). These should never be used on the bunch as this will cause burn. A number of chemicals registered for use in bananas have different formulations. Ensure you use the correct formulation.

Vegetation in the inter-row helps in the management of spider mites.

Band/stool applications. Some band or stool applications for banana weevil borer will also help to manage rust thrips populations. Rust thrips pupate in the soil, so soil applications help control the portion of the population present in the soil, not the population present on the plant.

Timing treatment. It takes 30-60 days for all rust thrips on the plant to go through the soil pupation phase. This means soil pesticide applications should be scheduled to allow sufficient lead time for the population to reduce.

Spider mites

Spider mite is a pest on banana leaves in tropical regions and a pest on leaves and bunches in the subtropics. Certain conditions favour spider mites and allow them to become a problem. These include the environmental conditions, plant stress or increased spider mite fecundity (reproductive capacity). The conditions most favouring spider mites are:

- hot, dry and dusty conditions
- water stressed plants
- applying high rates of nitrogen (learned from extensive field observations)
- using pesticides that disrupt mite predators
- using chemicals that increase spider mite egg laying

Physical control

Maintaining vegetation in the inter-row. Slashing the inter-row helps manage spider mite populations. The grass provides an alternative host crop for the spider mites and their predators, and also helps to stabilise the temperature and humidity in the block, reducing stress on the banana plant.

Adult Stethorus is a spider mite predator.

Biological control

Predatory insects. Of all the banana pests, spider mites are the most commonly controlled with beneficial insects. Lady beetles such as *Stethorus* and *Halmus* are common predators and very effective at controlling spider mites. Mite predators are very sensitive to many chemicals, so spraying for spider mites will also have an impact on these beneficial insects.

Introducing predatory insects. You can buy predatory mites such as *Phytoseiulus persimilis* to help control spider mite populations. The Good Bugs website (http://www.goodbugs.org.au./) is hosted by the Association of Beneficial Arthropod Producers Incorporated and

Monitoring the underside of the leaf is essential for judging when mite treatments are required.

provides information on commercially available predatory insects available in Australia and their suppliers. For this approach to be successful, the beneficial insects need a food source when they are released. Therefore it is probably best to release them in spring.

Cultural control

Avoid plant water stress. Water stressed plants are more susceptible to a mite outbreak, so a regular irrigation program is essential during dry weather.

Applying nitrogen. Excessive nitrogen applications can cause spider mite flare-ups. Small and frequent applications of nitrogen are preferable to larger applications. It is recommended that raw manures are composted to avoid a potential nitrogen peak.

Regular monitoring. Monitoring mite and predator populations is essential to control spider mites effectively.

- It is not necessary to treat whenever spider mites are present, but rather when thresholds are met, and the beneficial *Stethorus* and *Halmus* lady beetles are not present or unable to control spider mites on their own.
- It is important to inspect plants regularly, especially during hot and dry conditions, as spider mites can multiply rapidly. During conditions favourable to spider mites, weekly monitoring may be necessary.
- Look for the presence of spider mites on the underside of leaves, with the help of a hand lens, or turn the leaves into the sunlight.
- The leaf number that the spider mites are present on is important. Spider mites will start feeding on older leaves and move up the plant. Their presence on the cigar, first or second leaves indicates a very high pressure.
- Look for the presence of *Stethorus* and *Halmus* and note the age of the youngest leaf they are present on. If predators are present on the same, youngest leaf as the spider mites, it indicates they are keeping up with them and treatment may not be necessary.
- Be aware of hot spots on your farm and regularly check these sections.
- Rapidly growing plants (i.e. at the pre-bunching stage) are often targeted by spider mites so include these plants in any monitoring efforts.
- Feeding marks alone are not an effective monitoring method as they may only indicate old damage and not the presence of live mites.

Feeding marks alone are not an effective monitoring method as they may only indicate old damage.

An application rate of at least 500 L/ha is required to provide acceptable coverage.

Chemical control

Correct application rates. This is essential for good coverage, which is required to get an effective kill and subsequently avoid resistance. An application rate of at least 500 L/ha is required to provide acceptable coverage. If you do not want to recalibrate your mister, leave it on the current settings and travel each row in both directions. **NOTE:** This may seem time consuming but it is better to not apply miticides at all, rather than apply them incorrectly, as this creates a resistance problem for you and your neighbours.

Prevent resistance issues. Rotate chemical groups and do not overuse a chemical in a single season. Clofentezine (e.g. Apollo®) should only be used once per season.

Products resulting in mite flare. The application of some products can cause spider mite populations to increase, either by knocking out predators or by increasing mite fecundity. Care is required when applying broad spectrum insecticides to the leaves and some systemic products to the stem.

SUBTROPICS EAST COAST – Growers in the eastern states may find the chlorpyrifos strips (Suscon® strips) useful for banana russet mite.

Severe soldier fly damage.

Soldier fly

Very little is known about this pest. Soldier flies were formerly only a banana pest in New South Wales, but they were first detected on a commercial banana operation in Far North Queensland in 2011. It appears that at least two species of soldier fly are causing damage to bananas. Currently, there are no commercially viable control options.

Soldier flies damage the banana skin when the female oviposits (lays eggs) on the fruit. This means multiple fingers in a single hand or several hands in the bunch can be affected.

Cultural control

Delayed application of bunch cover. Egg lay by the female soldier fly occurs very early in bunch development, generally before the bracts have fallen. Anecdotal evidence in far north Queensland suggest that delaying the application of the bunch cover until after bract fall produces a bunch environment less attractive to the soldier fly. This delayed bagging theory was not supported by some growers from New South Wales, but we now understand there are probably two different species, one in each region.

Banana leaves infected with yellow Sigatoka.

Chemical control

There are no chemicals registered for the control of soldier fly in bananas. The difficulty in treating this fly with a chemical is that the fly does not feed on the fruit; the damage is caused during egg lay. Therefore, unless the chemical comes directly into contact with the fly it will not be effective.

Leaf diseases – yellow Sigatoka, leaf speckle, leaf rust

Physical control

Reduce disease levels. A regular deleafing program is essential for removing infected leaves and maintaining low levels of disease in the paddock and across the farm. Disease is more easily managed in lower plant density, or where plant to plant contact is minimised. Regular deleafing and desuckering is essential to control yellow Sigatoka. While it is important to maintain leaves going into winter in the subtropical growing regions, east coast growers affected by yellow Sigatoka will benefit from removing infected leaves; this will reduce further infection and ultimately provide more green leaves.

Remove potential sources of infection. Knock out or inject older blocks once they are no longer being managed to prevent them from becoming a potential source of infection. If a block is to be knocked out and the last few bunches are still hanging, consider injecting the rest of the block with glyphosate. The permit for glyphosate use in the banana industry is available at the Australian Pesticides and Veterinary Medicines Authority website by searching the permit database for permit 11733 or by following this link http://permits.apvma.gov.au/PER14850.PDF.

A regular deleafing program is critical for effective disease control.

Cultural control

Plant and soil health. Maintaining good plant and soil health means plants are less susceptible to pests and diseases.

Monitor leaf disease levels. Monitor disease levels and apply treatments based on the thresholds, rather than apply calendar sprays. Industry consultants can provide this service if staff do not have the expertise or time.

Reduce plant to plant contact. The higher the planting density the harder it is to manage disease once established. This is because infection is easier with plant to plant contact, more surface areas need covering with spray treatments, and air flow is reduced, which may make the micro climate more conducive to disease.

Crop hygiene. As well as deleafing and desuckering, practices such as improving drainage and controlling weeds will reduce moisture levels in the block and enhance the control of leaf rust and leaf speckle.

Good spray coverage is essential for effective control with spray treatments.

Chemical control

Rotate fungicides. Rotate fungicides to avoid any overuse in a single season. This is especially important for the strobilurins, which are naturally more prone to resistance development. Recent testing has shown that yellow Sigatoka in far north Queensland has developed resistance to strobilurins.

More information about the fungicide resistance strategy for the Australian banana industry is available at CropLife Australia's website http://www.croplife.org.au/. To download or print a copy of the strategy, go to: http://www.croplife.org.au/downloadpdf.php?url=wp-content/uploads/2013/05/2014-Banana-Yellow-sigatoka.pdf

Deleafing. Remove infected leaves regularly, especially before applying triazole and strobilurin. This will improve the chemical's efficacy and also help to avoid pest resistance.

Oil applications. When disease levels are low, consider using oil alone to reduce the amount of chemical used and to spread out the treatments. It is important to maintain a monitoring program so treatment can be increased if disease levels begin to build.

Chlorothalonil. This is an effective fungicide for controlling yellow Sigatoka. Read the product label carefully before using it to confirm its compatibility with other products. Do not mix chlorothalonil with oils or emulsified concentrates (including residues on plants from previous treatments) as it will burn banana fruit and leaves.

Ground application of fungicide is more effective for controlling leaf speckle and leaf rust.

Under-tree applications. Ground misting is recommended for treating leaf speckle and leaf rust so the chemical makes contact with the underside of the leaf.

SUBTROPICS EAST COAST – Chemical treatment of leaf diseases are generally only required over the summer months. Trimming infected leaves will reduce the need for chemicals significantly.

SUBTROPICS WEST COAST – Leaf diseases are generally not a concern and, for the most part, do not require treatment. Trimming infected leaves will, in most cases, be sufficient.

TROPICS – Recent testing has shown that banana leaf disease pathogens have developed resistance to strobilurins. Consult your chemical providers for the latest advice about using strobilurins with respect to resistance.

Typical Panama disease infection symptoms in the pseudostem.

Ensure there is adequate signage for visitors and staff.

Zoning your farm limits movement of people and vehicles

Panama disease (Fusarium wilt)

Panama disease is caused by the pathogen *Fusarium oxysporum* f. sp. *cubense*. This pathogen survives in both the banana plant and the soil, so it spreads in several ways, including in moved plant material, on machinery, in surface runoff water, and on animals and people.

To reduce the risk of infection or spreading the disease, adopt a quarantine-type approach to all farm practices.

- Install biosecurity signage at all farm entry points and critical points along the farm boundary. These signs should be clearly visible and provide clear instructions for visitors.
- Zone your farm to limit the movement of people and vehicles.
- Exclude all non-essential vehicles by providing a visitor car park and access point to limit contact with farm vehicles and machinery.
- Ensure that all visitors footwear is either changed and/or decontaminated prior to entry.
- Consider dedicating machinery, vehicles and shoes to the farm and ensure they do not leave the farm.
- Ensure that essential vehicles and machinery that are required to enter the farm are thoroughly washed and disinfected prior to entry and upon departure.
- Use products containing 12% didecyl dimethyl ammonium chloride e.g. Sporekill®, Sterimax® etc. to disinfect footwear, vehicles, machinery and tools.
- Consider fencing the perimeter of your property.
- Minimise surface water run-off from neighbouring properties.
- Do not irrigate from catchments where the disease is located.
- Teach staff to identify disease symptoms and understand infection pathways, so they can be effective in helping to minimise the spread of the disease. (https://www.youtube.com/watch?v=DheDd8J1IUE)
- Only source plant material from certified clean planting material suppliers.
- Maintain records of the sources of all planting material. This enables trace-back for potential outbreaks.
- Inputs including organic green waste and soil amendments may contain the disease. Source these only from a trusted supplier.
- Early detection and effective destruction of infected plants are essential to containing Panama disease. Report any suspect plants to Biosecurity Queensland 13 25 23

Perimeter fencing controls Movement of people and vehicles.

The Panama disease tropical race 4 Grower Kit provides information to help protect properties from Panama disease TR4.

Typical infection symptoms with the older leaves turning yellow.

Information and resources are available for banana growers at the following link: https://www.business.qld.gov.au/industry/agriculture/crop-growing/fruit-and-nuts/queenslands-banana-industry/panama-kit.

The grower's kit provides information about the disease, decontamination procedures, an on-farm biosecurity checklist and also the biosecurity standards and guidelines:

https://publications.qld.gov.au/dataset/panama-disease-tropical-race-4-grower-kit.

Information and video's about panama disease is also available at www.panama.org.au.

Physical control

Limit compaction. Any form of stress on the plant will make it less tolerant to disease.

Ensure good drainage. Plants experiencing waterlogging, stress and subsequently oxygen deficiency are more susceptible to infection from Panama disease.

Biological control

Encourage a diversity of soil microorganisms. There is evidence to suggest bananas grown in soils with a rich diversity of microorganisms are able to tolerate Panama disease better than plants grown in soils with less biological activity. Encouraging a diversity of soil organisms as well as using practices promoting good soil and plant health (e.g. grassed interrows) will help suppress soil borne diseases.

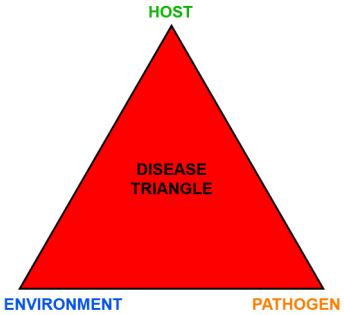
There are no registered biological control products for Panama disease.

Cultural control

On-farm biosecurity. *Fusarium oxysporum* f. sp. *cubense* is spread with plant material, soil and water. Excluding all non-essential vehicles, machinery and personnel from entering your paddocks is the best way to reduce the risk of spreading the disease. Ensure that ALL machinery, vehicles, personnel, clothing and equipment (e.g. cane knives) that are required to enter your paddocks are washed down to remove all soil then sprayed with a disinfectant (e.g Sterimax®, Sporkill®) before entry and upon exit. For more information refer to www.panama.org.au & https://publications.qld.gov.au/dataset/panama-disease-tropical-race-4-grower-kit

On-farm biosecurity checklist. Use the On-farm biosecurity checklist to identify the business' strengths and weaknesses with respect to managing potential pest and disease incursions.

Dirty footwear is a potential source of infection.



For disease to occur the pathogen must be present along with a susceptible host and a conducive environment.

Tissue cultured plant material is free of Panama disease.

Limit plant stress. There is evidence to suggest that plants located on farms with good soil and plant health are more tolerant to Panama disease. Conversely, plants experiencing any form of stress are more susceptible to disease. While it is not possible to prevent all forms of plants stress, practices that minimise the frequency and extent of plant stress will help.

- Monitor soil and plant nutrition, and maintain it at optimal levels,
- Monitor soil moisture and irrigate as required,
- Control pests such as banana weevil borer and plant-parasitic nematodes,
- Try to limit soil compaction to the inter-row space only,

Understand the disease. It is important to understand the pathogen's epidemiology and the infection pathways so you can manage potential points of infection. Fungal spores that can travel in soil, water and plant material cause Panama disease.

Plant material. Using tissue cultured material is the only way to be sure the plant material is free of Panama disease.

Fallow crops. Use fallow crops between banana crop rotations to reduce the level of inoculum in the soil. Crops such as alliums (e.g. leeks and chives), rice and taro have been shown to reduce inoculum levels.

Avoid high rates of nitrogen. High levels of nitrogen increase the incidence of Panama disease infection.

Chemical control

There are no known chemical control options or registered chemicals available for Panama disease.

Bacterial corm rot (*Erwinia*) is identified by the dark border around the infection zone and, in most cases, an unpleasant odour.

Bacterial corm rot and bacterial heart rot caused by *Erwinia*

Cultural control

Avoid water stress. Plants are often infected with bacterial corm rot when water-stressed in hot and dry conditions. The symptoms are usually expressed after heavy rainfall associated with the first storms of the season. The plant and first ratoon crops seem to be the most prone.

Organic matter should be decomposed. Bacterial corm rot has occurred when bananas have been planted into areas with large amounts of un-decomposed organic matter. Ensure organic matter is well-decomposed before planting bananas, particularly on compacted, degraded soils.

Avoid mid-day overhead irrigation. Bacterial heart rot is believed to be associated with water collecting in the plant throat. Where possible avoid using overhead irrigation during the middle of the day as this can exacerbate the problem.

Remove infected plants. Plants showing symptoms should be cut down early as the sucker is often unaffected. Sterilise the knife before cutting into healthy plants to prevent further spread.

Identification. Even if you suspect the problem to be caused by bacterial corm rot or bacterial heart rot, it is recommended you have a sample examined to rule out other possible diseases. Bacterial corm rot and bacterial heart rot symptoms resemble symptoms for other serious quarantine diseases such as Panama disease and Moko disease.

A banana plant showing signs of infection with bacterial corm rot (*Erwinia*).

Weeds

Physical control

Slashing. Maintaining vegetation on headlands and in the inter-row is preferable to spraying. Vegetation helps to stabilise the soil, improves the soil structure, filters surface water and slows runoff water. Vegetation also helps to reduce the amount of soil moved around on machinery. Regular slashing also encourages low growing grass species to dominate the vegetation structure.

Suppress weeds. Once the canopy is established in the banana plantation, weeds become less of an issue. Placing mulch over the row area also helps to suppress weeds. This can be achieved by placing harvested heads and downed leaves on the row area and by using a side-throw slasher or 'V' mower.

It is better to slash headlands rather than to spray.

Grasses, once sprayed out on the row , form a thick mulch layer that helps to suppress weeds.

A closed canopy and banana trash on the ground helps to manage weeds.

Crown end rot infection in ripe bananas.

Mulching. In drier climates, where organic matter decays more slowly, mulching trash material in the inter-row space suppresses weeds and provides an effective ground cover.

Cultural control

Companion planting. Consider a companion plant to smother out weeds. Depending on the planting configuration, the companion can be grown all over the block or on the row only. Pinto peanut has been trialled on some farms in the tropics with varying success, and some clovers have also been used in the subtropics.

Sprayed mulch layer. Some growers in the east coast subtropics are having success with molasses grass as a fallow crop, and then spraying it out and planting bananas. This means the plant crop grows amongst a thick mulch layer. Take care with this method because mulch close to the base of the plant may encourage bacteria such as bacterial corm rot (BCR).

Chemical control

Fallow block maintenance. Volunteer grass or a weedy fallow is better than a bare fallow for soil erosion and also general soil health.

Volunteer bananas. Control these with spot sprays, rather than boom spraying to retain vegetation on the fallow block.

Problem weeds. If the block is to be worked and there is a problem weed present, spray the weed before moving any soil to prevent the weed from spreading further.

Ground cover. If spraying is required in the banana block, allow the grass and weeds to grow before spraying with a knock-down herbicide. A knock-down is preferable to a systemic herbicide because it preserves the root system, and 60% ground cover, (either dead or living) is effective for managing soil erosion.

Residual herbicides. These herbicides can be harmful to the environment due to their persistence. Residual herbicide use is limited in the banana industry because a single application is made at planting time, and at no other time during the crop cycle. Typically, planting occurs in the drier time of the year, so there is less risk of erosive rainfall.

Post-harvest diseases

Physical control

Dehanding. The cut crown end provides a perfect access point for disease. To reduce the risk of infection, use a sharp, clean knife for dehanding and leave a thick cushion at the crown end. This will increase the buffer between external pathogens and the banana. Sterilise the knife as regularly as possible.

Infection can occur in the paddock so maintain good paddock hygiene as well as shed hygiene.

Clustering. Use a knife to cluster rather than snapping the hand. This will reduce the cut surface area and therefore the potential entry points for infection.

Biological control

There are no known, effective biological controls.

Cultural control

Hygiene. Good general hygiene practices in the paddock and packing shed are essential to keep disease levels low. Use a sanitising agent and wash the packing shed out thoroughly as regularly as possible. Replace the water in troughs as often as possible and try to avoid recycling water during periods of high infection rates. If recycling, ensure the water is treated before it is re-used to prevent the spread of disease.

Regular deleafing and desuckering, along with good drainage will help manage postharvest diseases.

Paddock hygiene. Recent research demonstrated one organism causing crown end rot was present on the fruit before the fruit entered the packing shed. Therefore it is important to maintain good paddock hygiene. Practices that help to create an environment that is less conducive to disease include:

- removing bracts and any organic matter caught in the bunch
- trimming down leaves
- applying some fungicides from the ground rather than only aerially
- improving drainage where problems might develop in the paddock

Block layout and density. Often, the drainage requirements of the block dictate the row direction. However, where possible, face rows north to south, as this will allow more sunlight to penetrate into the block. Wider rows and a low plant density will also encourage greater air flow, which may help to limit levels of disease.

Standing water or excessive moisture encourages disease, so it is important to maintain good drainage in the paddock.

Time in the chain. Fruit age can also impact on the expression of crown end rot, and older fruit more often display symptoms. Where possible, work with your supply chain to reduce the time taken to display your fruit on the retail shelf.

Vacuum packaging and paraffin wax. Reports from overseas indicate vacuum packaging and paraffin wax applied to the crown end both help to manage the development of crown end rot.

Chemical control

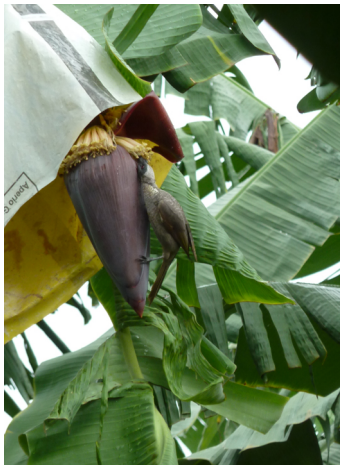
Rotation. Rotating between post-harvest products it is essential to avoid resistance issues. Ensure rotated products are from different chemical groups.

Read the product label and apply following the recommendations on the label.

Carbendazim products. **NOTE:** From August 2012, carbendazim products were subject to a two-year phase out period in the banana industry. Some brands were removed from the market immediately.

Effective application. Read the product label and apply following the recommendations on the label.

- *Concentration.* Maintain the correct concentration. Sprays will be easier to manage because the solution only needs to be prepared once. Dips need to be charged as required.
- *Application method.* Some post-harvest products must be applied as a dip, whereas a spray application is recommended for others. If using a spray application, the fruit should be relatively dry to enhance absorption. Application with a paint brush may also be possible where only small quantities of product are required.
- *Length of treatment.* The length of treatment will vary between products and application methods. The packing shed system may need to be modified to support this.
- *OH&S.* It is recommended the fruit is dried before reaching the packer.
- *Infection point.* Try to reduce the amount of fruit removed from the hand or cluster following post-harvest treatment, as this will provide a new, untreated area for potential infection.



Birds and bats can cause significant damage to the surface of banana skins. Bagging early can help to minimise damage.

Fruit Speckle

The disease known as fruit speckle is a disease caused by three different pathogens, *Colletotrichum musae, Fusarium oxysporum and Fusarium semitectum.* It had previously been known as 'swamp spot', 'salt and pepper spot' or 'Deightoniella spot'. The last name relates to the mistaken belief it was cause by the fungus *Deightoniela torulosa*. The disease causing pathogens can be found on banana flowers, bracts and old leaves. Fruit speckle spots are caused when fungal spores land on the fruit. All banana cultivars appear susceptible however, anecdotal evidence suggests Lady Finger may be more susceptible than Cavendish.

The fact sheet for managing fruit speckle can be found at http://abgc.org.au/projects-resources/industry-projects/national-banana-development-and-extension-program/factsheet_managing-fruit-speckle-5/.

Cultural Control

Farm hygiene. Deleafing and desuckering to remove diseased material prior to wet season will reduce the amount of fungal spores in a banana plantation.

Sap coming into contact with fruit skin, along with flower thrip infestations, can increase the number of speckle spots on fruit, particularly those caused by Fusarium sp. Early removal of bracts and bagging bunches to prevent bird and bat damage can result in sap contacting fruit, increasing fruit speckle damage.

Chemical Control

Dust bunches with mancozeb before bracts are fully open and again when bunch covering. Spray applications of mancozeb to all leaves in the canopy, including suckers, will reduce the number of spores. (http://permits.apvma.gov.au/PER81199.PDF)

Flying foxes and birds

Flying foxes and native birds are protected species. Culling these animals is illegal unless you are licensed or permitted to do so by the relevant state authority.

Cultural control

Bag before bract lift. Bag the emerged bells before bract lift to discourage flying foxes and birds from feeding on the banana flowers.

Staple bunch covers. Some growers go to the trouble of also stapling the bottom of the bunch covers to prevent the flying foxes from climbing inside.

Use heavier grade covers. Heavier grade bunch covers may help to reduce the amount of damage to the bunch.

Deterrents. Various fragrant products added to bell injection mixes have been used in an attempt to deter flying foxes. Ensure these products are food grade and will not cause burn to the fruit. Any products with an oil base have the potential to burn fruit. Scare guns, netting and fake predatory birds may also be useful.

Keep ripe fruit out of the paddock. Ripe fruit will attract birds and flying foxes.

Prescribed culling. Some states allow permits to cull a prescribed number of flying foxes. In Queensland these are called Damage Mitigation Permits. Queensland growers can complete an application online at the Department of Environment and Heritage Protection website http://www.ehp.qld.gov.au/. These permits are issued only as a last resort, and growers need to demonstrate other measures they have taken in an attempt to manage flying fox damage.

Bagging early is an effective way to minimise bird and bat damage.

For information and permits to control flying foxes, contact your relevant state environment and heritage department at:

- Queensland – http://www.ehp.qld.gov.au/wildlife/livingwith/flyingfoxes/
- New South Wales – http://www.environment.nsw.gov.au/animals/flyingfoxes.htm
- Northern Territory – https://parksandwildlife.nt.gov.au/
- Western Australia – www.environment.wa.gov.au/management-and-protection/animals/living-with-wildlife

Rodents

Cultural control

Hygiene. Maintain good hygiene practice in and around the banana blocks as well as in the packing shed. This will remove food sources and areas that could harbour rodents.

Chemical control

Currently there is only one product allowed for the control of rats and mice in bananas. This product is Ratoff® and the permit allows for use in all banana production areas. The permit can be located at the Australian Pesticides and Veterinary Medicines Authority website by searching the permit database for permit 14235 or by following this link http://permits.apvma.gov.au/PER14235.PDF.

Regular slashing will remove potential rodent habitat.

Flumes capture surface run-off and help researchers assess the level of sediment and nutrient movement after rainfall.

FERTILISER AND SOIL ADDITIVES

The addition of fertiliser in either organic or inorganic forms is essential for sustainable and productive agriculture. However, incorrectly applied fertilisers can degrade soil, ground water, watercourses and reefs. Good nutrient practices must maintain productivity while preventing or minimising off-target impacts.

The main environmental concerns relating to the use of fertilisers and soil additives are:

- leaching
- surface runoff
- mining the soil
- heavy metal accumulation
- gaseous losses
- over application, affecting soil health
- soil acidification

Specific management practices are required for each aspect and an appropriate fertiliser program will account for this.

In terms of water quality, phosphorus and nitrogen fertilisers cause the greatest impact on the wider environment.

Phosphorus binds tightly with the soil (sorption) and therefore is primarily lost with sediment movement in the form of erosion.

Nitrogen is generally lost by leaching through the soil profile in the form of nitrates, or through gaseous losses during the processes of volatilisation and denitrification as it does not bind readily with the soil. However, both nitrogen and phosphorus have the potential to be lost with surface water runoff, if heavy rainfall occurs before the fertiliser is washed into the soil.

Devices such as lysimeters can be buried to measure nutrient losses through leaching.

Increased nutrients in waterways cause:

- Eutrophication, where microscopic algae feed in nutrient-enriched water, creating an ‘algal bloom’.
- Water weed growth, which reduces the habitat and oxygen available for fish.
- Oxygen depletion, and therefore fish death, because the bacteria breaking down algae use up oxygen in the water and kill other aquatic animals.

Soil and leaf tests are the most reliable way to monitor your fertiliser program.

Increased nutrients and sediment on reefs cause:

- Marine plants and algae to thrive and compete with coral, due to the increased nutrient loads. An example is the crown-of-thorns starfish.
- 'Marine snow' from sediment smothers the surface of coral, disrupting the habitat of coral larvae and breaking their life cycle, which results in major changes to the ecosystem.

TROPICS – Due to the close proximity of reefs and the heavy rainfall experienced in this region; correct fertiliser application is one of the major environmental priorities for farmers in the Tropics.

Testing soil and plant tissue

Soil and leaf tissue tests are the most reliable way to monitor the effectiveness of your nutrient management program, and used in conjunction with each other. Sap tests are not recommended as these results do not consistently relate to plant nutrient status.

Soil and leaf tissue tests should be taken at least annually, and from more than one site on the farm. A single test for the whole farm will not account for the variation across soils and blocks. Only combine blocks for sampling if they have similar soil types, crop ages and ongoing fertiliser programs. Otherwise test blocks individually. Many growers in the north Queensland industry test each block twice a year in order to maintain high productivity while optimising total fertiliser inputs.

Soil tests are useful for determining nutrient levels in the soil.

Suggestions for tests –

- Use a reputable laboratory, preferably one that is part of the Australian Soil and Plant Analysis Council (ASPAC) proficiency program (http://www.aspac-australasia.com/). This will ensure the tests are suited to Australian conditions and use consistent measurements.
- Seek professional advice for correct sampling procedures and interpretation.
- Soil tests are useful for understanding both nutrient levels and soil characteristics.
- Aim to take paired soil and leaf tissue tests annually.
- Paired soil and leaf tissue tests help determine how effective the fertiliser program is, and to identify any potential uptake problems. Sometimes an element may be at optimum levels in the soil and below optimum in the tissue. In this situation, adding

Leaf samples should be taken from the third fully unfurled leaf on an unbunched plant.

more fertiliser will not necessarily address the limiting factor as there may be problems with nutrient uptake in the plant.

- Regular tests allow you to review the effectiveness of the fertiliser program and, combined with the corresponding yield data, they help identify where adjustments are required. As a minimum, tests should be carried out at least once a year.
- Keep all test results and yield data on record and monitor trends. This will demonstrate how effective the fertiliser program is.
- Nitrogen cycles readily in the soil, so soil tests rarely show nitrogen at adequate levels, especially nitrate-nitrogen. Nitrogen is best monitored in the leaf rather than the soil. The exception is at planting where recent cultivation prior to planting causes nitrogen mineralisation, which may result in high nitrogen levels. In some cases these may be sufficient to meet the crop's needs.
- A soil test should be taken before planting to allow:
  - pH amending products to be applied and incorporated into the soil before planting
  - elements such as calcium, magnesium, potassium and phosphorus to be applied (as determined with a soil test) and incorporated before planting
- Leaf tissue tests should be conducted on the third fully unfurled leaf of an unbunched plant, to maintain sampling consistency.

The banana industry has reduced the average annual nitrogen application significantly over the last 10 years.

Selecting nutrient type and amount

The banana industry has greatly reduced the average annual application of nitrogen over the last 10 years. A recent survey of banana growers in the tropics found nearly 80% of grower respondents are using 350 kg or less of nitrogen per hectare per year. This is applied in small amounts and frequently (e.g. fortnightly), greatly reducing the potential for loss.

A fertiliser program should be based on:

- crop requirement targets
- soil and leaf tissue test results
- soil type
- crop yield
- planting density
- application method
- risk of environmental impacts

If the crop is uniform the fertiliser program can be altered to suit the development stage.

Each farm has slightly different target rates based on a combination of these factors. It is recommended professional advice is sought to develop a nutrition program.

Important considerations for a fertiliser program –

- It should include a standard ongoing fertiliser program and nutrient corrections identified by soil and leaf tissue tests.
- It should include the type of product to be applied, the application date and rate.
- It should be tailored to suit the growing conditions. For example, when the plant is not growing as actively over winter, the fertiliser intervals can be increased by a week or two, compared with the summer applications.
- If the crop is uniform, the program can be altered to suit the developmental stage. For example, potassium applications can be increased before bunch development in plant and nurse-suckered blocks.
- Consider a custom blend instead of a generic blend. This will avoid over-applying one element in order to apply enough of another. Generally, a minimum product order of four tonnes is required.
- Calculate the total nutrient applications using the analysis of all the fertilisers applied. This includes organic, inorganic and foliar and trace elements applied in weed sprays.
- Know your soil type and manage nutrient inputs to suit your soil. Lighter soils would benefit from smaller, more frequent applications.

Know your soil type and manage nutrient inputs to suit your soil.

Considerations for selecting fertilisers –

- Some forms of fertiliser can reduce the soil pH while others can increase the pH.
- The banana plant absorbs nitrogen in the form of ammonium and nitrate, but prefers the latter.
- Gaseous loss of nitrogen occurs in volatilisation and denitrification, which reduces the amount of applied nitrogen that the plant can use.
  - Volatilisation can be avoided by irrigating ammonium based products, such as urea and diammonium phosphate DAP, into the soil or by using nitrate based products.
  - Denitrification can be minimised by not applying nitrogen fertilisers during water-logged conditions.

Only apply blends suitable for bananas.

- Consider using slow release forms of nitrogen. The effectiveness and economics of these products haven't been fully determined, but a trial is currently being conducted in far north Queensland.
- Raw forms of animal manure can have high levels of nitrogen and phosphorus. Test the products and apply them at acceptable rates.
- Only apply blends and custom blends suitable for bananas. This will avoid over-applying one element in an attempt to apply enough of another.
- Choose fertilisers that will not contaminate the soil with heavy metals (e.g. lead, mercury and cadmium). This is primarily relevant for poor quality fertilisers.

Nutrient budgeting

The recent ABGC and Terrain NRM survey of banana growers in the tropics found 80% of surveyed growers are using 350 kg or less of nitrogen fertiliser per hectare per year. This value relates to the tropics, and because nutrient cycle frequencies vary across production regions, so should the nutrient input programs.

The nutrient budget needs to take into account what is required to grow a commercial crop of bananas. Over-application of fertiliser can impact on the environment through leaching and runoff. Under-application is also an environmental concern, as continual cropping will mine the soil of nutrients, gradually reducing soil fertility.

Fertiliser application should be matched to the crop stage in plant blocks.

- Older plant blocks and ratoons in the tropics generally require about 20-30 kg of nitrogen, 60-70 kg of potassium, 4-7 kg of phosphorus per hectare per month. **This is a guide only, and soil and leaf tissue tests should be used as a guide for exact application rates.**
- These rates are a guide only and are the result of canvassing industry research, experienced growers, banana consultants and published crop removal rates. Growers should use these as a starting reference and adjust their program if required.
- Consider whether additional nutrients have been applied in irrigation water (not fertigation) and organic amendments. These should be factored into the fertiliser program to determine the total application amount.
- Fertiliser applications should be matched to crop stage in plant blocks. Young plant crops do not require as much fertiliser because they are smaller, so where possible, target the fertiliser application to suit the smaller root system.

Fertigation is an efficient way to apply fertiliser.

Applying fertiliser and soil additives

Some things to consider when applying fertiliser and soil additives to maximise crop uptake and product efficacy –

- Incorporate pre-plant pH amending products, calcium, magnesium, potassium and phosphorus into the soil, rather than applying them to the soil surface.
- Organic matter and ground cover will slow the speed of water passing over the soil surface, allowing increased infiltration and reducing nutrient loss in surface runoff.
- Maintain a healthy plant and root system.
- Avoid applying fertiliser immediately before intense rain or to water logged soils.
- If behind in the fertiliser program, make the applications more frequently and avoid the temptation to simply make up the difference in a single application, which would make leaching and surface runoff more likely to occur.
- Fertiliser applications can be applied either through fertigation, foliar or broadcast applications. All application methods have their place in a fertiliser program so choose the system that best suits your needs.
- Fertigation provides an efficient application method as it provides the fertiliser in a readily available form, directly to the plant's roots. However, a poorly designed irrigation system with uneven distribution throughout the block is not a suitable application method.
- When broadcasting, it is preferable to apply fertilisers to the banana root zone. In a row configuration, avoid broadcast fertiliser spreaders that apply fertiliser to the whole area, including the inter-row space.
  - Calibrate your fertiliser spreader regularly.
  - If broadcasting by hand it is important to use an application technique that accurately measures the amount of fertiliser you apply e.g. a small cup or container.
  - If fertilising every fortnight seems too time consuming, aim for every other row, every alternative application (every 2nd row, every 2nd week).
- Foliar applications are effective for applying trace elements and help to correct some short term deficiencies when there are uptake problems.

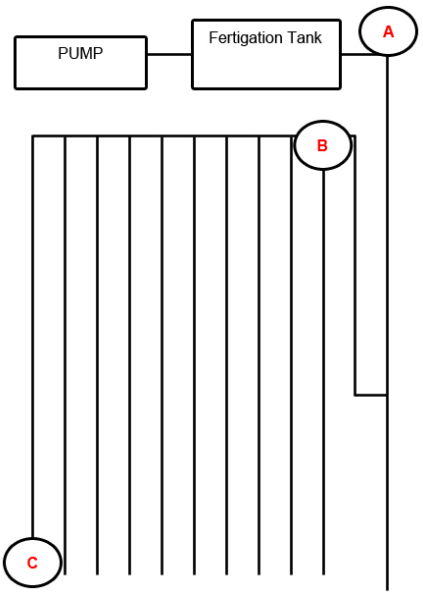
It is better to apply broadcast fertilisers to the row only, when using a fertiliser spreader. This places the fertiliser where it is required and reduces the total amount applied.

An even distribution is essential when fertigating.

Fertiliser should be applied at least every four weeks in the tropics.

- Important factors to consider when fertigating are:
  - Use soil moisture monitoring devices to prevent over-watering, which results in leaching past the root zone.
  - Monitor your irrigation system performance to ensure an even distribution of nutrients.
  - Use the correct injection duration – the minimum injection duration is the time it takes fertiliser to move from the first emitter in the block to the last.
  - Use the correct flush time – the minimum flush time is the time taken for fertiliser to travel from the fertigation tank to the furthest emitter. Growers consulted on this topic measured the time taken for fertiliser to move through the fertigation system with the aid of nitrogen test strips and marker dyes. Some growers used sheets of paper on the ground with the marker dyes.

How to calculate the minimum injection duration and flush times.



A = Fertigation tank

B = First emitter in block

C = Last emitter in block

The time it takes fertiliser to move from **B** to **C** is the minimum injection time.

The time it takes fertiliser to move from **A** to **C** is the minimum flushing time after fertiliser has been completely injected.

Issue compounded with Vee style tank.

Source: Callum Rowe, WaterWright Solutions, Cairns, Queensland

  - Use the correct fertiliser concentration – concentrations vary during fertigation, depending on how the fertigation tank and injection is managed.
    - DO dissolve the fertiliser and allow it to run out without topping up the water level in the tank to maintain the same concentration
    - DO understand the capacity of your tank and only apply as much fertiliser as the tank can dissolve
    - DO inject the fertiliser for at least the minimum injection time, longer if possible

To prevent volatilisation apply sufficient irrigation after the application of ammonia based fertilisers.

Raw manures and compost should be stored on an impervious surface, preferably undercover in high rainfall areas.

- Seek professional advice on system design and performance for both new and existing systems.

- As a minimum, fertiliser should be applied every four weeks and preferably more regularly. In the east coast subtropics, it is common to apply fertiliser four times a year. Increasing the frequency may be difficult due to the manual nature of application, however the more frequent the application the better for plant utilisation and less risk of surface erosion.
- For optimum nitrogen uptake in the tropics, application intervals should not exceed three weeks. Research in bananas in far north Queensland using nitram (ammonium nitrate) with isotope N15 (nitrogen tracer) found most nitrogen was absorbed in the first three weeks following application. Without a further application after three weeks, nitrogen levels decreased in plant tissue. This trial also found some nitrogen was present in the plant three days after ammonium nitrate was applied.
- Research demonstrated that when using broadcast urea, up to 30% of the nitrogen can be lost through volatilisation. This means urea may no longer be the cheapest form of fertiliser. To prevent volatilisation, apply sufficient irrigation after applying ammonia based fertiliser, such as urea, to dissolve and wash it into the soil or use coated products.
- Maximising crop uptake – The banana plant will only take up as much nutrient as the root system allows. Water logging, compaction or pests such as nematodes will affect the plant's ability to access nutrients, so applying more fertiliser will not necessarily help the plant to take up more nutrients.
- Nitrogen applications are not only about annual targets, but also the amount applied in a single application. Smaller, frequent applications are critical in climates with high rainfall.
- The availability of phosphorus to plants is reduced in some soils due to chemical bonding with aluminium, iron and calcium. When developing a nutrient program, it is vital the soil tests also measure the Phosphorus Buffering Index (PBI). The PBI is a measure of the ability of a soil to adsorb phosphorus, making it less available to the plant. Paired leaf tissue and soil tests are especially useful on high PBI soils because the leaf tissue test will indicate if there is an uptake problem.
- Adequate soil moisture is important because roots access nutrients from the soil solution. If the soil is too dry, nutrients present in the soil will be difficult for the plant to access.

Most fertiliser records are paper based, rarely referred to and difficult to retrieve information from.

Storing fertilisers

Fertiliser should be stored in a way that prevents nutrients from reaching waterways, either by leaching or in surface runoff. Raw manures and compost should be located on an impervious surface and efforts made to divert surface water away from the site and to contain any potential runoff. Preferably, raw manures will be stored undercover to prevent leaching during rainfall.

Liquid fertilisers should be stored in bunding. Freshcare recommends the bunding is capable of holding 125% of the contents of the largest container, plus 25% of the total volume stored.

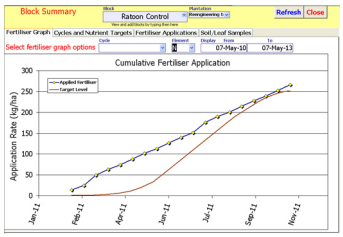
MSDS should be kept for any fertilisers stored on the property. These are obtained from the supplier.

Recording fertiliser applications

Previous environmental BMP reviews in the banana industry noted that growers implement many aspects of nutrient BMP, but only keep records sufficient for their quality assurance requirements. These records are mostly paper-based, rarely referred to and retrieving information for management decisions proves tedious and time-consuming.

A more effective system would record dates, rates and fertiliser type and have the capacity to:

- allow a quick assessment of the total nutrients applied to a block up to a particular point in time
- compare nutrient applications back to yield, to monitor performance
- show trends in soil and tissue tests over times relevant to nutrient applications



Bananaman is an Access based electronic program for monitoring fertiliser use.

Electronic versions are generally more suited to this type of application and can be as simple as a Microsoft Excel spreadsheet. A Microsoft Access based computer program called Bananaman was developed as a prototype so growers can record fertiliser usage at the block level. This is available to growers who contact DAFF's reception desk at the Centre for Wet Tropics Agriculture on (07) 4064 1130.

Records should also be kept for servicing and calibrating fertiliser equipment and machinery.

For additional information refer to the subtropical bananas best practices guide, Banana nutrition part 1 and part 2, on the ABGC website or by following this link http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0006/251898/Banana-growing-guide-cavendish-bananas-Complete.pdf.

Water requirements of banana crops vary with the production region and crop age.

WATER

Water management program

The annual irrigation requirement for banana production varies significantly between the production regions. For instance, Carnarvon relies almost entirely on irrigation whereas subtropical production on the east coast is primarily rain-fed. Tropical production experiences significant rainfall, although most farms rely on irrigation during dry periods.

The appropriate irrigation program will depend on climatic conditions, soil type, water availability, irrigation system design and crop stage. On the east coast, bananas irrigated with an efficient irrigation system will generally require approximately 1 ML of water per hectare per month, if there is no rainfall. This figure will be higher in production areas such as Carnarvon, which experiences higher temperatures, stronger winds, has higher plant densities and higher evaporation rates compared with other production regions. In this region the annual irrigation demand for bananas can range from 18 to 22 ML.

The other main use for water on a banana farm is in the packing process. Water use will vary between farms depending on the packing system and scale of operation.

Producers should consult with their relevant government agency to determine how they need to comply with government regulations, as the requirements for irrigation licensing vary between production regions.

Knowing the water holding capacity of the soil enables you to determine the irrigation intervals.

Efficient irrigation

Know your soils

Know the characteristics of the soil types on your property and irrigate accordingly. Lighter soils have a lower water holding capacity and require shorter and, possibly, more regular irrigation intervals than heavier soils.

Irrigation system design

Seek professional advice when installing a new irrigation system or improving an existing system. A well designed irrigation system takes into account:

- crop requirement
- soil type
- water availability/licensing
- water quality
- topography
- future requirements

Seek professional advice when installing an irrigation system.

These factors determine the system requirements, pump size and type of filtration. Similarly, the system capacity needs to be considered during any future expansion. A correctly designed system may negate the need for a variable speed pump and pressure compensated sprinklers.

Pump

To select the most appropriate pump size for your system, consider the peak water use requirement. When irrigating bananas, this is usually in the height of summer.

If the aim is to run the most efficient pump to minimise the total energy consumed for irrigating, select a pump capable of servicing this requirement in 20 hours per day. This allows some down time for maintenance and provides a margin if problems arise.

If the aim is to irrigate at night, to take advantage of lower evaporation rates and optimise water use efficiency, it may be worth selecting a pump capable of servicing this requirement during the night. This will also take advantage of cheaper electricity tariffs, although these have been increased in recent times.

To determine which pump size is better financially, the electricity costs of both systems should be compared against the increased irrigation infrastructure cost over a five year term for a larger pumping system.

Emitter type

Under-tree emitters are more water-efficient than overhead irrigation.

Each emitter type has positives and negatives, but recently, the trend has been towards installing under-tree sprinklers. Under-tree sprinklers and drip tape are the most water-efficient and provide the opportunity for fertigation. Overhead irrigation uses more water, the pumping costs are higher and they can encourage fungal leaf diseases such as yellow Sigatoka. For these reasons overhead irrigation has largely been replaced with under-tree systems.

Drip irrigation is one of the water efficient irrigation options, but the system does not allow 'broadcast' fertilisers to be dissolved and washed into the soil. This means the fertiliser is unavailable to the plant and increases the chance of volatilisation of ammonium-based fertilisers and surface runoff during a rainfall event. One advantage of drip irrigation is it encourages fewer weeds because the wetted zone is reduced.

An advantage of under-tree sprinklers is they alter the micro-climate in a block, increasing the relative humidity and evaporative cooling. This is particularly beneficial in production regions like Carnarvon, which experiences high temperatures. Many farms in this area use drip irrigation to establish the plant crop and then switch to under-tree sprinklers once the plants are about six months old.

Soil moisture monitoring devices are useful for the development of irrigation programs.

Soil moisture monitoring

Soil moisture monitoring devices are used to determine an appropriate irrigation period and frequency. Several monitoring options are available, ranging from low cost manual systems read in the paddock, to fully automated systems downloaded, remotely, to a computer, or even a smart phone. Professional advice on how to install monitoring devices and how to interpret the data is essential.

When using soil moisture monitoring devices, it is important to know where the devices are located for a number of reasons –

Differing soil types. Try to place the device in an area with a soil type that is representative of most of the block or farm; this will depend on the number of devices available. The full point (the point at which the soil cannot hold any more water so any additional applications will be lost below the root zone) and stress point (the point at which soil moisture levels are so low the plant is not able to readily access it) will both vary depending on the soil type.

Surrounding plants. A device next to a small plant will not give a true indication of how much moisture a bunched plant requires, so be aware of the size of the adjacent plant in relation to those in the rest of the block.

Automated systems. While it is a significant investment, an automated system can improve water use efficiency and reduce labour requirements. Advanced automated systems, in conjunction with soil moisture monitoring, identify when to irrigate, when to switch irrigation runs between blocks and when to inject set levels of dissolved fertilisers into the irrigation line for fertigation. They allow a level of refinement not possible with a manual system.

Bunch size is reduced when plants experience water stress.

Develop a farm water budget

A farm water budget will help to match the farm and crop requirements with the farm water allocation. The longer cropping cycle of bananas makes developing a farm water budget for bananas relatively easy compared with other seasonal crops. In drier areas such as Carnarvon, it may be necessary to irrigate fallow crops, so this should also be factored into a farm water budget. The water used in the packing process should also be considered, although this is likely to be related to a separate licence.

Know your water supply

It is important to understand the reliability of irrigation water. During dry periods bores, dams, creeks and rivers may experience low water levels. This can potentially change the water quality and in some instances water restrictions may be enforced.

Ensure all required licences and permits are applied for and adhered to. Contact your state natural resources department for area-specific information.

Ensure compliance with all the of the necessary licences and permits.

TROPICS – Some Queensland farms will need to prepare a land and water management plan. More information on this is available at https://www.dnrm.qld.gov.au/. All water sources (excluding tidal reaches) and licences are currently under review in the Cassowary Coast Shire while the water moratorium is in place. This came into effect in 2010 and is yet to be lifted.

SUBTROPICS EAST COAST – For more information relating to irrigation in the sub tropics refer to the subtropical banana growers best practice guide, Irrigating Bananas in the Subtropics available at the ABGC website http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0006/251898/Banana-growing-guide-cavendish-bananas-Complete.pdf

Determine an irrigation schedule

Although banana root systems can extend to a meter deep in the soil, about 80% of the water extracted by bananas comes from the top 30 cm of soil. Therefore irrigation is rarely required past the 50 cm level.

Problems associated with over-watering include nutrient leaching, especially nitrates, and the potential loss of gaseous nitrogen through denitrification.

Water stressed plants (**under-** or **over-**watered plants) are more likely to experience longer crop cycles, produce smaller bunches with shorter fruit and be affected by pests and diseases. Some common problems are outlined below:

Insufficient water severely impacts bunch size.

- Plants commonly show increased susceptibility to spider mites when they are water stressed.
- Bacterial corm rot (*Erwinia*) is often expressed in plants that have experienced stress. Generally, infection occurs when stress is caused by insufficient water and high temperatures, and then it is most evident during the first storms or heavy rains.
- Plants infected with Panama disease (races 1 and 2) may show little or no sign of infection until they become stressed.
- Maturity bronzing can also be a symptom of variable growth rates exacerbated by water stress.
- Severely water stressed plants may not be able to support the weight of a bunch.

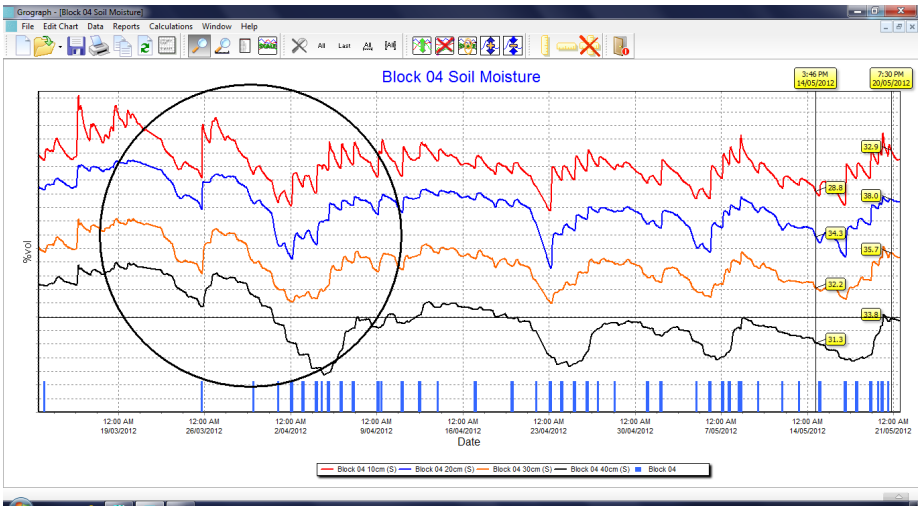
Water stress during bunch initiation will reduce the number of hands and fingers on the bunch.

When the bunch starts to develop in the banana plant, approximately 11 leaves are still to emerge. This stage is called 'bunch initiation' and it occurs when the growing point switches from vegetative (producing leaves) to reproductive (producing the bunch) growth. Closely following bunch initiation is the bunch differentiation stage, when the number of fingers and hands on the bunch is determined. During this stage, any stresses on the plant will have an impact on bunch size. Uniform plant crops or nurse-suckered blocks potentially can draw down significantly on soil moisture reserves once bunch emergence occurs because all the plants are reaching the peak water demand period at similar times.

Increasing soil organic matter will increase soil water holding capacity. A 1% increase in organic matter to a depth of 30cm per hectare will hold an additional 60,000L of water

The water draw down in a plant block is illustrated in the circled region of the figure below. In this case, the irrigation frequency was increased to match the increased crop demand.

Graph of soil moisture from a banana block. The circled area shows a high demand for water when the crop starts bunching.



Source: Callum Rowe, WaterWright Solutions, Cairns, Queensland

To minimise the rate of evaporation, leave harvested heads and leaves in the inter-row space to increase surface mulch, and water at night, where possible. Watering at night will also allow you to take advantage of cheaper power tariffs.

Leaving the harvested heads on the row helps to reduce evaporation.

Manage nutrient input and salinity

Use soil moisture monitoring devices to avoid over-watering and subsequent nutrient leaching through the soil profile. This is important because of the potential impact on the environment and the expense of inefficient fertiliser use. Leaching can occur with both cations (positively-charged ions) and anions (negatively-charged ions), but is especially important for anions, such as nitrates, because they leach so readily.

Be aware of the quality of water used on farm.

Underground water may potentially have higher than normal levels of certain nutrients. Testing will reveal whether the fertiliser program needs to be altered to account for irrigation inputs.

- Growers irrigating from underground water sources prone to salinity should test their water source regularly, especially after periods of rain, and manage accordingly.
- Where more than one source of irrigation water is available, it may be possible to mix water sources (shandy) to reduce the salinity level.
- Growers irrigating out of tidal reaches should avoid irrigating at high tide so they use only fresh water. It is also recommended the water between high tides is tested to ensure salinity levels are acceptable.

Check irrigation system performance

For optimum irrigation performance it is essential the system is regularly monitored and maintained.

- Ensure the system uses a filter size suitable for the water quality.
- Flush the system regularly to minimise blockages.
- Regularly check sprinklers or emitters to ensure they are working.
- Monitor and repair cut lines.
- Measure flow rates and outputs to ensure even coverage and monitor irrigation performance.
- Pressure sensors (flow meters) should be installed to stop the pump in the event of an irrigation failure.

For optimum irrigation performance it is essential the system is regularly monitored and maintained.

Monitor, record and evaluate performance

It is important to keep irrigation records, including information about the date applied, area irrigated, volume of water applied and the person responsible. These can then be cross-checked against productivity records. Records may be hard copy diaries or in electronic form, in computerised systems. Systems using soil moisture monitoring devices and automation may already have a lot of this information stored electronically. If the water is purchased, retain the water usage notices as a record.

As well as being useful for normal production management decisions, record systems can also show external parties you are using water efficiently and can support the water allocation.

Packing sheds can potentially use large volumes of water.

More information on irrigation and water use efficiency can be found in factsheets developed as part of Growcom's Water for Profit program. Factsheets are available at http://www.growcom.com.au/land-water/water-for-profit/resources-water-for-profit/.

Packing shed water efficiency

Banana packing sheds can potentially use large volumes of water. Shed systems vary between farms in terms of wheel or trough wash, recirculating water or run to waste, and the type of bunch line wash. Whichever system is in place, review the shed washing system and consider where efficiencies can be introduced.

Review the water use and where efficiencies can be introduced.

Recirculating wash water, rather than running straight to waste, will reduce the amount of water used. Recirculating systems should include a filtering system to remove debris and treatment to manage potential disease infection. Refer to the Packing shed water treatment options factsheet, produced as part of Growcom's Water for Profit program available at http://www.growcom.com.au/wp-content/uploads/2013/12/Packing-shed-water-treatment-options.pdf.

Another way of increasing efficiency is to use a sensor-operated bunch wash that triggers the water to turn on only when a bunch passes.

Managing water quality to minimise harm to the environment

The two considerations for managing water quality are:

- the water used on-farm is suitable for the intended use
- the farming operations do not have a negative impact on the on-farm water quality or in the wider environment

This constructed wetland helps to remove suspended solids from runoff water before it leaves the banana farm.

Water quality suitability for intended use

Poor quality irrigation water can cause environmental harm, both on and off-farm (as runoff). Salinity and excess nutrient problems may be introduced when poor quality water is used. Some banana diseases, such as Panama disease, can also be spread in irrigation water. Currently there is no known practical method to effectively treat irrigation water containing Panama disease spores.

Water used on-farm for packing, spraying and irrigation should be tested to confirm it is fit-for-purpose.

Water quality on and off-farm

Water quality encompasses both the quality of water used for farming practices as well as the quality of water leaving the farm. Some problems associated with poor quality runoff water include:

Stabilise areas with rock to reduce sediment movement.

- Freshwater
  - algal blooms (i.e. blue green algae)
  - increased growth of aquatic weeds
  - oxygen depletion as bacteria work to break down algae or weeds
  - increased sedimentation changes hydrology, which can lead to flooding and stream bank erosion
  - pollution, which can harm aquatic animals
- Marine
  - high nutrient levels are linked to crown-of-thorns starfish outbreaks
  - increased growth of marine macro algae, which alters fish habitats and can outcompete corals

Suggested practices to protect water quality

Ensure appropriate measures are in place to prevent nutrients, sediment, chemicals, organic debris, waste material and fuels from reaching waterways. Some examples of practices to improve the quality of surface water leaving the farm are outlined here. More information is available in each relevant module.

- Where large volumes of water cause wash, stabilise the area with rocks or similar materials.
- Place all fuel and chemical storage areas away from watercourses and flood-prone areas.
- Implement and maintain a fertiliser program that allows optimum nutrient uptake.
- Time inputs (chemical/fertiliser) and cultivation to minimise the risk of loss.
- Allow runoff water to be filtered through vegetation or grassed headlands.
- Leave wide, grassed headlands to stabilise the soil, filter runoff water and allow room for tractors to turn without damaging the headlands.
- Wide, grassed headlands are especially important at the bottom of hills due to the volume of water filtering over these areas.

Runoff water should be filtered to remove sediments. Grassed headlands are very effective for this purpose.

Grates in the packing shed remove banana flowers and other debris effectively from waste water.

Polishing ponds are the ultimate in water filtration. Waste water from the packing shed passes through a series of settling ponds that remove organic and waste material, before the water is discharged.

Packing shed waste water quality

Measures should be in place to ensure shed waste water is free of debris and chemicals. Banana flowers and other organic debris can be harmful to waterways because decomposition increases the risk of oxygen depletion. Systems vary from farm to farm, depending on the volume of water to be treated, the block topography and proximity to a water course.

- Testing waste water for Biological Oxygen Demand (BOD) may be useful when designing a system.
- Remove strings, bunch flowers and other waste from the packing shed floor before hosing down. This will prevent organic material from entering drains or waterways.
- Some troughs have measures in place that allow flowers to be caught rather than falling on the shed floor. Consider how your system could be improved.
- Grates are effective at removing flowers and other debris. They can be removable frames/baskets or smaller scale grates inserted across the top of the waste outlet pipe.
- Sand and rock trenches act as good filtration systems. The sand or rock is replaced as required.
- Grass and other vegetation are also suitable, especially when filtration occurs over a long distance.
- Sediment ponds, where solids drop out and only the overflow leaves the pond, are effective.
- If waste water currently runs directly into a waterway, consider using a drain or pipe to divert the waste water. This provides an opportunity for the remaining debris to be removed.

More information on irrigation and water use efficiency can be found in factsheets developed as part of Growcom's Water for Profit program http://www.growcom.com.au/land-water/water-for-profit/resources-water-for-profit/.

Biodiverse areas may exist on your farm, a neighbouring farm or within your local area.

BIODIVERSITY

Biodiversity relates to all native flora, fauna and microorganisms. Biodiverse areas may exist on your farm, neighbouring your farm or within the local area. Identify these areas on a farm map and mark environmentally sensitive areas, native vegetation, watercourses and wildlife habitat occurring on your farm as well as your neighbour's farm.

Your local natural resource management (NRM) group/Local Land Services (LLS) will be able to assist in identifying regional priorities for biodiversity.

- Queensland
  - Terrain – Wet Tropics coast http://www.terrain.org.au
  - North Gulf Region – areas to the west of Mareeba http://www.northerngulf.com.au
  - Cape York Natural Resource Management – Lakeland/Cooktown http://www.capeyorknrm.com.au
  - Burnett Mary Regional Group – Bundaberg http://www.bmrg.org.au
  - SEQ catchments – Sunny Coast/Caboolture http://www.seqcatchments.com.au/
  - a full list of Queensland NRM groups is available at http://www.nrm.gov.au/regional/regional-nrm-organisations
- New South Wales
  - Northern rivers Local Land Services www.northcoast.lls.nsw.gov.au
- Northern Territory
  - NRM Board (Northern Territory) Inc http://www.territorynrm.org.au/
- Western Australia
  - Rangelands NRM (northern and eastern WA) http://www.rangelandswa.com.au/

Note: In NSW many biodiversity activities are being undertaken by local councils.

Know the environmental management priorities for your local area.

Biodiversity management program

A farm biodiversity management program needs to identify the type of flora and fauna present on the farm and any major ecosystems neighbouring your property. The impact your activities have on water

Many banana farms are on the boundary with sensitive ecosystems.

quality is also important as this has the potential to affect systems geographically removed from your farm, for example in-shore reefs.

The biodiversity management program should take the following into account.

Regional biodiversity priorities

The biodiversity priorities will vary between production regions. Depending on your state, your local natural resource management (NRM) group or Local Land Services (LLS) will provide an overview of the main biodiversity priorities for your region. The business uses this information to assess which farming practices may potentially impact on regional biodiversity priorities and how impacts can be avoided or minimised.

The following link is also useful in identifying regionally specific species and ecosystem priorities. This information is provided by the Department of Sustainability, Environment, Water, Population and Communities http://www.environment.gov.au/cgi-bin/sprat/public/conservationadvice.pl.

Identify the vegetation

Environmentally sensitive areas, vegetation and wildlife habitat on and near to your farm should be identified during an initial assessment of vegetation. A larger area of vegetation has a greater potential for containing assessable biodiversity. While you may not have the vegetation or habitat on your farm, you may be neighbouring such an area and therefore need to be mindful of this with your farming activities.

While you may not have the vegetation or habitat on your farm, you may be neighbouring such an area.

Assess special importance

Some native vegetation stands are more important than others. This includes:

- threatened species protected under legislation
- remnant vegetation (land which has never been cleared or if previously cleared, regrowth is now mature)
- larger areas of vegetation
- areas serving as wildlife corridors

More information can be found on the Department of Sustainability, Environment, Water, Population and Communities website at http://www.environment.gov.au/biodiversity.

Assess off-farm impacts and threats

Your farming activities potentially have an impact on land, air and waterways outside of the confines of the farm boundary. By assessing the local flora, fauna and regional biodiversity priorities, you will be in

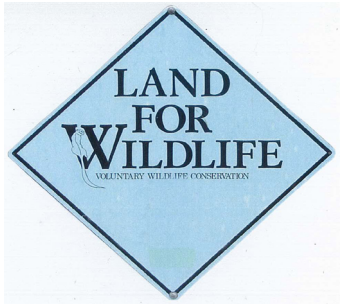
The Great Barrier Reef Marine Park Authority (GBRMPA) is piloting a reef guardian 'farms' initiative.

a better position to consider potential farming impacts. Work with your neighbours to protect and potentially enhance these areas. Also consider the quality of water leaving your farm because it may have an impact on environmentally sensitive areas that may be some distance away from your farm.

Comply with biodiversity laws and regulations

The three levels of law to comply with are local, state and commonwealth. For national and state based information refer to https://www.daf.qld.gov.au/plants/fruit-and-vegetables/farm-management/emss and select the relevant link based on your farm location. This will provide an overview of all relevant acts.
Websites for relevant acts:

- Australian Government ComLaw
  https://www.legislation.gov.au/
- The Australasian Legal Information Institute
  http://www.austlii.edu.au/
- Environmental Defenders Office – this provides a network of independent community environmental law centres
  http://www.edo.org.au/



Consider registering your farm under the 'Land for Wildlife' program if it operates in your area.

Managing vegetation

When the vegetation on your property has been identified, consider ways to protect it.

- Encourage a diversity of plants and consider their role in biodiversity.
- Exclude people and machinery from environmentally sensitive areas where necessary or minimise traffic in these areas.
- Protect and maintain areas of remnant vegetation on your farm.
- Enhance or restore environmentally sensitive areas by controlling weeds and revegetating riparian or wildlife corridors.

An effective way to increase native vegetation on your farm is to use native species as wind breaks and buffers around blocks.

Consider registering your farm under the 'Land for Wildlife' program if it operates in your area. This program is delivered by different organisations in each state. In Queensland, the program doesn't operate at a state level and individual councils determine availability. Good reference points for programs, funding and networks operational in your region are available from Greening Australia at https://www.greeningaustralia.org.au/ and www.landcareonline.com.au.

Maintain vegetation in the riparian zone along creek banks.

Increasing on-farm native vegetation

An effective way to increase native vegetation on your farm is to use native species as wind breaks and buffers around blocks. In some instances these can also act as wildlife corridors, if they are sufficiently wide. Consider working with your neighbours where possible to enhance the benefits of wildlife corridors.

Unproductive areas of your farm may also be suitable for revegetation. Consider steeper land, creek banks and low-lying areas for this purpose. Existing water points such as dams and creeks make great wetland habitats when revegetated. A banana case study and more information on wetlands can be found at http://wetlandinfo.ehp.qld.gov.au/wetlands/management/wetland-management/.

http://wetlandinfo.ehp.qld.gov.au/resources/static/pdf/resources/reports/farming-case-studies/cs-bananas-12-04-2013.pdf.

Contact your local council or NRM or LLS group for advice on which species to plant, and any potential funding opportunities for undertaking revegetation activities.

Native wildlife species are often found in banana bunches brought into the packing shed.

Living with native birds and animals

Identify and protect native animal species and their habitat. In most cases, native birds and animals can co-exist without having an impact on the farming operation. However, in some instances they can have a significant impact on productivity and fruit quality. Where you need to manage problem birds and animals, make sure you comply with the regulations and permit conditions. Contact your state environmental department for the regulatory requirements and information on how to manage the animals concerned.

In many cases, impacts can be prevented with simple management practices. Some common control options used in the banana industry include:

- Birds and flying foxes
  - Bag bunches early to reduce the chance of damage.
  - Do not leave ripe fruit in the paddock.
  - Some growers have tried fragrant products in the bell injection mix to deter flying foxes, although this hasn't been confirmed as an effective control measure. Anecdotal evidence suggests some scents actually attract birds and flying foxes.
  - Gas guns may be effective, although they are not practical close to residences due to noise issues.

Identify and protect native animals and their habitat.

Return wildlife to the paddocks to reduce the chance of transporting them with fruit consignments.

- Wallabies
  - Generally wallabies are only a problem for small banana plants.
  - Growers have used electric fences around the perimeter of plant blocks.
  - Place individual covers around each plant in the form of bags or wire fencing products.
  - If irrigation is applied through overhead or micro-sprinklers, irrigating at dusk and dawn could help to deter wallabies.
- Rats
  - Slash grass to remove the seed heads, which removes a food source and some habitat.
  - Trees around the blocks (e.g. in riparian areas and as windbreaks) reduce the grass and encourage predators.
  - If baiting for rats, use a registered product and use according to the label directions. Baits must be placed in a bait station. Currently there is only one product allowed for the control of rats and mice in bananas. This product is Ratoff® and the permit allows for use in all banana production areas. The permit can be located at the Australian Pesticides and Veterinary Medicines Authority website by searching the permit database for permit 14235 or by following this link http://permits.apvma.gov.au/PER14235.PDF.

Be vigilant, and remove wildlife such as frogs, snakes and gliders from the shed and return them to the paddock or adjacent native vegetation. Move pallets into cold rooms as soon as possible to reduce the chances wildlife can enter cartons and subsequently get transported with the produce.

Piles of banana waste can encourage feral pigs. If possible mulch and spread banana waste.

Consider registering your farm under the 'Land for Wildlife' program if it operates in your area. This program is delivered by different organisations in each state. In Queensland, the program doesn't operate at a state level and individual councils determine availability. Good reference points for programs, funding and networks operational in your region are available from:

- Greening Australia https://www.greeningaustralia.org.au/
- Landcare Australia http://www.landcareonline.com.au/

Local councils may have biodiversity plans that could potentially affect the way you manage your business. For example, the Lismore Shire Council is proposing a wildlife corridor that will impact directly on some farms in the district, restricting farming activities along these corridors.

Siam weed is a Weed of National Significance and must be controlled by law.

Controlling feral animals and invasive species

Invasive species can be both native and exotic. They can have an impact on the environment by competing with native plants and animals and, potentially, can cause soil degradation and water quality issues. If pests such as feral pigs, deer and weeds are a problem, contact your local natural resource department or council to get advice or assistance to control them.

Some specific control options used by banana growers include:

- Exclusion methods such as a perimeter fence in the worst affected area may be useful.
- Trapping pigs is an effective way to reduce pig populations.
- Pigs have been known to favour suckers recently treated with 2,4-D so be mindful of this if pigs are a problem.
- Piles of banana waste will encourage pigs. Where possible, mulch and spread banana waste.
- While pig hunters may help in managing pig numbers, it is important to note the hunters, their vehicles and dogs may be a potential pathway for pests and diseases onto your property.

Managing environmental weeds

Weeds have a significant impact on the environment because they compete with native plants and reduce habitat and food sources for wildlife. Weeds Australia publish 'Weeds of National Significance' (WoNS), which currently lists 32 weeds that, by law, must be controlled if they are present on your land. The website for WoNS is http://www.weeds.org.au/WoNS/.

'Noxious' weeds must also be controlled under legislation at a state or territory level. Weeds Australia also publish a searchable list of noxious weeds at http://www.weeds.org.au/noxious.htm.

Burning is detrimental to soil health because it removes organic matter, biology and moisture.

Identify and manage weeds on your property according to the relevant legislation. Weeds around riparian areas and watercourses are also the landowner's responsibility. General information relating to identification and control measures for weeds can be found on the Weeds Australia website at http://www.weeds.gov.au.

Soil amendments, mulch and fill may harbour weeds, so only source these products from a trusted supplier and manage these inputs as well as possible. Inspect the places where these products are applied regularly to identify any potential weed incursions.

Managing fire

If permits are required, obtain the appropriate ones before burning. Ensure there is a sufficient fire break around the area to contain the fire and only burn during suitable weather conditions. Depending on the purpose, consider management options other than fire, including:

- Disc, or spray and disc the block, rather than burning, to prepare the land. Burning is detrimental to soil health because it removes organic matter, biology and moisture.
- Put waste material in a skip bin, take it to the local dump or mulch paper and cardboard products, rather than burn it. Under no circumstances should plastics be burned.

A photographic record demonstrates any changes in vegetation over time.

Monitoring and recording

The business should monitor progress, to ensure that the measures implemented are effective.

- Inspect environmentally sensitive areas regularly for weeds or pests. This will facilitate early intervention and control. It is also important to monitor the success of any weed control operations.
- Maintain a record of soil ameliorants, mill mud or other inputs brought onto the farm. This will enable any future weed or disease incursions to be traced to the source material.
- A photographic record demonstrates any changes in vegetation over time. Keep a land mark or distinguishing feature visible in the photo as a reference point, or use GPS and permanent markers to identify the location.
- Where possible, record sightings of native, endangered species. Aim to protect or minimise disturbance to areas where native species occur.
- Document how the business manages native birds and wildlife, and review this annually
- Implement and monitor the success of the farm's environmental management plan and make changes where required.

Aim to protect or minimise disturbance to areas where native species occur.

Promote a system whereby waste products are collected from the paddock on a regular basis.

WASTE

Waste management program

A waste management program first lists all waste products on the property and then documents how the waste from each item will be minimised. Consider which products can be re-used, recycled or are biodegradable, and switch to these products where possible. Also minimise the amount of packaging by buying suitable products in bulk.

Promote a system whereby waste products are collected from the paddock on a regular basis, rather than leaving items such as string and old bunch covers in the paddock. Most growers collect string and fallen bunch covers from the paddock during harvest to reduce in-field waste.

Minimise, re-use and recycle

Where possible *minimise* the amount of packaging on products, *re-use* products or *recycle* products. Disposal should be the last resort.

The most common waste products on a banana farm are:

Bunch covers and bunch products

- Where possible, re-use bunch covers, bands, ties and clip slips. These should be stored and cleaned appropriately to reduce disease transfer.
- If cost effective, consider paper bunch covers as these are biodegradable.

Reuse bunch covers as many times as possible. Clean and store in an appropriate manner between uses.

Fertiliser bags and containers

- Return fertiliser bags to suppliers.
- Large fertiliser shuttles are often returnable. If not, re-use them on the property. Alternatively, they are often sought after by other producers.

Pots and trays

- Store pots and trays left over from tissue culture in a suitable location until the nursery collects them.
- Consider using biodegradable pots, if available.

Oil, fuel and lubricants

- Where possible re-use these for cleaning, rust prevention or desuckering.

Store oils on an impervious surface, preferably with bunding.

- Store them in appropriate containers to prevent leaks. Ensure the storage area is either bunded or at least has an impervious surface, and is located away from ignition sources.
- When re-using these products, make sure they are handled carefully to prevent spills.

Props

- Props can be re-used for a number of years. Storing them off the ground will increase their lifespan. It may then be possible to find other uses for them around the farm when they are no longer suitable for propping.

Waste plant material

- Waste plant material might include leaves on picking trailers, remaining plant material when bits are prepared or left-over plantlets. This material should be returned to the paddock or disposed of far removed from waterways and drainage areas, but accessible for treating any volunteers (ferals) growing from the material.

Waste bananas and stalks


Waste bananas can be mulched and spread back onto the banana paddock.

- Mulch and spread waste fruit and stalks back onto the banana paddock.
- If not mulched, dispose of waste away from waterways and drainage areas, and preferably not in a single pile. Be careful not to allow runoff or leachates from the waste material to contaminate waterways or groundwater.
- In future, new technologies may enable viable alternatives such as power generation using banana waste.

Miscellaneous

- Batteries – return to the supplier for recycling. Some charities and schools collect batteries as a fund raising initiative.
- Tyres – recycle through your local tyre dealer or take to the local waste station.
- Use a scrap metal dealer to take away discarded machinery, equipment and other metal materials.
- Materials for recycling need to be stored on-site in dedicated, labelled recycling containers or in areas ready for pickup.

Presses compress waste bunch covers to reduce their total volume.

Disposal

Irrigation tape

- It is best to check with the local waste station before delivering irrigation tape, because not all councils accept this product. Currently, the Cassowary Coast Shire Council does not accept irrigation tape.
- Until a suitable disposal method is found, growers whose waste station does not accept irrigation tape should stockpile it in a location where it will not be an environmental hazard, and away from ignition sources.

String and bunch covers

- Stock-pile used string and bags in a way that minimises dirt contamination and use a licensed waste contractor to collect it. Alternatively take to the local waste station.

Chemical containers

- Triple rinse chemical containers, putting the rinsate into the spray tank and store the drums in a suitable location until disposed of in a DrumMUSTER® (www.drummuster.com.au) receival depot at your local tip or during a collection round.
- Information about how to rinse these containers correctly is available at the DrumMUSTER® website www.drummuster.com.au.
- Keep your receipts for proof of correct disposal

Store chemical containers in a suitable location until disposed of.

Chemical Disposal

- For disposal of unwanted or out of date chemicals book them into ChemClear® either online(www.chemclear.com.au) or by phone (free call 1800 008 182)and keep them in a cordoned off area of your chemshed until notified of a Chemclear collection in your area.

Mixed chemical

- To limit left over chemical, ensure tanks are properly calibrated and only mix enough for the activity.
- Any left over chemical from activities such as spraying or post-harvest treatments should be treated with hydrated lime or diluted with water, then disposed of away from waterways and drainage areas.
- Evaporation ponds can also be used to treat left over chemical. Ensure ponds are built away from waterways, drainage areas and flood-prone areas.

Items for disposal should be placed in skip bins located on the farm or taken to the local waste station.

Biobeds

A biobed is a mixture of peat free compost, soil and straw (biomix) covered with turf that is placed in a lined pit. A biofilter uses the same biomix, but does not require turf and uses a series of IBCs (Intermediate Bulk Containers) instead of a pit. Liquids enter the biomix within a biobed or biofilter from a bunded sprayer filling area either by gravity drain or pump, where they undergo bioremediation and are then drained from the biobed for reuse in sprayer washing.

See www.voluntaryinitiative.org.uk/en/water/biobeds

Oil, fuel and lubricants

- Use a local resource recovery contractor to collect waste. If there aren't any resource recovery contractors in your region, take these materials to your local waste station and dispose of according to their instructions.

Miscellaneous

- Items for off-site disposal should be stored in a location away from waterways, drainage areas and flood-prone areas while on your property, and disposed of through a waste contractor or taken to the local waste station.
- For on-site disposal, ensure the business complies with all government and local authority requirements.

Monitoring and recording

Identify the waste products generated by the business as well as strategies to reduce, reuse, recycle or dispose of them.

Develop a waste management program to identify the waste products generated by the business as well as strategies to reduce, reuse, recycle or dispose of them. This should be reviewed annually to ensure it remains current.

Keeping some basic records will show external parties the business is environmentally responsible:

- Documentation from DrumMUSTER®
- Documentation from ChemClear®
- Receipts from waste contractor
- Receipts from resource recovery

Be aware of the impact farming activities have on your neighbours.

AIR

Air quality management plan

Your farming activities have the potential to impact on neighbouring properties and the surrounding environment. Be aware of the impact farming activities have on your neighbours and discuss ways to minimise or eliminate this disturbance. Document how farming practices may impact on air quality and what remedial action will be taken to reduce this impact.

Managing odour

While most banana farming activities do not have associated odour issues, a few specific activities such as applying manures, disposing of waste bananas and using some chemicals may create odour problems.

Raw manure

- Apply composted manure, rather than in its raw form, to reduce the odour.
- If using raw manure, incorporate it into the soil as soon as possible after application.
- Store raw manure on-farm in a manner and place that minimises the odour impact on surrounding properties. For example, consider the location of your neighbouring properties and the prevailing wind direction. Store raw manure on an impermeable surface to prevent leaching, and preferably undercover to prevent runoff. Control surface water so it does not run across the site.

If possible, apply composted manure rather than in its raw form.

Waste bananas

- Mulch and spread waste bananas, where possible, or feed to livestock, if allowable, or consider composting it.
- If the waste bananas are to be dumped, spread the waste piles and do not put them upwind of neighbouring properties. Also, locate them away from waterways, so surface runoff cannot reach the waterways.

Chemicals

- Apply chemicals following the instructions on the label or permit.
- Consider the prevailing wind direction before and during chemical application.

Consider the wind direction when undertaking activities that will create dust.

Managing dust

Dust can cause increases in spider mite populations, both in the canopy and on the bunch. Dust can also impact on fruit quality, especially if the bunch cover causes abrasion. Besides production issues, excessive dust generated on your farm may create health problems.

- Consider the wind direction in relation to neighbouring properties and avoid dust-creating activities (e.g. liming) that would affect residences and surrounding buildings in certain wind conditions.
- Maintain buffer zones and vegetation barriers in problem areas around blocks and along roadways. Choose fast-growing natives. Your local council will have information on suitable species.
- Explore alternative liming-type products and application methods that minimise dust emissions.
- Apply gravel or sand to roadways to minimise dust, where necessary.
- Products for applying to road surfaces to minimise dust are available, although oil should never be sprayed on roads.
- To reduce dust in the short term, irrigate roads before they are used by large volumes of traffic, for example, when staff are arriving and leaving for the day.

Managing smoke

Consider wind direct in relation to neighbouring properties.

Similarly to dust, smoke can cause annoyance and health problems to neighbouring properties. Avoid burning whenever possible and consider alternative solutions. Never burn plastics; put them in a skip bin for collection or take them directly to the local dump.

Burning to prepare a paddock is not recommended. It removes organic matter, soil biology, soil moisture and leaves the soil prone to erosion. If burning is necessary:

- Apply for a permit, and comply with the conditions.
- Check the wind direction before burning to minimise disturbance to neighbouring properties.
- Comply with all laws on waste disposal.

Managing noise

Excess noise can be harmful for staff and irritating for neighbours. To minimise the noise impact:

- Begin noisy activities at appropriate times. Talk to your neighbours about suitable times.

Excess noise can be harmful for staff and irritating for neighbours.

- Consider switching to an electric pump, rather than diesel or PTO.
- If using a diesel or PTO pump, consider installing a noise barrier.
- Consider running pumps at times that minimise disturbance.
- Maintain machinery to ensure it is in correct working order.
- Consider ways to reduce the decibel rating coming from the packing shed. This would be more comfortable for workers, as well as benefit neighbouring properties.

Managing artificial lights

Consider the impact lights from machinery and buildings could have on neighbouring properties and wildlife.

- Plant vegetation buffers around blocks and boundaries to minimise light disturbance.
- Where possible, 'dip' any lights that have direct impact on a neighbouring property.

Vegetation around the edges of blocks and the farm minimises the impact of dust, noise and lights on neighbouring properties.

Select the most appropriate machinery for the job.

ENERGY

Conserving energy

Conserve energy by operating machinery efficiently and by adopting proficient management practices. Although not an energy saving, be aware of different power tariffs and take advantage of discounted rates where possible.

Machinery

- Select the most appropriate machinery for the job. Avoid excess capacity, but do not use equipment lacking the capacity to do the job efficiently.
- Service machinery and equipment regularly and maintain it well, for optimum performance.

Pump

- Use efficient pumps and motors in your irrigation system.
- Operate your pump so the head pressure and the output volume are working with optimum efficiency.
- Match the suction size (intake) and outlet size to the flow rate to reduce head loss.
- Use under-tree sprinklers or drip irrigation (rather than overhead irrigation) to minimise the pumping required. This is more energy efficient, water efficient and less conducive to fungal disease such as yellow Sigatoka.
- Change from diesel to an electric pump, where possible. Electric pumps are more energy-efficient.
- Carry out regular servicing, maintenance and performance checks on pumps to make sure they are running optimally.

Under tree sprinklers are more energy efficient than overhead irrigation.

Management practices

Adopt management practices that reduce the amount of energy used wherever possible.

- Apply compatible foliar fertilisers and foliar fungicides together. Read the product labels carefully to make sure the products are compatible and not phototoxic to the plant. Be very careful with **chlorothalonil** and do not mix it with spraying oil, emulsifiable concentrates (EC), wetting agents or surfactants.
- Apply trace elements with the weed spray to the rows.

Injecting plants with glyphosate will remove the need for large machinery and potentially the amount of cultivation required.

- Fertigating is energy-efficient because it combines two activities and can be used if the irrigation system and the weather are suitable.
- Leave trash on the row to reduce the evaporation rate and, therefore, the need to irrigate.
- A custom fertiliser blend may help to reduce the total number of fertiliser applications required.
- Inject the plants in knock-out blocks with glyphosate, which will remove the need to use large machinery, and may mean less discing is required. The permit for glyphosate use in the banana industry is available at the Australian Pesticides and Veterinary Medicines Authority website by searching the permit database for permit 11733 or by following this link http://permits.apvma.gov.au/PER14850.PDF.
- Consider using permanent beds and only working the row at planting. This will halve the area to be disced.
- Encourage crop scheduling or uniform cropping. This will reduce the need to travel each row of every block for 52 weeks a year, especially for practices such as bell injecting, bagging and harvesting.
- Maintain throughput in the packing shed to maintain efficiency for every carton produced.

Regularly check cold room seals to make sure they are not losing air.

Cold rooms

- Use properly designed and built cold rooms.
- Check cold room seals and associated fittings regularly, to make sure they are not damaged or losing air.
- Service cold room motors regularly, to make sure they are operating efficiently.
- Position cold rooms so they are protected from direct sunlight. Sunlight puts additional pressure on the motor to maintain a constant temperature.
- Minimise the amount of time the cold room doors are open.

General

- Consider energy efficient options when designing new buildings or upgrading existing systems.
- Consider other ways to reduce the temperature of banana fruit (e.g. hydro-cooling), rather than relying on cold rooms alone.
- Turn equipment off when not in use; this includes office equipment.

Refrigeration gases have a very high global warming index.

- Monitor energy use by checking the electricity bills and consider carrying out an energy audit on the business.
- Consider using 'green' energy from electricity providers or the potential for generating your own power supply using, for example, solar power.

More information about energy conservation is available from the Greenpower website at http://www.greenpower.gov.au.

Greenhouse gases

For banana production, the primary greenhouse gas concerns are:

- nitrous oxide (N_2O), which is produced during denitrification (also known as oxidation)
- carbon dioxide (CO_2), which is produced by burning fossil fuels, for operating machinery and using electricity, for example
- leaking refrigerant gas

Nitrous oxide

Under certain conditions, nitrates (NO_3) in the soil are converted to nitrous oxide (N_2O). This occurs when oxygen levels in the soil are depleted, (usually during water logging), and the soil bacteria start using oxygen (O_2) from nitrates. The remaining product is nitrous oxide (N_2O), which is lost into the atmosphere. This is classed as a **direct** emission.

Water logged conditions encourage the production of nitrous oxide.

The loss of nitrates to nitrous oxide can be minimised by:

- improving drainage in banana blocks to reduce the occurrence of water logging
- limiting fertiliser applications when the soil is already saturated

Nitrogen can also be lost as an **indirect** emission by leaching, surface runoff and volatilisation of ammonia based fertilisers that may eventually end up as nitrous oxide. The total Greenhouse Gas emissions for horticulture can be calculated as:

- direct emissions – denitrification (nitrous oxide)
- indirect emissions – nitrogen losses through leaching and surface runoff and volatilisation of ammonia based fertilisers

There are no other specific emissions allocated to horticulture.

Tree planting is the only carbon farming project methodology currently approved.

Carbon farming initiatives

Land managers can earn carbon credits by storing carbon (**sequestration**) or by reducing the total amount of emissions (**mitigation**). These projects must be approved so growers can then sell the credits.

Currently, the only approved project method is tree planting for sequestration. Other projects that have not yet been approved but that may be possible in the future include:

- reducing nitrogen fertiliser use (mitigation)
- using nitrification inhibiting products (mitigation)
- storing soil carbon (sequestration)

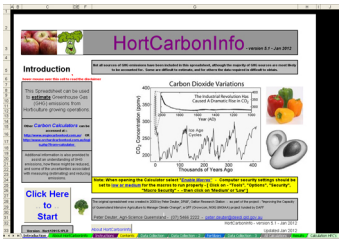
There is no limit to the amount of credits earned through sequestration. However, growers can only claim credits through mitigation that equals the reduction in business emissions made for reducing or improving applications of nitrogen.

For more information about the carbon farming initiative, refer to https://www.environment.gov.au/climate-change/emissions-reduction-fund/cfi/about.

For more information about approved project methods or method development, refer to http://www.climatechange.gov.au/government/initiatives/carbon-farming-initiative/methodology-development.aspx.

A carbon calculator for horticultural businesses is available at https://publications.qld.gov.au/dataset/agbiz-tools-business-and-finance-carbon.

To find out more about the carbon price and how it may affect your business refer to the factsheet at http://www.growcom.com.au/_uploads/114251_Climate_change_and_horticulture.pdf.



The carbon calculator can be used to estimate greenhouse gas emissions.

Monitoring and recording

The Freshcare Environmental Code requires that:

- A service record sheet is completed whenever maintenance and servicing is carried out (either by the business owner or personnel).
- When service providers conduct maintenance and servicing, the receipts and invoices are sufficient records of the work.
- Electricity and fuel use is monitored.

Fuel tanks should be located a safe distance from waterways.

FUEL

Ensure all fuel is stored and handled in a way that minimises the chance of accidental spills or soil and waterway contamination.

National legislation

For more information on relevant, national legislation, refer to:

- National Standard for Storage and Handling of Workplace Dangerous Goods (NOHSC:1015(2001)) http://www.safeworkaustralia.gov.au/AboutSafeWorkAustralia/WhatWeDo/Publications/Pages/NS200103StorageAndHandling.aspx.
- National Code of Practice for the Storage and Handling of Dangerous Goods (NOHSC:2017 (2001)) http://www.safeworkaustralia.gov.au/sites/SWA/AboutSafeWorkAustralia/WhatWeDo/Publications/Pages/CP2001StorageAndHanding.aspx.

Location

Fuel tanks should be located where they are easily accessible, safe from damage (in relation to adjacent activities) and where leakages can be managed to avoid flowing directly into a watercourse. Choose locations that are:

- a safe distance from waterways
- not placed up-hill of a waterway
- away from flood-prone areas
- in an open and easily accessible area
- away from activities that may cause physical damage to the tank
- away from potential sources of ignition such as chemicals and fertilisers

Fuel should only be stored in tanks specifically designed for this purpose.

Mobile fuel tanks

Ensure mobile fuel tanks are not left or used in locations where they may be a threat to waterways.

Ensure fuel is handled and stored in a way that minimises any potential spills.

Storing and maintaining

- Fuel should only be stored in tanks specifically designed for this purpose.
- Tanks should be installed on suitable surfaces such as hard ground, a concrete slab or steel footings.
- Fuel tanks should be checked regularly, especially underground tanks, to ensure they are in sound condition and not leaking.
- All associated equipment (stands, bunding, valves, hoses etc) should also be checked and maintained as required.

Spills

- In agricultural or horticultural situations, bunding is required for petrol tanks greater than 5,000 L and diesel tanks greater than 10,000 L.
- For storage tanks below these quantities, a risk assessment should be performed to determine how potential spills could be managed and whether bunding is required. Refer to Appendix F – Issues to be considered in a risk assessment, from Australian Standard AS 1940-2004, for further information. Australian Standards can be purchased from SAI Global at http://www.saiglobal.com.au/store.
- Fuel spills can be contained with a dirt barrier. However, this means the dirt and equipment must be available at short notice.
- Small spills can be absorbed by placing fine sand over the area.
- Use bottom-fill tanks on large tanks, where possible.
- Ensure filling and dipping points are easy to access.
- Turn valves off and lock nozzles when not in use, to prevent accidental spills.
- Ensure the fuel spout is stored in an upright position, to prevent residue fuel in the hose from leaking out.
- Ensure the nozzle's cut-out switch is in working order, to prevent over filling.

Bunding is required for petrol tanks greater than 5,000 L and diesel tanks greater than 10,000 L.

Consider any potential risks and develop strategies to minimise the likelihood of these events occurring as well as their impacts.

MSDS

Current Material Safety Data Sheets (MSDS) must be kept for all stored bulk fuels. These can be obtained from the supplier. They can also be accessed online. Each supplier will have a slightly different MSDS and these are links to the most common suppliers:

- BP – http://www.msds.bp.com.au/
- Shell – http://www.shell.com.au/products-services/on-the-road/fuels/msds-tds.html
- Mobil - http://www.msds.exxonmobil.com/IntApps/psims/psims.aspx
- Caltex – http://www.caltex.com.au/Pages/default.aspx > Products and Services > Material Safety Data Sheets

Monitoring and recording

Record fuel use and review the records to monitor fuel use efficiency.

MORE INFORMATION

Agrilink: Tropical banana information kit and Subtropical banana information kit

(Department of Agriculture Fisheries and Forestry, Queensland)
Pathway – http://www.daf.qld.gov.au > plants > fruit and vegetables > fruit and nuts > bananas > eResearch Archive > new search > and search 'banana agrilink'

General banana information and resources

http://www.daf.qld.gov.au/plants/fruit-and-vegetables/fruit-and-nuts/bananas
(Department of Agriculture Fisheries and Forestry, Queensland)
Pathway – http://www.daf.qld.gov.au > plants > fruit and vegetables > fruit and nuts > bananas

Land and Soil

Banana related soil resources

http://www.dpi.nsw.gov.au/agriculture/horticulture/tropical
(New South Wales Department of Primary Industries)
Pathway – http://www.dpi.nsw.gov.au > agriculture NSW > horticulture > tropical fruit

Banana root and soil health user's manual

http://era.daf.qld.gov.au/3498/
(Department of Agriculture Fisheries and Forestry, Queensland)
Pathway – http://www.daf.qld.gov.au > plants > fruit and vegetables > fruit and nuts > bananas

Case study: Bananas - Nurturing the soil and neighbouring wetlands on a banana farm in the wet tropics

http://wetlandinfo.ehp.qld.gov.au/resources/static/pdf/resources/reports/farming-case-studies/cs-constructed-wetlands-12-04-2013.pdf
(Queensland Government)
Pathway –http://www.ehp.qld.gov.au/ > topics > wildlife and ecosystems > wetlands > Wetland*Info* > management > wetland management tools and guides > case studies > banana farming for healthier wetlands

Factsheets and general information relating to land degradation and management options

http://www.qld.gov.au/environment/land/vegetation/
(Department of Natural Resources and Mines)
Pathway – http://www.nrm.qld.gov.au > land management > land degradation

Permit for glyphosate use in the banana industry

http://permits.apvma.gov.au/PER14850.PDF
(Australian Pesticides and Veterinary Medicines Authority)
Pathway – http://www.apvma.gov.au > permit search > permit number 11733

Soil and water best management practices for NSW banana growers

http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0007/242359/soil-and-water-best-management-practices-for-nsw-banana-growers.pdf
(New South Wales Department of Primary Industries)
Pathway - http://www.dpi.nsw.gov.au > agriculture NSW > horticulture > tropical fruit

Stream bank planting guidelines

http://www.qld.gov.au/dsiti/assets/soil/stream-bank-planting-guidelines.pdf
(Department of Natural Resources and Mines)
Pathway – http://www.nrm.qld.gov.au > resource centre > factsheets > river fact sheet series

Tillage implements, their benefits and potential impacts

http://www.dpi.nsw.gov.au/agriculture/resources/soils/structure/cultivation
(New South Wales Department of Primary Industries)
Pathway – http://www.dpi.nsw.gov.au > agriculture > natural resource management > soil health and fertility > soil types > structure and condition > how cultivation affects soil

Wetland management handbook: Farm management systems (FMS) guidelines for managing wetlands in intensive agriculture

http://wetlandinfo.ehp.qld.gov.au/resources/static/pdf/resources/reports/fms/fms_025_handbook_web.pdf
(Queensland Government)
Pathway – http://www.ehp.qld.gov.au/ > topics > wildlife and ecosystems > wetlands > Wetland*Info* > management > wetland management tools and guides > guidelines and reports > wetland management handbook: farm management systems guidelines for managing wetlands in intensive agriculture

Biosecurity

Banana Disease Risk Assessment Tool

http://abgc.org.au/projects-resources/industry-projects/best-management-practice-project/
Pathway > http://abgc.org.au/ > projects and resources > industry projects > best management practices project > Banana Disease Risk Assessment Tool

Banana Farm Biosecurity Manual

http://www.planthealthaustralia.com.au/wp-content/uploads/2015/03/Farm-Biosecurity-Manual-for-the-Banana-Industry.pdf.
Pathway - http://www.planthealthaustralia.com.au/ > Industries > Bananas > Biosecurity plans, manuals and resources > Farm Biosecurity Manual for the Banana industry

Decontamination Guide

https://publications.qld.gov.au/dataset/panama-disease-tropical-race-4-grower-kit/resource/566b02f0-eff4-4966-8da7-976c5e64dad6.

Exotic pests
http://www.planthealthaustralia.com.au/industries/bananas/
Pathway - http://www.planthealthaustralia.com.au/ > Industries > Bananas > Pests

Pesticides

Aerial spraying

http://www.aerialag.com.au
(Aerial Agricultural Association of Australia Limited)

Chemical use training and accreditation

http://www.chemcert.org.au
(Chemcert®)

Chemical use training and accreditation

http://www.smarttrain.com.au
(SMARTtrain)

Collection of unwanted chemical or out-of-date chemical

http://www.chemclear.com.au
(ChemClear®)

Collection of empty chemical containers

http://www.drummuster.com.au
(DrumMUSTER®)

Design and plant selection for buffer zones to reduce spray drift

http://agriculture.vic.gov.au/agriculture/farm-management/chemical-use/agricultural-chemical-use/spraying-spray-drift-and-off-target-damage/using-buffer-zones-and-vegetative-barriers-to-reduce-spray-drift
(Department of Primary Industries, Victoria)
Pathway – http://www.dpi.vic.gov.au > agriculture > farming and management > chemical use > agricultural chemical use > spraying, spray drift and off target damage > using buffer zones and vegetative barriers to reduce spray drift

Banana Integrated Pest and Disease Management

Agricultural chemical users' manual: Guidelines and principles for responsible agricultural chemical use

https://www.daf.qld.gov.au/__data/assets/pdf_file/0009/54738/AgChem-UsersManual.pdf
(Department of Agriculture Fisheries and Forestry, Queensland)
Pathway – http://www.daf.qld.gov.au > plants > agvet chemicals and residues > chemical use > agricultural chemical users' manual

Banana disease risk assessment tool

http://abgc.org.au/projects-resources/industry-projects/best-management-practice-project/
(Australian Banana Growers Council)
Pathway – http://abgc.org.au > projects and resources > industry projects > best management practices project > bmp & info > banana disease risk assessment tool

Banana industry biosecurity plan and the banana farm biosecurity manual

http://www.planthealthaustralia.com.au/wp-content/uploads/2015/03/Farm-Biosecurity-Manual-for-the-Banana-Industry.pdf
(Plant Health Australia)
Pathway – http://www.planthealthaustralia.com.au > industries > bananas > expand Biosecurity plans, manual and resources

Banana pest and disease resources

http://www.dpi.nsw.gov.au/agriculture/horticulture/tropical
(New South Wales Department of Primary Industries)
Pathway – http://www.dpi.nsw.gov.au > agriculture NSW > horticulture > tropical fruit

Burrowing nematode management booklet (provides information on how to calculate a RDI)

http://abgc.org.au/wp-content/uploads/2013/04/Managing-banana-nematodes_edited-version.pdf
(Australian Banana Growers Council)
Pathway – http://abgc.org.au > projects and resources > industry projects > best management practices project > bmp & info > managing banana nematodes

Chemical activity tables (groups) for fungicides, insecticides and herbicides to help develop chemical rotation programs

http://www.croplifeaustralia.org.au/default.asp?V_DOC_ID=1952
(Crop Life Australia)
Pathway – http://www.croplifeaustralia.org.au > resistance management

Design and plant selection for buffer zones to reduce spray drift

http://agriculture.vic.gov.au/agriculture/farm-management/chemical-use/agricultural-chemical-use/spraying-spray-drift-and-off-target-damage/using-buffer-zones-and-vegetative-barriers-to-reduce-spray-drift
planthealth (New South Wales Department of Primary Industries)
Pathway – http://www.dpi.vic.gov.au > agriculture > farming and management > chemical use > agricultural chemical use > spraying, spray drift and off target damage > using buffer zones and vegetative barriers to reduce spray drift

Factsheets about pests and diseases and production aspects of bananas

www.daf.qld.gov.au/plants/fruit-and-vegetables/fruit-and-nuts/bananas
(Department of Agriculture Fisheries and Forestry, Queensland)
Pathway – http://www.daf.qld.gov.au > plants > fruit and vegetables > fruit and nuts > bananas

Legislation about pesticide use

- Queensland – http://www.legislation.qld.gov.au/OQPChome.htm
- New South Wales – http://www.legislation.nsw.gov.au
- Western Australia – http://www.legislation.wa.gov.au
- Northern Territory – http://www.legislation.nt.gov.au

Search the databases under 'A' for Agriculture and Veterinary Chemicals

Material safety data sheets (MSDS) – soon to be referred to as SDS

http://www.apvma.gov.au
(Australian Pesticides and Veterinary Medicines Authority)

Permit for glyphosate use in the banana industry

http://permits.apvma.gov.au/PER14850.PDF
(Australian Pesticides and Veterinary Medicines Authority)
Pathway – http://www.apvma.gov.au > PERMITS: search > 11733

Permit for rodent bait use in the banana industry

http://permits.apvma.gov.au/PER14235.PDF
(Australian Pesticides and Veterinary Medicines Authority)
Pathway – http://www.apvma.gov.au > PERMITS: search > 14235

Pheromone baits for banana weevil borers

https://bugsforbugs.com.au/product/banana-weevil-borer-trap-pheromone/

Predatory insects commercially available in Australia, suppliers and toxicity of certain chemicals to predatory insects

http://www.goodbugs.org.au./

(Association of Beneficial Arthropod Producers Incorporated)

Search engines for products registered and permitted in the banana industry

http://www.apvma.gov.au

(Australian Pesticides and Veterinary Medicines Authority)

Subtropical banana growers best practice guide

http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0006/251898/Banana-growing-guide-cavendish-bananas-Complete.pdf

Fertiliser and Soil Additives

Subtropical banana growers best practice guides

- Factsheet 2 – Banana Nutrition - Part 1, The nutrient cycle
- Factsheet 4 – Banana Nutrition - Part 2, Leaf analysis as a guide

http://abgc.org.au/projects-resources/industry-info/fact-sheets-info/
(Australian Banana Growers Council)
Pathway – http://abgc.org.au > projects and resources > industry info > factsheets & info > subtropical fact sheets

Water

Irrigation and water quality factsheets produced as part of the Water for Profit initiative

http://www.growcom.com.au/land-water/water-for-profit/resources-water-for-profit/
(Growcom)
Pathway – http://www.growcom.com.au > projects and case studies > water for profit > resources

Soil and water best management practices for NSW banana growers

http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0007/242359/soil-and-water-best-management-practices-for-nsw-banana-growers.pdf
(New South Wales Department of Primary Industries)
Pathway http://www.dpi.nsw.gov.au > agriculture NSW > horticulture > tropical fruit

Biodiversity

Acts, policies and codes of practice relevant to each state

https://www.daf.qld.gov.au/plants/fruit-and-vegetables/farm-management/emss
(Department of Agriculture Fisheries and Forestry)
Pathway – http://www.daf.qld.gov.au > search 'ems biodiversity'

Banana disease risk assessment tool

http://abgc.org.au/projects-resources/industry-projects/best-management-practice-project/
(Australian Banana Growers Council)
Pathway – http://abgc.org.au > projects and resources > industry projects > best management practices project > bmp & info > banana disease risk assessment tool

Banana Industry Biosecurity Plan and the Banana Farm Biosecurity Manual

http://www.planthealthaustralia.com.au/wp-content/uploads/2015/03/Farm-Biosecurity-Manual-for-the-Banana-Industry.pdf
(Plant Health Australia)
Pathway –http://www.planthealthaustralia.com.au/wp-content/uploads/2015/03/Farm-Biosecurity-Manual-for-the-Banana-Industry.pdf > industries > banana > expand Biosecurity plans, manual and resources

Case study: Bananas - Nurturing the soil and neighbouring wetlands on a banana farm in the wet tropics

http://wetlandinfo.ehp.qld.gov.au/resources/static/pdf/resources/reports/farming-case-studies/cs-constructed-wetlands-12-04-2013.pdf
(Queensland Government)
Pathway – http://www.ehp.qld.gov.au/ > topics > wildlife and ecosystems > wetlands > Wetland*Info* > management > wetland management tools and guides > case studies > banana farming for healthier wetlands

Conserving Australia's biodiversity

http://www.environment.gov.au/biodiversity
(Department of Sustainability, Environment, Water, Population and Communities)
Pathway – http://www.environment.gov.au > biodiversity

Flying foxes and control permits

- Queensland – http://www.ehp.qld.gov.au/wildlife/livingwith/flyingfoxes/
- New South Wales – http://www.environment.nsw.gov.au/animals/flyingfoxes.htm
- Northern Territory – https://parksandwildlife.nt.gov.au/
- Western Australia – www.environment.wa.gov.au/management-and-protection/animals/living-with-wildlife

(State based environment and heritage departments)

Identification of regional priorities

http://www.environment.gov.au/cgi-bin/sprat/public/conservationadvice.pl
(Department of Sustainability, Environment, Water, Population and Communities)
Pathway – http://www.environment.gov.au > biodiversity > threatened species and ecological communities > conservation advices by NRM region

Identify regional priorities and potential on-farm projects

- Queensland
  - list of Queensland NRM groups http://www.nrm.gov.au/regional/regional-nrm-organisations
  - wet tropics coast , Terrain http://www.terrain.org.au
  - west of Mareeba, North Gulf Region http://www.northerngulf.com.au
  - Lakeland and Cooktown areas, Cape York Natural Resource Management http://www.capeyorknrm.com.au
  - Bundaberg, Burnett Mary Regional Group www.bmrg.org.au
  - Sunshine Coast and Caboolture, SEQ catchments http://www.seqcatchments.com.au/
- New South Wales
  - Northern rivers Local Land Services www.northern.LLS.nsw.gov.au

- Northern Territory
  - NRM Board (Northern Territory) Inc http://www.territorynrm.org.au/
- Western Australia
  - Rangelands NRM (northern and eastern WA) http://www.rangelandswa.com.au/

(Local Land Services (LLS) or natural resource management group (NRM))

Native vegetation selections and projects
https://www.greeningaustralia.org.au/
(Greening Australia)

Native vegetation selections and projects
http://www.landcareonline.com.au/
(Landcare)

Permit for rodent bait use in the banana industry
http://permits.apvma.gov.au/PER14235.PDF
(Australian Pesticides and Veterinary Medicines Authority)
Pathway – http://www.apvma.gov.au > PERMITS: search > 14235

Weeds and noxious weeds
http://www.weeds.org.au/noxious.htm
(Weeds Australia)

Weeds of national significance (WoNS)
http://www.weeds.org.au/WoNS/
(Weeds Australia)

Waste

Collection of empty chemical containers
http://www.drummuster.com.au
(DrumMUSTER®)

Collection of unwanted chemical or out-of-date chemical
http://www.chemclear.com.au
(ChemClear®)

Energy

Carbon calculator for horticultural businesses
https://publications.qld.gov.au/dataset/agbiz-tools-business-and-finance-carbon
(Queensland Government)
Pathway –https://www.business.qld.gov.au/industry/agriculture/agribusiness/agbiz>
Agbiz calculators for farm business and finance > carbon > Horticulture carbon

Carbon farming initiative
http://www.environment.gov.au/climate-change/emissions-reduction-fund/cfi/about
(Department of Climate Change and Energy Efficiency)
Pathway – http://www.climatechange.gov.au > carbon farming initiative

http://www.cleanenergyregulator.gov.au/Carbon-Farming-Initiative/Pages/default.aspx
(Clean Energy Regulator)
Pathway – http://www.cleanenergyregulator.gov.au > carbon farming initiative

Save energy and alternative sources of energy
http://www.greenpower.gov.au
(Green Power)

Fuel

Australian Standard AS 1940-2004
http://www.saiglobal.com.au/store
(SAI Global)
Pathway – http://www.saiglobal.com.au/store > products and services > standards, legislation, codes and business information > standards and technical information services > search publications

National Code of Practice for the Storage and Handling of Dangerous Goods (NOHSC:2017 (2001))
http://www.safeworkaustralia.gov.au/sites/SWA/about/Publications/Documents/249/CodeOfPracticeStorageAndHandingDangerousGoodsNOHSC2017-2001_PDF.pdf
(Safe Work Australia)
Pathway – http://www.safeworkaustralia.gov.au > about Safe Work Australia > publications and resources > use the search function

National Standard for Storage and Handling of Workplace Dangerous Goods (NOHSC:1015(2001))
http://www.safeworkaustralia.gov.au/sites/swa/about/publications/pages/ns200103storageandhandling
(Safe Work Australia)
Pathway – http://www.safeworkaustralia.gov.au > about Safe Work Australia > publications and resources > use the search function

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APPENDIX – FLOWCHART OF BANANA ACTIVITIES

Land preparation

Crop eradication
⬇
Fallow management
⬇
Site selection
⬇
Ground preparation
⬇
Pre-plant fertiliser application/soil improvement

⬇

Growing

Planting
⬇
Irrigation
⬇
Fertilising
⬇
Machinery and vehicles
⬇
Integrated pest, disease and week control (including animals)
⬇
Crop husbandry (bagging, desuckering, stringing, etc)
⬇
Paddock, drain and road maintenance
⬇
Picking
⬇
Transport to packing/processing/storage

⬇

Packing

Packing
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Storage and dispatch

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For more information

visit the Australian Banana Growers' Council website at abgc.org.au