Brassica Best Practice

Integrated Pest Management

State Government Victoria

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DEPARTMENT OF PRIMARY INDUSTRIES | farm services

A Guide to Integrated Pest Management for Brassica
- Insect Pest, Disease, Virus, Nematode and Weed Control

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Purpose of this Guide

This guide outlines the key issues that should be considered in relation to the implementation of Integrated Pest Management (IPM) for brassica crops on a whole of crop basis. The guide addresses the key control methods and their rating in an IPM system for the major insect pests, disease, virus, nematode and weed control.

The guide should be used in conjunction with the posters; "Brassica crop protection products – A guide to potential impacts on beneficials" and the "Best Practice IPM – Overview". The guide should also be used alongside other publications such as the, "Field Guide to – Pests, Diseases and Disorders of Vegetable Brassicas.

If you would like to receive this information/publication in an accessible format (such as large print or audio) please call the Customer Service Centre on 136 186, TTY 1800 122 969, or email customer.service@dpi.vic.gov.au.

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What is IPM (Integrated Pest Management)?

IPM is an effective combination of chemical, cultural (such as, farm management practices) and biological methods to keep, weeds, insect pest numbers, disease pressure and other crop production problems low enough to prevent significant economic loss.

In an IPM system the term pest includes insects, diseases, viruses, nematodes and weeds.

IPM tactics

Good forward planning and the careful design of a production system will minimise the risk of pest, weed and other problems and reduce the need for chemical control. To implement IPM you must understand:

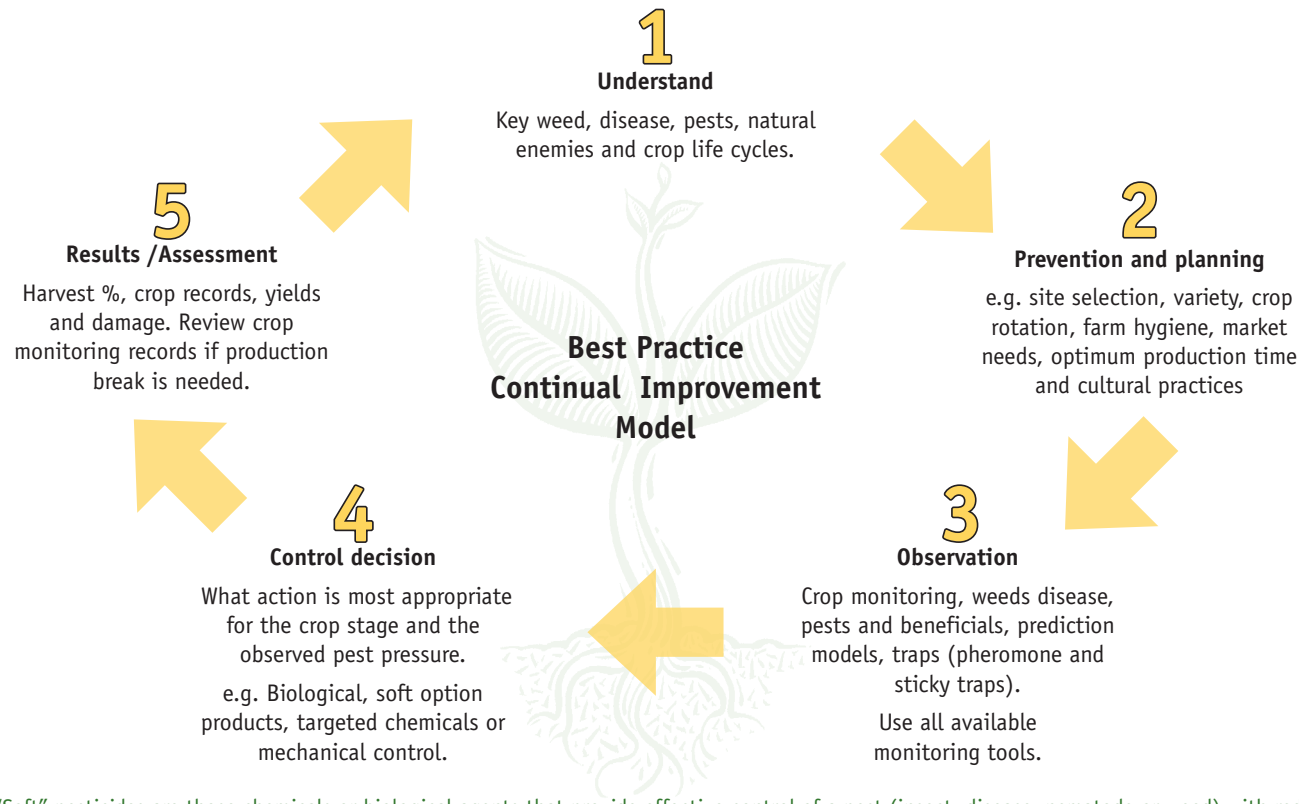
- crop rotation
- identification of your best production window
- efficient irrigation and drainage systems
- monitoring and pest thresholds
- beneficials and pests
- good farm hygiene
- available pest control techniques and products including their IPM rating.

A range of issues must be considered when considering an IPM production system:

- **Identify the main pest and crop issues for the season and time of production.**
- **If not controlled, do the pests pose a production threat?**
- **Identify the actions required to minimise any potential impact – eg. cultural, crop rotation, variety selection.**
- **Know which pests, diseases and beneficials are in your crop -** monitor for beneficials and insect pests and regularly scout your crop for any disease incidence.
- **Understand the pest pressure to determine if control is necessary.**
- **Identify whether or not there is a threat to production, or the potential impact, if the pests are not controlled.**
- **Once a decision is made to apply a chemical control, then the choice of product will depend on the pest to be controlled versus the impact on beneficials, as well as other production issues.**
- **Record yields and damage to assess effectiveness of control methods and review the IPM program.**

"Beneficials" can be generalist predators such as spiders or more specialised like hoverflies whose larvae prefer to feed on aphids or they may be parasitoids such as wasps whose eggs may be laid in pest insect larvae or eggs which are then parasitized by the emerging larvae.

Step by step guide to decision making and the improvement of IPM Practices



Note: "Soft" pesticides are those chemicals or biological agents that provide effective control of a pest (insect, disease, nematode or weed) with reduced impact on beneficial species.

How to monitor/scout a crop

The purpose of scouting/monitoring is to gain a good understanding of insect pest, disease, weed and beneficial insect activity in your crop. Effective monitoring includes assessing the numbers of insect pests and beneficials in a crop as well as the incidence of diseases and weeds. Recording this information and any control actions taken, will help you to better understand your crop management practices over time. A record of this information, allows you to refer to previous monitoring results and determine the impact and effectiveness of your control decisions.

Crop monitoring

A number of tools are available for monitoring pests and beneficials, including:

- Pheromone traps (which attract males of specific pests such as the Diamond Back Moth).
- Yellow sticky traps (which attract a broad spectrum of flying insects – blue sticky traps can be used for some thrips and leafminers).

These tools will help provide information about the range and activity of pests and beneficials present in your crop. Data from traps should be recorded to identify flights, or periods of peak activity. This data will assist in determining the frequency of crop scouting. Obviously, during peak production periods check traps more frequently. For example, if a large flight of moths occurs, then crops should be scouted at least twice a week during the next few weeks.

Forecasting models

There are certain forecasting programs which can assist in determining the likelihood of infection or emergence, once suitable conditions are met.

For example, there is a disease forecast model for White Blister called the Brassica$_{spot™}$ Disease Predictive Model. The Model provides an indication of disease pressure based on the current weather conditions. Such models can be useful to either trigger a control action or indicate the importance of increased scouting and vigilance over the next few days of a crop's production cycle.

Crop scouting

Scouting each area or block regularly, twice a week in warmer weather and once a week in winter, provides a picture of the beneficials, insect pest, disease, virus and weed levels in a crop. When scouting, cover a thorough cross section of a block, as pest problems can occur in patches at one end or side of a block or at the crop edge. There may also be "hot" spots in different areas of a block.

The number of plants to check will depend on a crop's growth stage and the total area of the planting. Growth stages can be grouped as one if plantings are close together e.g., group together plantings at two and three weeks of age.

For some pests there are specific recommendations for thresholds and the number of plants to check. When scouting use a zigzag or M pattern over a paddock (see diagram for examples) and generally check at least three plants at a minimum of 10 random sites. There is more detailed information on scouting patterns in a range of publications on specific pests.

As you walk through a crop, you are likely to spread infection particularly if the leaves are wet. Always scout clean paddocks before moving into blocks that are known to be infected and remember to practice good hygiene between crops.

Scouting pattern

Scouting involves moving through paddocks looking for pests and beneficials, measuring populations and then using this information to make pest control decisions. The information helps growers know if a pest control treatment is needed, where it is needed and what options are available and practical. When scouting a crop, it is important to get a random sample using various patterns such as a zigzag, M or V pattern as indicated below.

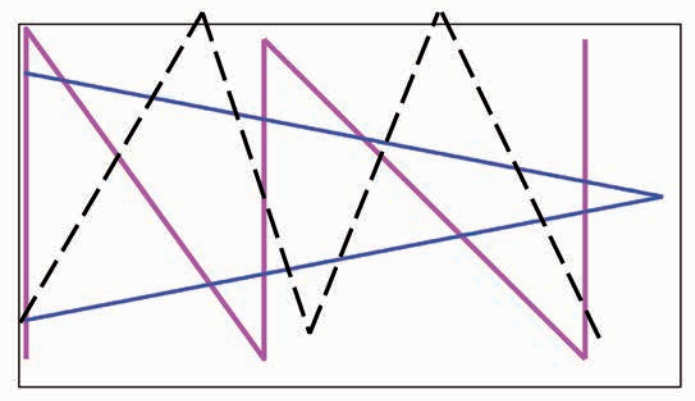


Diagram 1: A sample of some scouting patterns.

Farm hygiene

Good farm hygiene is one of the simplest, but most often overlooked, methods of managing weeds and pests. Good hygiene reduces the risk of bringing new infections onto the farm, and reduces the spread of existing problems.

- Production areas of the farm should always have restricted access.
- Vehicles and equipment must be cleaned before entering and people should also be made aware of the risk they pose as potential carrier of pests.
- Ensure clothing and footwear is clean.
- Ensure all people entering the farm report to a central point away from the production zone, such as a shed or office. This includes suppliers, contractors, workers and visitors.
- Be sure to explain how to comply with your hygiene practices.
- Seedling trays, boxes, crates and other equipment are also a source of potential infection and should be inspected before entry.
- Only accept clean transplants and ensure they are obtained from a quality nursery who complies with your pest management strategies. Avoid using transplants that are infected or contaminated with pests.

If you have your own nursery it should be isolated from crops or host plants and free of weeds. Use soil-less potting mix, place trays up on benches, maintain good air movement, control infection and manage pests.

Internal farm hygiene means avoiding the movement of soil, insects and plant material around the farm. These can all spread infection to clean areas. Spread usually occurs via dirty equipment, machinery, vehicles and soil on workers' boots. Work from young to old plantings rather than the other way around or if there is a known infection site be sure to do that last, whether it is when you are crop scouting, moving a tractor or hand weeding.

Keeping headlands clear of weeds is good hygiene practice. It ensures there is no place for insects and diseases to carry-over between crops. Clean headlands also reduce weed seed sources contaminating a crop.

Removal of crop residues and self-sown plants also forms an important part of an efficient IPM hygiene routine as they too can act as habitat for insect pests and diseases when the main crop has been removed.

Note: Weeds may provide habitat for beneficial insects. Therefore you may need to consider the weeds that are present and the likelihood that they may cause production problems and / or be a host for pests.

Generic IPM Practices

There are standard IPM practices that apply to all cropping issues, pests and weed control.

A production break: Avoids a weed or pest problem being carried over from one season to the next.

Land preparation: Good land preparation assists with plant establishment, weed control and reduces the risk of water logging and plant losses from soil borne diseases.

Selecting the right crop and site: Select a crop and production site that maximises your chance of success.

Keeping records: Records help build a picture of weed and pest risks on different parts of the farm.

Crop rotation: To break the life cycle of diseases and pests and control germinating weeds.

Green manure crops: Improve soil structure, water and nutrient holding capacity, as well as provide a break from intensive production. Green manure crops have the potential to suppress weed growth and may also act as a harbour for beneficials, but do not let green manure crops set seed as these can be another weed source.

Isolate nursery: A nursery should be isolated from crops or host plants and free of weeds.

Nursery hygiene: Use sterile soil-less potting mix, place trays up on benches, maintain good air movement, control infection and manage pests.

Use only clean healthy transplants: Avoid using transplants that are infected or contaminated with pests.

Post harvest: Destroy old crop residues and weeds promptly by ploughing in or spraying off, as these may be a reservoir for pests and diseases.

Subsequent plantings: These should be up-wind (of prevailing winds), where possible, to minimise the chance of contamination. If feasible, put a physical barrier between crops (such as a trap crop, alternate crop or wind break) so pest and disease problems don't migrate from one planting to the next.

Designing the production system

Good farm management practices are vital in the control of pest problems, such as:

- Healthy well-grown plants are less likely to suffer disease and pest problems than plants stressed from poor irrigation and / or nutrition.
- Overhead irrigation may, if timed incorrectly, increase the length of leaf wetness times and hence encourage disease.
- Furrow irrigation if timed incorrectly can delay follow-up sprays, which are needed to manage a pest outbreak, and encourage soil borne diseases.
- Drip irrigation saves water, allows quick crop re-entry after watering and doesn't wet plant leaves.
- Bedding-up improves drainage and air circulation around plants – both help reduce disease problems.
- Good spray coverage is essential but more difficult to achieve in high-density plantings.
- Poor air circulation in a crop increases disease risk. Ensure there is good airflow around plants so the leaves dry quickly and the humidity doesn't build up.

Production window

The key is to select a production period and site that will minimise weeds, insect pest and disease problems. For instance:

- caterpillar problems are usually worse in warmer weather
- foliar diseases and bacterial head rots are usually worse in warm, wet weather
- club root also prefers warm conditions.

First select the right variety for a growing season and a particular market and then consider options for resistant varieties for insect pest and disease issues.

Weed control – pest and beneficial habitat

Weeds are a significant host of both pests and diseases in brassica crops, some specific weeds are known hosts of viruses and the vectors of those viruses.

Weed control and control of pests such as aphids and thrips in weeds on headlands may be a necessary management practice for virus control.

Weeds that are good hosts of viruses may also be good hosts for a range of pests which transmit the viruses. However, they may also be a good host for beneficials such as parasitoids and predators of these pests.

It is important to control weeds that are virus hosts as well as pest hosts and green manure crops have the potential to significantly suppress weed growth.

It is vital that a beneficial habitat is encouraged in order to support an IPM program.

There can be a conflict in maintaining beneficial habitat and managing the risk of disease presence and pest activity:

- Monitor weeds and remove and control those which are critical hosts of pests.
- Encourage beneficial habitat in areas adjacent to production areas but not within a crop.
- Consider the use of native vegetation or the use of grass species in headlands as alternative options for beneficial habitat. (For further information refer to the “Re-Vegetation by Design” project.)

The following tables indicate the key control methods, their IPM rating and management for the major insect pests, disease, nematode, virus and weed control issues.

Each of the pest areas is colour coded.


Insects


Disease


Nematode


Snails and slugs


Virus


Weed control

Aphids *spp.*

Range of species: Cabbage aphid *Brevicoryne brassicae*, Green Peach aphid *Myzus persicae*, Turnip aphid *Lipaphis erysimi*

Effective IPM Rating √ √ √ √ √

Critical Comments: Some chemicals not suited to IPM need to be chosen carefully. There are good targeted IPM options available. It is important to consider the aphid species present and whether control is needed.

Infestation Risk Factors		Cultural Practices			Chemical Control			Conflicts / Issues
Increases the risk	**Reduces the risk**	**Monitoring Control Thresholds**	**Beneficial Insects**	**Other**	**Pest Lifecycle**	**Chemical**	**IPM Issues**	
A nearby crop or a weedy area could be a source of insect pests. Mild weather – spring and autumn plantings. Brussel Sprouts- aphids in crevices can make them unmarketable even if no damage is done.	Cool /cold weather.	3-4 aphids on most seedlings checked. When scouting check for aphid "mummies" to indicate parasitoid activity. Monitor using yellow sticky traps to check aphid levels.	**Parasitoid** · Aphid wasps (*Aphidiidae*) **Predators** · Spiders · Predatory bugs · Ladybird beetles · Lacewings · Hoverflies Consider providing habitat for beneficial insects.	Plant with spacing that allows maximum spray coverage. Subsequent plantings should be up-wind in a different area of the farm. Select a production period that will minimise pest pressure.	Aphids can be a source of virus spread within the crop. (Refer to virus table). Identify the pest accurately. Cabbage aphid colonies may be confined to single plants and commercial cut out may not be greatly affected.	Range of IPM suitable and soft option aphid-specific chemicals available with good IPM Rating.	Year-round production increases the risk of insecticide resistance. Use targeted chemicals if possible when control is required. Monitor closely some soft option products take a few days before you see a visual effect.	Effective control can be achieved by beneficials. Need to monitor beneficial activity and aphid pressure to determine the need for chemical control.

Infestation Risk Factors		Cultural Practices			Chemical Control			Conflicts / Issues
Increases the risk	**Reduces the risk**	**Monitoring Control Thresholds**	**Beneficial Insects**	**Other**	**Pest Lifecycle**	**Chemical**	**IPM Issues**	
				Aphids are generally not a problem during cooler weather and once the crop is established.			Evaluate other pests and beneficials present when deciding on control methods.	Allow for a lag to allow beneficial build up for control. Remove virus affected plants and weeds. Some systemic chemicals not suited to IPM.

Cabbage Centre Grub

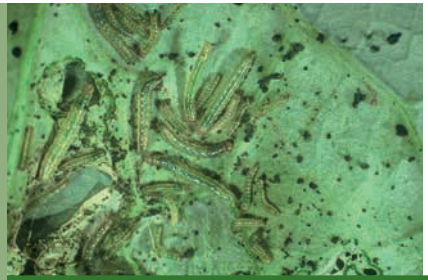
Hellula hydralis

Effective IPM Rating √ √ √ √ √

Critical Comments: Need to consider if control is required particularly in southern production areas.

Infestation Risk Factors		Cultural Practices			Chemical Control			Conflicts / Issues
Increases the risk	**Reduces the risk**	**Monitoring Control Thresholds**	**Beneficial Insects**	**Other**	**Pest Lifecycle**	**Chemical**	**IPM Issues**	
A nearby crop or a weedy area could be a source of insect pests. Warmer weather conditions can favour insect activity. Younger seedling stages are the most susceptible though older plants can be affected.	Monitor crops – in Victoria and SA production areas, high activity in the field does not necessarily mean that there will be significant crop damage.	1 caterpillar in 20 seedlings. Check carefully within the young growing point of seedlings. Look for tell-tale pin holes in the lower stem of younger leaves near the growing point.	**Predators** · Spiders · Assassin bugs · Ladybird beetles · Lacewings · Ants · Native earwigs Consider providing habitat for beneficial insects.	Plant with spacing that allows maximum spray coverage. Select a production period that will minimise pest pressure. Control is important from seedling to head formation.	Control easiest at first sign of infestation, before caterpillars burrow deep into the plant growing point or leaf stem tissue. High water volumes required to try and get product into the plant growing point.	There are registered insecticides and options with good IPM Rating.	Be aware of what **chemicals** have been applied to the seedlings in the nursery. Good spray coverage is essential as the caterpillar tunnel into the tissue and growing point. Several new soft options (Group 28 products are effective).	DBM control programs may provide adequate control of this pest. Plants at seedling stage are most at risk. In southern production areas control may not be needed.

Infestation Risk Factors		Cultural Practices			Chemical Control			Conflicts / Issues
Increases the risk	**Reduces the risk**	**Monitoring Control Thresholds**	**Beneficial Insects**	**Other**	**Pest Lifecycle**	**Chemical**	**IPM Issues**	
Early season and summer plantings are most at risk in Qld and WA. In southern production areas some Asian leafy vegetables are most at risk.		Webbing and wind blown soil around the growing point are indicators of Centre Grub activity.		Good soil preparation can reduce pupae that live in soil. Older plants can tolerate mild infestations. Plough in crop residue.				



Cabbage Cluster Caterpillar

Crocidolomia pavonana

Effective IPM Rating √ √ √ √ √

Critical Comments: DBM program will generally provide control.

Infestation Risk Factors		Cultural Practices			Chemical Control			Conflicts / Issues
Increases the risk	**Reduces the risk**	**Monitoring Control Thresholds**	**Beneficial Insects**	**Other**	**Pest Lifecycle**	**Chemical**	**IPM Issues**	
A nearby crop or a weedy area could be a source of insect pests. Warm weather. Early season plantings are most at risk in QLD and WA.	No other surrounding brassica producers.	1 to 2 egg masses in 10 plants (wait for eggs to hatch before taking action). Look for webbing as a sign of activity. Prefer inner leaves and head. Found in groups.	**Parasitoids** · *Trichogramma* **Predators** · Spiders · Predatory bugs · Ladybird beetles · Lacewings Consider providing habitat for beneficial insects.	Plant with spacing that allows maximum spray coverage. Good soil preparation can significantly reduce numbers. Subsequent plantings should be in a different area of the farm so there is a physical barrier between crops.	Control easiest at small caterpillar stage. Caterpillars occur in groups (clusters).	There are registered insecticides and options with good IPM Rating. *Bacillus thuringiensis* (Bt) only works well against small caterpillars apply it early in an insect's lifecycle.	Be aware of what **chemicals** have been applied to the seedlings in the nursery. Good spray coverage essential. Soft option products are available.	DBM control programs should provide adequate control of this pest. Bt stops caterpillar feeding but takes several days to kill. Apply Bt's after irrigation not before.

Infestation Risk Factors		Cultural Practices			Chemical Control			Conflicts / Issues
Increases the risk	**Reduces the risk**	**Monitoring Control Thresholds**	**Beneficial Insects**	**Other**	**Pest Lifecycle**	**Chemical**	**IPM Issues**	
				Select a production period that will minimise pest pressure. Plough in crop residue.				

Cabbage White

Pieris rapae

Effective IPM Rating √ √ √ √ √

Critical Comments: Control effective with DBM program.

Infestation Risk Factors		Cultural Practices			Chemical Control			Conflicts / Issues
Increases the risk	**Reduces the risk**	**Monitoring Control Thresholds**	**Beneficial Insects**	**Other**	**Pest Lifecycle**	**Chemical**	**IPM Issues**	
A nearby crop or a weedy area could be a source of insect pests. Warm weather		10 small caterpillars in 10 plants. (Wait to see how many survive - use the DBM guideline for your spray decision).	**Parasitoids** · *Cotesia spp* · *Pteromalus puparum* · *Tachinid* fly · *Trichogramma* **Predators** · Spiders · Predatory bugs · Ladybird beetles · Lacewings Consider providing habitat for beneficial insects.	Plant with spacing that allows maximum spray coverage. Subsequent plantings should be in a different area of the farm so there is a physical barrier between crops. Select a production period that will minimise pest pressure.	Control easiest at small caterpillar stage. Avoid spraying at large caterpillar stage.	There are registered insecticides and options with good IPM Rating. *Bacillus thuringiensis* (Bt) only works well against small caterpillars apply it early in insect lifecycle. Two species of Bt are available.	Be aware of what **chemicals** have been applied to the seedlings in the nursery. Good spray coverage is essential, but more difficult to achieve on some varieties or crop stages, for example, cabbage with strongly crinkled leaves, cauliflower with a high degree of self-covering.	DBM control programs should provide adequate control of this pest. Some chemical groups less IPM friendly need to target use carefully. Bt stops caterpillar feeding but takes several days to kill.

Infestation Risk Factors		Cultural Practices			Chemical Control			Conflicts / Issues
Increases the risk	**Reduces the risk**	**Monitoring Control Thresholds**	**Beneficial Insects**	**Other**	**Pest Lifecycle**	**Chemical**	**IPM Issues**	
				Control important during seedling to hearting. Plough in crop residue.		If spraying is required close to harvest use a soft option product with a short withholding period.	Rotate soft option products.	Apply Bt's after irrigation not before.

Cluster Caterpillar

Spodoptera litura

Effective IPM Rating √ √ √ √ √

Critical Comments: DBM program will generally provide control.

Infestation Risk Factors		Cultural Practices			Chemical Control			Conflicts / Issues
Increases the risk	**Reduces the risk**	**Monitoring Control Thresholds**	**Beneficial Insects**	**Other**	**Pest Lifecycle**	**Chemical**	**IPM Issues**	
A nearby crop or a weedy area could be a source of insect pests. Warmer weather. Early season plantings are most at risk in QLD and WA.	Good hygiene.	1 to 2 egg masses in 10 plants (wait for eggs to hatch before taking action). Prefer to lay eggs on inner leaves and head. Small caterpillars found in groups. Older caterpillars are solitary.	**Parasitoids** · *Trichogramma* · *Microplitis* **Predators** · Spiders · Predatory bugs · Ladybird beetles · Lacewings Consider providing habitat for beneficial insects.	Plant with spacing that allows maximum spray coverage. Good soil preparation can significantly reduce numbers. Subsequent plantings should be checked as soon as insect pest is detected.	Control easiest at small caterpillar stage. Avoid spraying at large caterpillar stage.	There are registered insecticides and options with good IPM Rating. *Bacillus thuringiensis* (Bt) only works well against small caterpillars apply it early in an insect's lifecycle.	Be aware of what chemicals have been applied to the seedlings in the nursery. Good spray coverage is essential; ensure adequate water volumes and a suitable wetter.	DBM control programs should provide adequate control of this pest. Bt stops caterpillar feeding but takes several days to kill. Good coverage essential and avoid spraying in the heat of the day.

Infestation Risk Factors		Cultural Practices			Chemical Control			Conflicts / Issues
Increases the risk	**Reduces the risk**	**Monitoring Control Thresholds**	**Beneficial Insects**	**Other**	**Pest Lifecycle**	**Chemical**	**IPM Issues**	
				Select a production period that will minimise pest pressure. Plough in crop residue.		Soft option products and new softer chemistry is available.		

Cutworm

Agrotis spp.

Effective IPM Rating √ √ √ √ √

Critical Comments: Control is best achieved with cultural and management practices, consistent with IPM practices but if chemical control is required it will not fit into an IPM system.

Infestation Risk Factors		Cultural Practices			Chemical Control			Conflicts / Issues
Increases the risk	**Reduces the risk**	**Monitoring Control Thresholds**	**Beneficial Insects**	**Other**	**Pest Lifecycle**	**Chemical**	**IPM Issues**	
A nearby crop or a weedy area could be a source of insect pests. Consider previous cropping history for paddock such as crops coming out of pasture. Warm weather. Uncultivated or weedy ground.	Avoid opportunistic weed growth. If the paddock is a known problem area, cultivate several weeks prior to planting and consider a period of farrow.	Active at night or early evening. Look for damaged (cut off) seedlings and then search for curled up caterpillars in the first few centimetres of soil.	**Parasitoid** · *Trichogramma* **Predators** · Spiders · Common brown earwig · Predatory beetles Consider providing habitat for beneficial insects.	Plant with spacing that allows maximum spray coverage. Good soil preparation can significantly reduce numbers. Select a production period that will minimise pest pressure. Control important during seedling to buttoning. Plough in crop residue.	Pest is active and feeding at night. Control most effective with a late afternoon early evening spray. Ground dwelling pest so high water volume application essential (minimum 600L/Ha).	Soil borne insect - treat affected area late in the day for best results. Chemical control still relies on broad spectrum products. Not suited to IPM.	Good spray coverage is essential as this is a soil dwelling pest. Late afternoon control applications tend to give best results.	Chemical control can be difficult to achieve as the pest hides in the soil. Management best achieved with cultural practices. Good ground preparation and hygiene will assist in pre-plant control.

Diamond Back Moth (DBM) / Cabbage Moth

Plutella xylostella

Effective IPM Rating √ √ √ √ √

Critical Comments: Resistance management strategy essential, broad spectrum control not effective and some new chemicals have a variable IPM Rating.

Infestation Risk Factors		Cultural Practices			Chemical Control			Conflicts / Issues
Increases the risk	**Reduces the risk**	**Monitoring Control Thresholds**	**Beneficial Insects**	**Other**	**Pest Lifecycle**	**Chemical**	**IPM Issues**	
A nearby crop or a weedy area could be a source of insect pests. Some types and varieties of brassica may be more attractive to DBM. Cabbages less tolerant of damage to marketable heads.	A summer production break recommended in QLD (northern production areas). Good farm hygiene.	**Broccoli** 4 to 6 small caterpillars in 10 plants. **Cabbage** 1 to 3 small caterpillars in 10 plants. **Cauliflower** 2 to 4 small caterpillars in 10 plants.	**Parasitoid** · *Diadegma* – more effective in cooler weather. · *Diadromus* · *Oomyzus* · *Trichogramma* It is important to assess the level of parasitism (if >85% consider not spraying).	Plant with row spacing that allows maximum spray coverage. Subsequent plantings should be up-wind of current crops and preferably in a different area of the farm so there is a physical barrier between crops.	Control easiest at small caterpillar stage. Avoid spraying at large caterpillar stage.	There are a range of registered insecticides and many options with good IPM Rating. *Bacillus thuringiensis* (Bt) only works well against small caterpillars apply it early in crop lifecycle.	Year-round production increases the risk of insecticide resistance. Be aware of what chemicals have been applied to the seedlings in the nursery.	Two-Window' resistance management strategy developed. (refer to SARDI web-site / Brassica ICM CD) **. Some chemical groups are less IPM friendly and their use should be targeted carefully.

Infestation Risk Factors		Cultural Practices			Chemical Control			Conflicts / Issues
Increases the risk	**Reduces the risk**	**Monitoring Control Thresholds**	**Beneficial Insects**	**Other**	**Pest Lifecycle**	**Chemical**	**IPM Issues**	
Warm weather increases pest pressure through spring – autumn.		Use sampling plan* Use pheromone traps to monitor moth activity and to guide frequency of field monitoring.	**Predator** · Spiders · Predatory bugs · Ladybird beetles · Lacewings Consider providing habitat for beneficial insects.	Select a production period that will minimise pest pressure. Effective control is important right from seedling production. Plough in crop residue.		Two species of Bt are available. If spraying is required close to harvest choose a soft option with a short withholding period.	Good spray coverage is essential, but more difficult to achieve on some varieties or crop stages, for example, cauliflower with a high degree of self-covering. Rotation of products is important and a resistance management strategy is essential.	Bt stops caterpillar feeding but takes several days to kill. Apply Bt's after irrigation not before. Avoid high UV times of the day. Some new chemistry is less suited to IPM than others. Check IPM rating.

* Sampling plan and thresholds available from DPI Victoria on www.dpivic.gov.au and follow links "Agriculture and Food" then "Plant diseases and pests".

** SARDI website for sampling plans and information www.sardi.sa.gov.au/pestsdiseases/horticulture/horticultural_pests/diamondback_moth

Heliothis – Corn earworm or Native budworm

Helicoverpa armigera or *Helicoverpa punctigera*

Effective IPM Rating √ √ √ √ √

Critical Comments: DBM program will generally provide control however you need to consider if corn earworm or native budworm are present as corn earworm has resistance to some chemical groups.

Infestation Risk Factors		Cultural Practices			Chemical Control			Conflicts / Issues
Increases the risk	**Reduces the risk**	**Monitoring Control Thresholds**	**Beneficial Insects**	**Other**	**Pest Lifecycle**	**Chemical**	**IPM Issues**	
A nearby crop or a weedy area could be a source of insect pests. Warm weather decreases the time between egg lay and hatching. Vegetable, corn, sunflower, cotton or lucerne crops nearby or in rotation.	Healthy beneficial insect population. Ploughing in crops after harvest – destroys pupated caterpillar and prevents them emerging.	4 small caterpillars in 10 plants. Moth will lay eggs in more sheltered areas of the plant. Use pheromone traps for both *H. armigera* and *H. punctigera*. Visual monitoring or bugvacs.	**Parasitoids** · *Microplitis spp* · *Netelia spp* · *Cotesia spp* · *Hyposoter spp* · *Trichogramma* wasp · *Telenomus* · *Tachinid* fly **Predators** · Spiders · Assassin bugs · Ladybird beetles · Lacewings · Predatory wasps · Predatory shield	Plant with spacing that allows for maximum spray coverage. Good soil preparation can significantly reduce overwintering pupae numbers. Select a production period that will minimise pest pressure.	Control easiest at small caterpillar stage. Avoid spraying at large caterpillar stage. Active at dusk and into the night. Pupate in soil. Bt only works well against smaller caterpillars; apply it early in pest lifecycle.	There are registered insecticides and options with good IPM Rating. Biological options to assist control include: · *Nuclear Polyhedrosis Virus* (NPV) · *Bacillus thuringiensis*	Year-round production and poor product rotation increases the risk of insecticide resistance. Be aware of what chemicals have been applied to the seedlings in the nursery.	Native budworm is the most likely pest and a DBM program would provide control. Heliothis (corn earworm) in your area may have developed resistance to broad spectrum chemicals. Bt stops caterpillar feeding but takes several days to kill.

Infestation Risk Factors		Cultural Practices			Chemical Control			Conflicts / Issues
Increases the risk	**Reduces the risk**	**Monitoring Control Thresholds**	**Beneficial Insects**	**Other**	**Pest Lifecycle**	**Chemical**	**IPM Issues**	
Historical presence of the pest.		Look for eggs, small caterpillar, feeding damage, frass and beneficials.	· Bugs · Birds Consider providing habitat for beneficial insects.	Control important during seedling to harvest. Plough in crop residue to minimise pest survival to a depth of 10 cm.	*Nuclear Polyhedrosis Virus* (NPV) (virus product) a very effective soft option.	If spraying is required close to harvest use product with a short withholding period.	Good spray coverage is essential but difficult to achieve on some varieties, eg, cauliflower with a high degree of self-covering. There are a number of new chemistries that are much less disruptive to beneficials.	NPV only effects Heliothis and no other caterpillar species. Apply Bt's or NPV after irrigation not before. Avoid high UV times of the day.

Thrips *spp.*

Several species: Onion thrips *Thrips tabaci*, Western flower thrip *Frankliniella occidentalis*

Effective IPM Rating √ √ √ √ √

Critical Comments: Some chemicals are not suited to IPM and need to be chosen carefully as not all species are controlled by IPM options.

Infestation Risk Factors		Cultural Practices			Chemical Control			Conflicts / Issues
Increases the risk	**Reduces the risk**	**Monitoring Control Thresholds**	**Beneficial Insects**	**Other**	**Pest Lifecycle**	**Chemical**	**IPM Issues**	
Warm, dry weather. Some varieties may be more attractive. A nearby crop or a weedy area could be a source of thrips.	Nursery ideally should be fully insect-screened to prevent insect entry. Ensure transplants are free of thrips.	Yellow or blue sticky traps can be used to monitor thrips for pest pressure and species present. Need to monitor crops for thrips number.	**Predators** · Spiders · Predatory bugs · Ladybird beetles · Lacewings · Predatory mites Consider providing habitat for beneficials.	Plant with spacing that allows maximum spray coverage. Subsequent plantings should be in a different area of the farm so there is a physical barrier between crops. Select a production period that will minimise pest pressure.	Lifecycle is quicker in warm weather. The full life cycle can be completed in as little as 10 days at 20°C. Western Flower Thrips (WFT) Sprays only effective against certain lifecycle stages.	Range of chemicals available and some have a reasonable IPM Rating but will not control all species. IPM options are limited. Not all thrips are controlled by specific chemicals – know your target thrips and choose suitable control.	Year round production increases the risk of insecticide resistance. Western Flower Thrips (WFT) is difficult to identify with the naked eye from other thrips.	Thrips can spread virus. Beneficial habitat may also host thrips. Follow a resistance management strategy for Western Flower Thrips (WFT). Spinosad resistant populations of WFT exist in some production areas.

Infestation Risk Factors		Cultural Practices			Chemical Control			Conflicts / Issues
Increases the risk	**Reduces the risk**	**Monitoring Control Thresholds**	**Beneficial Insects**	**Other**	**Pest Lifecycle**	**Chemical**	**IPM Issues**	
				Consider using screening mesh in nursery area if pest pressure is high. Control important from seedling production to buttoning.	Good hygiene in and around the crop minimises pest pressure.		WFT is quick to develop resistance so use a range of chemicals to reduce development. Predatory beneficials are available for commercial release.	

Whiteflies (silverleaf whitefly)

Bemisia tabaci

Effective IPM Rating √ √ √ √ √

Critical Comments: Some chemicals not suited to IPM so need to choose carefully.

Infestation Risk Factors		Cultural Practices			Chemical Control			Conflicts / Issues
Increases the risk	**Reduces the risk**	**Monitoring Control Thresholds**	**Beneficial Insects**	**Other**	**Pest Lifecycle**	**Chemical**	**IPM Issues**	
A nearby crop or a weedy area could be a source of insect pests. Some varieties may be more attractive to Whitefly. Warm weather.		2-4 flies per leaf present on 40% of plant. Yellow sticky traps can be used to monitor whitefly.	**Parasitoids** · *Encarsia* · *Eretmocerus* Generalist predators. Consider providing habitat for beneficials.	Plant with spacing that allows maximum spray coverage. Select a production period that will minimise pest pressure. Control important during seedling to buttoning. Plough in crop residue.	Pupal stage of life cycle can be parasitised. Broad spectrum products will kill beneficials and cause a rapid increase in Whitefly population.	Several chemicals registered and some with good IPM Rating. Choose products carefully. Know how your chosen control product works. Some products only effective against certain life cycle. stages.	Year-round production increases the risk of insecticide resistance. Remember that Insect growth regulator (IGR) formulations target immature stages only.	Choose chemical controls carefully. Some systemic chemicals not suited to IPM.

Wireworm / False Wireworm

Elateridea spp. / Tenebrionidae spp.

Effective IPM Rating √ √ √ √ √

Critical Comments: Control is best achieved with cultural and management practices, consistent with IPM practices but if chemical control is required it will not fit into an IPM system.

Infestation Risk Factors		Cultural Practices			Chemical Control			Conflicts / Issues
Increases the risk	**Reduces the risk**	**Monitoring Control Thresholds**	**Beneficial Insects**	**Other**	**Pest Lifecycle**	**Chemical**	**IPM Issues**	
A nearby crop or a weedy area could be a source of insect pests. Consider previous cropping history particularly if coming out of pasture or lucerne rotation. Poorly drained paddocks.	If following pasture or known problem paddock, cultivate several weeks before planting and consider a period of fallow.	Look for damaged (missing, wilted) seedlings and then search for damaged roots and wireworms in soil around the plant.	Common brown earwig.	Plant with spacing that allows maximum spray coverage. Good soil preparation can significantly reduce numbers. Control important during seedling to establishment.	Monitor young crop carefully. Pest activity should occur in first 14 – 21 days while crop is establishing. Ground dwelling pest so high water volume application essential (600L/Ha).	There are registered insecticides. Chemical control still relies on broad spectrum products. Not suited to IPM.	Late afternoon control applications tend to give best results.	Chemical control can be difficult to achieve as the pest hides in the soil. Management best achieved with cultural practices. Good ground preparation essential after a pasture rotation.

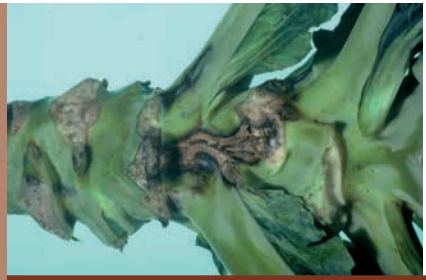
Alternaria Target Spot

Alternaria spp. (Blackspot, Grey leaf spot and Pod spot)

Effective IPM Rating √ √ √ √ √

Critical Comments: Monitor crops to determine if control warranted.

	Rotation Crop		Cultural Practices				Chemical Control		Conflicts / Issues
Resistant varieties available	**High Risk**	**Disease Break**	**Nutrition**	**IPM**	**Irrigation**	**Other**	**Chemical**	**IPM Issues**	
	Favours moist conditions. Stressed plants are more susceptible. Brassica weeds will be hosts and the source of inoculum.	Three years of non-host crops needed if there is a disease problem. Crop break will be less effective if there is poor control of weed hosts.	Maintain good nutrition.	Maintain even watering schedule so crop is not stressed.	Hot water treatment of seed. Keep crop and headlands weed free.	Spread by wind, can be spread up to several 100m. Also spread by water splash. Disease problem best avoided disease by management practices. Plant crops upwind. Plough in crop residue immediately after harvest.	Begin at first signs of disease and continue while weather conditions favour development. Chemicals are only protectants, therefore crop monitoring is essential.	Pay attention to irrigation practices. Plant disease-free seedlings.	Hot water treatment may reduce seed viability.



Black Leg

Phoma lingam (asexual stage)

Leptosphaeria maculans (sexual stage)

Effective IPM Rating √ √ √ √ √

Critical Comments: Management and cultural practices are the only effective control.

	Rotation Crop		Cultural Practices				Chemical Control		Conflicts / Issues
Resistant varieties available	**High Risk**	**Disease Break**	**Nutrition**	**IPM**	**Irrigation**	**Other**	**Chemical**	**IPM Issues**	
There are tolerant varieties. Cabbage has a high level of resistance.	Other brassica species, including weeds. Wet, windy weather.	Disease more prevalent in autumn and spring. Rotate out of brassicas for 3-4 years. Be aware of paddock history and do not plant into affected paddocks.	Balanced nutrition is important to maintain a healthy crop.	Treat seed with fungicide or hot water (50°C for 15-30 minutes). Ensure good drainage. Pay attention to seedling transplant depth.	Minimise leaf wetness eg. irrigate at dawn when dew is normally on the leaf. Avoid evening irrigation. Avoid overhead watering as the fungus is spread by water splash.	Align row spacing to allow for maximum ventilation. Subsequent plantings should be up-wind of current crops. Grow seedlings outside the area of crop production to avoid cross contamination. Rogue infected seedlings.		Management is the only effective control. Good irrigation management is important. Seedling hygiene. Crop hygiene and rotation is essential.	Hot water treatment may damage seed and reduce viability. Flooding can spread other pests and diseases. Fungicides do not control soil-borne infection, only suppress.

	Rotation Crop		Cultural Practices				Chemical Control		Conflicts / Issues
Resistant varieties available	High Risk	Disease Break	Nutrition	IPM	Irrigation	Other	Chemical	IPM Issues	
					Spores mainly released in high humidity or after rain.	Reduce crop residue by removing, burning or deep tillage as buried crop residue is more rapidly decomposed.			

Black Rot

Xanthomonas campestris pv. campestris

Effective IPM Rating √ √ √ √ √

Critical Comments: Monitor crops to determine if control warranted.

	Rotation Crop		Cultural Practices				Chemical Control		Conflicts / Issues
Resistant varieties available	**High Risk**	**Disease Break**	**Nutrition**	**IPM**	**Irrigation**	**Other**	**Chemical**	**IPM Issues**	
Resistant varieties becoming available.	Avoid susceptible varieties. Wetter areas or areas sheltered from morning sun are likely to be affected. Favoured by warm wet conditions.	Bacteria survive in soil for 1-2 years. Rotate to non-Brassica or fallow if high disease pressure was experienced. Can be seed borne.	Balanced nutrition and robust plants provide some level of protection.	Can be spread by water and irrigation splash. Harvest staff can spread to uninfected area on clothes and equipment.	Do not handle wet transplants and avoid transplanting in wet conditions. Do not enter crop when wet. Irrigate when leaves can dry out quickly. Mainly spread by water splash.	It is highly recommended to use seed that has been heat or fungicide treated. Keep different batches of seed separate in case of varying levels of infection. Plough in crop residues soon after harvest.	Copper sprays can reduce pathogen spread in seedling trays. Use copper spray as a preventative treatment and to reduce disease spreading. No reports of copper tolerance found in Black Rot.	Rotate fungicides. Copper based products act as protectant.	Note that copper can damage some varieties of Brassicas. Do not apply if frost likely. Hot water treatment may damage seed and reduce viability.

Club Root

Plasmodiophora brassicae

Growers should consider the following questions to determine the overall risk rating for the intended planting and use this to help decide upon an appropriate management strategy.

		Low	Medium	High
1	Severity of last observed clubroot infection.	Mild	Moderate	Severe
2	Time since last observed clubroot infection.	More than 7 years	2-5 years	0-2 years
3	Intended sowing time (for brassicas).	May-Aug	March/April and Sept/Oct	Nov-Feb
4	Have brassica weeds been observed on the site since last infection (including wild radish, mustards, shephard's purse).	Never	Infrequently	Often
5	Intended crop.	Non - brassica	Broccoli, Brussels sprouts, cabbage. Other Asian veg brassica	Cauliflower, Chinese cabbage
6	Soil pH.	7-8	6-7	Less than 6
7	Source of planting material.	Cell grown transplants - reputable nursery	Seed bed on farm	Direct seeded onto site
8	Variety.	Tolerant/ Resistant	Susceptible	Highly susceptible
9	Drainage.	Excellent	Fair	Poor
10	Soil type.	Sand	Loam	Clay

Low risk

- Be rigorous about farm hygiene.
- Lime responsive soils to pH 7.0-7.5. There are many forms of lime available. Fine, calcium oxide (hot lime, quick lime, Ground Burnt Agricultural GBA lime) limes have a pH of 12, react rapidly in the soil and should be applied 7 days before planting. These limes are the most effective at increasing soil pH. Coarser, calcium carbonate (aglime) limes have a pH of 7 and react more slowly. These limes should be applied at least 3 months before planting. All limes should be spread and incorporated immediately. Followed by light irrigation. Do not leave lime on the soil surface or water in.
- Improve drainage (if necessary) by laser grading low lying areas or raising bed heights.
- Monitor for symptom development. Look for stunted or wilting plants, particularly in low lying or wet areas of the paddock. Remove and check roots for galls. Treat any spot infections immediately.

Medium risk

- Where possible practice a 3-yr crop rotation using non-brassica hosts to prevent build-up of clubroot in the soil, maintain all crops free of brassica weeds.
- Lime responsive soils to pH 7.0-7.5.
- Maintain high soil calcium in the first 3 weeks after planting. If applying calcium in the form of calcium cyanamide (Perlka™), this product should be incorporated into the soil and irrigated at least 7-10 days before planting to avoid crop damage. Irrigation initiates decomposition of the product releasing active ions which are toxic to the pathogen but can also be phytotoxic to the transplants if applied too close to planting. Calcium nitrate products are highly soluble and can be applied at or after transplanting.
- Improve drainage (if necessary) by laser grading low lying areas or raising bed heights.
- Use a tolerant/resistant variety where available and suited to agronomic and market needs. Clubroot resistant cauliflower and cabbage are available in Australia. To prolong the effectiveness of the resistance in these varieties they should be used as part of an integrated management strategy, not as a 'stand alone' method of control.

High risk

- Avoid summer plantings.
- Do not crop Chinese cabbage.
- Practice a 3 yr crop rotation; maintain rotation crops free of all brassica weeds.
- Avoid mustards as a green manure crop.
- Lime responsive soils to pH 7.0-7.5.

If a crop must be grown:

- Apply a preventative chemical treatment, fumigate the site or incorporate into bands along the transplant rows immediately before planting.
- Maintain high soil calcium in the first 3 weeks after planting.

Club Root

Plasmodiophora brassicae

Effective IPM Rating √ √ √ √ √

Critical Comments: Management is critical.

	Rotation Crop		Cultural Practices				Chemical Control		Conflicts / Issues
Resistant varieties available	**Risk**	**Disease Break**	**Nutrition**	**IPM**	**Irrigation**	**Other**	**Chemical**	**IPM Issues**	
Clubroot resistant cauliflower and cabbage are available. To prolong resistance use as part of an Integrated Management Strategy, not as a 'stand alone' method of control.	Brassica weeds will host the disease and increase disease pressure.	Ensure brassica weeds are kept out of rotation crops. Monitor for stunted or wilting plants, particularly in low lying or wet areas of the paddock. Remove and check roots for galls.	Thrives in acidic soils. Test soil pH & lime if necessary to pH 7-7.5. Fine, calcium oxide (hot lime, quick lime, Ground Burnt Agricultural GBA lime) limes have a pH of 12, react rapidly in the soil and should be applied 7 days before planting.	Only bring clean seedlings onto the farm. Spores can be spread on or in anything that can carry soil or water. Insist on the cleanliness of shared bins, seedling trays and other equipment.	Avoid waterlogging. Spores washed into dams settle to the bottom so draw irrigation water from the top of the dam. Improve drainage (if necessary) by laser grading low lying areas or raising bed heights.	New or spot outbreaks can be cleaned up. Examine the roots at the extremity of spot infections to gauge the size of patches of disease and determine whether clean-up is feasible.	There is no effective treatment that can be applied from buttoning through to harvest.	Manage liming program carefully for if greater than pH 7.5 nutrient disorders can be induced. It is essential to have a program to check soil pH regularly. Alkaline soils pH>7 may induce scab diseases in potatoes.	

Low risk

	Rotation Crop		Cultural Practices				Chemical Control		Conflicts / Issues
Resistant varieties available	**Risk**	**Disease Break**	**Nutrition**	**IPM**	**Irrigation**	**Other**	**Chemical**	**IPM Issues**	
			Coarser, calcium carbonate (aglime) limes have a pH of 7 and react more slowly. These limes should be applied at least 3 months before planting. All limes should be spread and incorporated immediately. Followed by light irrigation.	Quarantine infected patches to reduce the spread. Work known affected sites last and wash machinery afterwards. Practice good hygiene when moving from paddock to paddock.		If feasible, remove affected material. Burn or dispose of in an industrial tip. Disinfest the site using a suitable fumigant. Treat any spot infections **immediately**.			

Low risk

	Rotation Crop		Cultural Practices				Chemical Control		Conflicts / Issues
Resistant varieties available	**Risk**	**Disease Break**	**Nutrition**	**IPM**	**Irrigation**	**Other**	**Chemical**	**IPM Issues**	
Use resistant varieties of cauliflower and cabbage if they are suitable for your growing conditions and meet your market requirements.	Thrives in warm, moist, acidic soils.	Practice a minimum 3-year rotation using non-brassica hosts.	Nutrition practices as for Low Risk. Calcium nitrate products are highly soluble and can be applied at or after transplanting.			If applying calcium in the form of calcium cyanamide (Perlka™), this product should be incorporated into the soil and irrigated at least 7-10 days before planting to avoid crop damage.			Calcium cyanamide can be phytotoxic to the transplants if applied too close to planting. Use of fumigation is not IPM friendly.

Medium risk

	Rotation Crop		Cultural Practices				Chemical Control		Conflicts / Issues
Resistant varieties available	**Risk**	**Disease Break**	**Nutrition**	**IPM**	**Irrigation**	**Other**	**Chemical**	**IPM Issues**	
	Paddocks with a history of the disease or that have grown brassicas in previous years. Infected seedlings ensure that seedling roots checked for galls.	Do not crop Chinese cabbage.	Nutrition practices as for Low Risk. Maintain high concentrations of calcium in the first 3 weeks.				If site is a high-risk, apply fungicide into bands along rows immediately before transplanting. It is effective when placed evenly around the transplant root zone.		

High risk

Downy Mildew

Hyaloperonospora parasitica (formerly *Peronospora parasitica*)

Effective IPM Rating √ √ √ √ √

Critical Comments: Need to evaluate whether or not control is required.

	Rotation Crop		Cultural Practices				Chemical Control		Conflicts / Issues
Resistant varieties available	**High Risk**	**Disease Break**	**Nutrition**	**IPM**	**Irrigation**	**Other**	**Chemical**	**IPM Issues**	
Tolerant varieties available	Other brassica species		Avoid high levels of Nitrogen. A deficiency of potash increases the susceptibility of cauliflower to downy mildew and this may apply to other brassicas.	Can be carried on seed so use fungicide or hot water (48°C - 50°C for 20 minutes) treated seed.	Minimise leaf wetness eg. Irrigate at dawn when dew is normally on the leaf and avoid evening watering.	Align row spacing to allow for maximum ventilation. Subsequent plantings should be up-wind of current crops. Grow seedlings outside the area of crop production to avoid cross contamination.	Use different chemicals to control the disease on nursery stock than that used in the field. There are registered systemic and protectant fungicides. If spraying is required close to harvest check product withholding period.	Generally only seen on older leaves in the field. If fungicide sprays are applied for other fungal disease then co-control of downy mildew will probably occur.	Hot water treatment may damage seed and reduce seed viability. Evaluate need for chemical control.

	Rotation Crop		Cultural Practices				Chemical Control		Conflicts / Issues
Resistant varieties available	**High Risk**	**Disease Break**	**Nutrition**	**IPM**	**Irrigation**	**Other**	**Chemical**	**IPM Issues**	
				If incidence of the disease is low in the field (eg. only rarely seen on older leaves), it may not be worth spraying with fungicides which control downy mildew.	Avoid watering seedlings from 8.00am -12.00pm as most spores are released during this period, irrigation will act to wash spores out of the air and provide wet leaf surfaces for them to infect plants.	Seedlings / plants can be infected without showing symptoms. Plough in crop residue.			May conflict with optimum irrigation timing during the night – however in warm weather less of an issue as leaves will dry quickly.

Ring Spot

Mycosphaerella brassicicola

Effective IPM Rating √ √ √ √ √

Critical Comments: Monitor crops to determine if control warranted.

	Rotation Crop		Cultural Practices				Chemical Control		Conflicts / Issues
Resistant varieties available	**High Risk**	**Disease Break**	**Nutrition**	**IPM**	**Irrigation**	**Other**	**Chemical**	**IPM Issues**	
Older cultivars of Brussels sprouts are more resistant than newer varieties.	Cool moist conditions favoured by long periods of leaf wetness (24 hours). Can occur during warm days if nights are cool. Likely to begin appearing in autumn. More of a problem in high rainfall areas.	Rotate to non-susceptible crops.	A strong healthy crop is more resistant to disease.	Avoid long periods of leaf wetness. Monitor crop closely for up to 10 days following extended periods of leaf wetness.	Hot water treatment of seed – possibly seed borne.	Spread by wind and splash. Plough in crop residue immediately after harvest. Spores survive in crop residue.	Begin at first signs of disease and continue while weather conditions favour development. Only available chemicals are protectants therefore crop monitoring essential. Copper-based fungicides act as protectants.	Practice good hygiene and purchase good quality seed and seedlings.	Hot water treatment may reduce seed viability.

Sclerotinia white mould

Sclerotinia sclerotiorum and *Sclerotinia minor*

Effective IPM Rating √ √ √ √ √

Critical Comments: IPM is the most effective control, use of fungicides is not a sustainable long-term measure, management and cultural practices are essential.

	Rotation Crop		Cultural Practices				Chemical Control		Conflicts / Issues
Resistant varieties available	**High Risk**	**Disease Break**	**Nutrition**	**IPM**	**Irrigation**	**Other**	**Chemical**	**IPM Issues**	
Not readily available.	Windy, cool, humid weather. Wet soil. Cabbage and cauliflower more affected than other brassica. *S. minor* can infect brassica and legume green manure crops, mustards and vetch, will carry over disease.	The pathogen can survive as sclerotia in soil for 5 years or more. Broad host range including legumes, carrots, lettuce, capsicum and rocket. Also some green manure crops may be a host.	Soil amendments with high Nitrogen such as poultry manure can reduce survival of sclerotia in soil.	Use raised beds to improve drainage. Reduce excessive moisture by irrigating in the morning so that canopy and soil surface dries quickly.	Avoid planting in fields severely infested with sclerotia or history of the disease. Minimise spread of disease by cleaning equipment after use in infected paddocks.	Important to know the species of Sclerotinia present in a field to devise an effective control program. Researchers are currently determining the weather and farm factors that increase disease risk.	Limited options for chemical control. New products are becoming available for disease control but an integrated approach to management is essential.	Consider the use of biofumigants which may reduce the survival of sclerotia and subsequent disease caused by *S. minor*.	Crop rotation with non-host crops and soil fumigation may not prevent disease because it can still be spread by airborne spores. Fungicides alone do not provide absolute control and are not a sustainable control measure.

	Rotation Crop		Cultural Practices				Chemical Control		Conflicts / Issues
Resistant varieties available	**High Risk**	**Disease Break**	**Nutrition**	**IPM**	**Irrigation**	**Other**	**Chemical**	**IPM Issues**	
		Cereals & grasses are non-host and thus good for rotation in field with Sclerotinia. Crop residues from green manure biofumigant mustard crops (also a brassica) show suppressive effects against *S. minor*.		Irrigate with drip irrigation or subsurface drip system so that the soil surface is drier. In hot weather this is less of an issue.		Incorporate crop residues as soon as possible.	Hygiene, crop rotation and irrigation application can affect the severity of the disease. **IPM management is the only effective long-term control.**		An integrated approach is the best way to sustainably manage Sclerotinia. *S. minor* is more prevalent in the cooler southern states. Sclerotinia sclerotiorum occurs in the warmer production areas. Mustards used as green manure crops are a potential clubroot host.

Stem Canker

Disease complex with *Rhizoctonia solani* and *Leptosphaeria maculans*

Effective IPM Rating √ √ √ √ √

Critical Comments: Use cultural and management practices to limit impact – there are no fungicides registered for control.

	Rotation Crop		Cultural Practices				Chemical Control		Conflicts / Issues
Resistant varieties available	**High Risk**	**Disease Break**	**Nutrition**	**IPM**	**Irrigation**	**Other**	**Chemical**	**IPM Issues**	
Tolerant varieties available.	Canola crops and other vegetable hosts will increase the risk as would brassica weeds.	Rotate with non host crops, remove host weeds. Length of rotation required unknown.	Vigorous plants are more likely to resist infection.	Plant tolerant varieties.	Good drainage will help reduce disease occurrence.	Use clean seed. Use a well drained seedling mix. Control volunteer plants and weedy hosts. Well drained soils reduce likely incidence. Best management methods still being researched.	Chemicals trialled on the disease have not demonstrated control and at best only suppression when applied at planting.		Fungicides used to control other diseases may suppress incidence of stem canker.

White Blister

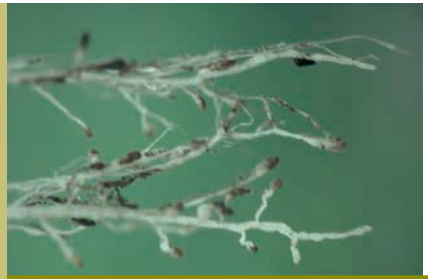
Albugo candida

Effective IPM Rating √ √ √ √ √

Critical Comments: Monitoring crops following suitable conditions for infection is critical to management and control.

	Rotation Crop		Cultural Practices				Chemical Control		Conflicts / Issues
Resistant varieties available	**High Risk**	**Disease Break**	**Nutrition**	**IPM**	**Irrigation**	**Other**	**Chemical**	**IPM Issues**	
There are tolerant and resistant varieties. Some varieties of broccoli seem more susceptible than others.	Volunteer plants from the previous crop. Infection most likely when temperature is 13 ˚C - 25˚C and leaf wetness is greater than 2-3 hours. Ensure seedlings are disease free – avoid seedlings with stem galls.	Preferable to have at least one season free of brassica crops to prevent potential carry-over on crop debris. Crop monitoring is essential and disease develops 7-21 days after infection.	Avoid high Nitrogen, it will increase susceptibility It is important to maintain a healthy crop.	Can be carried on seed so use fungicide treated seed. Can hot water treat seed (48°C - 50°C for 20 minutes).	Minimise leaf wetness eg. irrigate at dawn when dew is normally on the leaf and avoid watering in the evening. Where possible irrigate over short periods.	Align row spacing to allow for maximum ventilation. Subsequent plantings should be up- wind of current crops. Grow seedlings outside the area of crop production to avoid cross contamination.	Use a different chemical control on nursery stock than that used in the field. There are systemic, protectant and soft option chemicals available.	It is important to protect the buttons from white blister as they grow into the heads which are marketed. Low levels on leaves near harvest are not an issue.	Hot water treatment may damage seed and reduce viability. Control may not be required depending on crop stage and infection level – crop monitoring is essential.

	Rotation Crop		Cultural Practices				Chemical Control		Conflicts / Issues
Resistant varieties available	**High Risk**	**Disease Break**	**Nutrition**	**IPM**	**Irrigation**	**Other**	**Chemical**	**IPM Issues**	
						Symptomless seedlings / plants can be infected. Use the Brassica$_{spot™}$ disease predictive model to time fungicide sprays. Crop monitoring and systemic fungicides are currently required with the model. Plough in crop residue.	Spray buttons with a registered (systemic) fungicide. If spraying is required close to harvest check withholding period. e.g. copper. Essential to control before disease develops to epidemic levels.	Only young tissue is susceptible to infection so it is important to protect these tissues.	



Nematodes

Meloidogyne spp., *Heterodera spp.* and *Pratylenchus penetrans*

Effective IPM Rating √ √ √ √ √

Critical Comments: Effective long-term control will only be provided by management and cultural practices.

	Rotation Crop		Cultural Practices			Chemical Control		Conflicts / Issues
Resistant varieties	**High Risk**	**Disease Break**	**Nutrition and Irrigation**	**Hygiene**	**Other**	**Chemical**	**IPM Issues**	
	Avoid planting in fields with 'high' RKN or RLN numbers. Sandy soils are a higher risk for RKN. Nematodes can survive on host weeds.	Crop rotation with non-hosts of 1-2 years is generally sufficient to reduce RKN numbers to non-damaging levels. Eggs within cysts of cyst nematodes may remain dormant in the soil for several years.	Nematodes "swim" therefore avoid wet soil for long periods to reduce their spread. Avoid over overwatering by scheduling irrigation appropriately and ensure adequate nutrition.	Nematodes are moved on soil and machinery so hygiene is important for control. Always work infested paddocks last and clean machinery after working in infested paddocks.	Roots of stunted plants should be examined for galling caused by RKN. A pre-plant soil test should be done to determine nematode numbers in a field if galling is evident, a problem is suspected or there is a history of nematodes.	Nematicides are registered for use in some states. General soil fumigants such as metham sodium pre-planting will also provide control of nematodes.	Soil solarisation using plastic film prior to planting may be cost-effective in some situations. Growing and incorporating a biofumigant crop prior to planting may also provide control.	Chemical control will not be compatible with IPM practices. Note that some brassica biofumigants are good hosts of nematodes (e.g., RKN)

	Rotation Crop		Cultural Practices			Chemical Control		Conflicts / Issues
Resistant varieties	**High Risk**	**Disease Break**	**Nutrition and Irrigation**	**Hygiene**	**Other**	**Chemical**	**IPM Issues**	
		Some varieties of cereals, grasses and sorghum are non-hosts or poor hosts for RKN and can be grown prior to the crop to reduce nematode numbers.				Chemical options for nematode control are relatively expensive and toxic. Fumigation also kills all beneficial soil inhabitants – fungi and insects.	Effective incorporation and a good "kill", is essential to achieve control. Some biological controls and soft chemicals are available but their effectiveness can be variable.	

Several species of plant-parasitic nematodes have been associated with damage to brassicas in Australia. The most important are Root knot nematode (RKN) (*Meloidogyne arenaria*, *M. hapla*, *M. javanica* and *M. incognita*) cyst nematodes (*Heterodera schattii* and *H. cruciferae*) and root lesion nematode (*Pratylenchus penetrans*). Nematodes damage often causes stunting of plants and distinct patches in the field. RKN causes galling of brassica roots while cyst nematodes mature into brown cysts.

Control needs to carried out pre and post harvest. There is very little that can be done to control nematodes during crop growth.

Slugs and Snails

Mollusca

Effective IPM Rating √ √ √ √ √

Critical Comments: Control is best achieved with cultural and management practices.

Infestation Risk Factors		Cultural Practices			Chemical Control			Conflicts / Issues
Increases the risk	**Reduces the risk**	**Monitoring Control Thresholds**	**Beneficial Insects**	**Other**	**Pest Lifecycle**	**Chemical**	**IPM Issues**	
A nearby crop a weedy or grassy area such as headlands could be a source of pests. Long grass in drains. Wet areas from leaking irrigation. Following a pasture crop. Minimum tillage. Wet weather.	A physical barrier of empty land between headlands or grassy areas.	Larger plants generally do not sustain economic damage.	Carabid beetles.	Good soil preparation can significantly reduce numbers. Plants are vulnerable when small.	Cool moist environments favour pest survival and overwintering. Once established, a pest can survive in the soil between crops unless the lifecycle is broken.	No registered chemicals available for control in crops. Drains, damp areas that adjoin the crop can be baited. A protective border can be used to prevent movement to crop.	Need to control in borders and headlands and bait those areas if a problem likely. Remove debris that can be used as shelter areas and keep grass short. Encourage birds and predators.	Totally reliant on management practices. Good farm hygiene and drainage assists with population control.

Virus

IPM Control - Pre Plant Planning.

Effective IPM Rating √ √ √ √ √

Critical Comments: Vector and weed control is critical to virus management – IPM Rating will depend on chemicals used for vector control. Farm hygiene is critical.

	Cauliflower mosaic virus (CaMV)	Turnip mosaic virus (TuMV)	Beet western yellows virus (BWYV)
Transmission	Spread by aphids (more than 25 species, including *Myzus persicae* and *Brevicoryne brassicae*) which become infected after 15 to 30 minutes feeding on infected plants. Aphids will stay infectious for several days.	Many (more than 50 species, including *Myzus persicae* and *Brevicoryne brassicae*) aphid species spread the virus. Aphids only need to feed for less than a minute to infect a plant.	Spread by aphids (more than 10 species, including *Myzus persicae* and *Brevicoryne brassicae*). Aphids must feed for several hours to acquire the virus and then feed for a similar period to infect other plants. Once infected, aphids continue to transmit the virus.
Hosts	Infects most species in the brassica family including some brassica weeds.	Infects all vegetable brassicas. Losses are most likely in cabbage and leafy Asian brassica types.	Wide host range including vegetable brassicas, canola, brassica weeds and weeds outside the brassica family.
Key virus information for control	Remove old crops and control brassica weed species. In the early stages of aphid infestation in a crop insecticides may be effective in controlling the virus. However consider the spray's impact on beneficials.	Has a wide host range including lettuce and rhubarb and many brassica weeds. Remove old crops and control brassica weeds. NOTE: Use of insecticides may cause more harm than good.	Remove old crops and control brassica weeds. In the early stages of aphid infestation in a crop insecticides may be effective in controlling the virus. However consider the spray's impact on beneficials. Insecticides are of some value in reducing the spread.

	Cauliflower mosaic virus (CaMV)	Turnip mosaic virus (TuMV)	Beet western yellows virus (BWYV)
Key virus information for control *continued*		This is because the aphid only requires short feeding times to acquire the virus from an infected plant and to transmit TuMV to a healthy plant. The application of an insecticide may encourage the aphid to move to a new plant.	
Symptoms	Symptoms of mosaic patterns and vein clearing. These symptoms may be difficult to see in some brassica types. Symptoms may also be express as poor performing plants.	Symptoms include; ringspot, mosaic patterns and necrotic flecks. Internal dead areas may develop in stored cabbage. However classic symptoms may not always be present and could express as poor performing plants.	Symptoms are often indistinct and can be easily confused with nutrient imbalances, water-logging and damage from pesticides etc.

An integrated whole of farm approach is necessary to minimise potential virus hosts and vectors (insects that transmit virus).
Site selection, weed control, neighbouring crops and wind direction are just some of the many factors that influence virus potential.

Virus minimisation strategy

Pre-plant to nursery	Alter planting dates where necessary to avoid peaks in aphid activity. Avoid planting new crops adjacent to old crops and plant upwind of old crops. Rotate brassicas with other unrelated crops to reduce incidence of diseases, including virus diseases. Control host weeds, especially weeds from the brassica family in crops and on headlands and fence lines. Virus spread by aphids; see control methods for insect vectors as an important control measure for virus control.
Transplant to harvest	Use healthy transplants – "prevention is the best cure". Control host weeds in crops and on headlands. Good IPM control of insect vectors will help reduce virus spread. For TuMV once the virus is observed in the field, it is too late to eradicate and attempts to control aphid vectors can further spread virus in the crop due to the method of virus transmission. Insecticides are of some value in reducing the spread of persistently transmitted virus (eg BWYV) by reducing the vector population. It is important to reduce virus spread to subsequent crops.
Post harvest	Destroy old crops promptly after harvest. Have a brassica-free period where possible and eliminate alternative weed hosts during this period.
Issues	Need to ensure the correct identification of virus before attempting to control aphid vector. Applying insecticides may be counterproductive depending on the virus.

Weeds
IPM Control

Effective IPM Rating √ √ √ √ √

Critical Comments: Weed control is an essential component of IPM for a range of pest and disease issues.

In considering pests and diseases thought must be given to host plants for the diseases and their vectors (insects that transmit virus) as well as host plants for problem pests.

	General	Germinate and kill	Under Mulch	Fumigate	Pre-emergent herbicides
Pre – Plant	Ideally there should be a 2-year history of effective weed control before planting crop. Prevent seed and soil moving on and off farm. Consult the APVMA web site or local advisor for list of available products. Use cover cropping and crop rotation so weeds cannot get a foothold. Control weeds between crops and on fence lines and headlands. Do not let them set seed. Green manure crops can suppress weed growth.	Pre-irrigate to germinate an initial flush of weeds. Form beds well before planting to allow for pre-plant knockdown herbicide. Do not continuously use herbicides from the same group. Steam, flame or hot water treatment can also be used.	Form beds before planting. Lay plastic or paper mulch. Lay drip irrigation system under mulch.	Ensure soil moisture level suitable for fumigant. Form beds before planting.	Read product label. Avoid soil disturbance after application. Apply pre-emergent herbicide. Do not continuously use herbicides from the same group. Avoid water logging.

	General	Germinate and kill	Under Mulch	Fumigate	Pre-emergent herbicides
Nursery	Weed control is easier with transplants compared to direct seeding. Inspect seedling trays to ensure they are weed free. Prevent weed seed and soil movement by only using clean trays, pallets and vehicles. Nursery and plant holding areas should be kept weed free to minimise pest, disease and virus build up.				
Planting	Broadleaf weeds are of most concern, particularly the ones in the brassica family such as wild radish and shepherds purse. Rotate herbicide groups where possible. Prevent weeds setting seed. Be careful not to introduce weed seeds in manures or other soil ameliorants like lime and gypsum.	Very shallow cultivation if weeds already killed off or cultivation to kill emerged weeds if beds formed while planting.	Effective plastic biomulches are available. Mulch can be ploughed in and will break down in soil.		Irrigate within 24 hours to depth of 4cm. Avoid soil disturbance after application. Apply pre-emergent herbicide immediately after planting. Do not continuously use herbicides from the same group.
Transplant – hearting	As canopy closes many weeds will be shaded out. Avoid soil disturbance.				
Buttoning to harvest	Control all tall growing weeds that will not be shaded out in canopy close over. Ensure pickers and equipment is free of weed seeds and plant material. Avoid soil disturbance. Hand weeding may have long term benefit if it prevents seed set.				

	General	Germinate and kill	Under Mulch	Fumigate	Pre-emergent herbicides
Post harvest	Destroy crop residue as soon as possible after harvest. Cultivate to kill all weeds and remaining crop. A knockdown herbicide that kills everything will prevent some seed set. Do not leave bare ground for weeds to establish. Grow a green manure crop and kill it off before it sets seed. Grasses are preferable to broadleaf plants as a green manure crop. Regularly inspect fallow paddocks for weed growth. Keep records of weed incidence and severity. Grazed livestock feeding on green manure crops can be a weed source.				
Conflicts	Moderate to deep cultivations will cause more weeds to germinate in the crop and should be avoided. This may conflict with some pest control strategies – need to consider the importance of weeds and likely pests.				
Issues to consider	Poorly managed or ineffective weed control can be costly as it impacts on disease severity, harvest weight, head size and adds to weed potential in following crops. Weeds can be hosts for crop pests and may be a source of various virus, good weed control and hygiene are essential to minimise these crop impact. Herbicide effectiveness can be affected by unusual weather/soil conditions. Good effective soil preparation will maximise herbicide activity.				

Broadleaf weeds	Grass weeds
	Seldom a problem. Most will be controlled by the same cultural practices used to manage broadleaf weeds.
In an integrated weed management program, it is important to minimise the populations of weeds setting seed. It may make economic sense to selectively hand-weed in the weeks before harvesting, particularly if weed seed development can be prevented. There are herbicides registered for broadleaf weed management. They must be applied just before, at, or immediately after planting, before weeds have emerged. They will not kill established weeds. Choosing which herbicide to use will depend on several factors including which weed species is likely to be a problem, what you plan as the following crop in the rotation, and the types of herbicides used in previous crops. To avoid the build-up of resistant weeds, it is important not to continuously use herbicides with the same modes of action. Some chemicals can only be used before transplanting. Some chemicals can be applied directly after seeding or transplanting, and then irrigated in. It is essential to minimise the time between final cultivation (or knockdown herbicide application) and spraying pre-emergent herbicides. The longer the delay (eg. more than 2 to 3 days), the more likely it is that new weeds will germinate and not be controlled by the chemicals. Closer to harvest broadleaf weeds can only be killed by cultivation or hand weeding.	There are herbicides to control many grass species before emergence. There are registered chemicals for post-emergence grass control in brassica.

Weed control is an essential component for IPM for a range of pest and disease issues. Weeds can also act as a reservoir for beneficials so consideration must be given the weeds present and the risks they may be to crop production. Plants or vegetation that is not a host to diseases and some insect pests may help support a beneficial population.

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General

Agrilink information products.
Many of the original Agrilink titles have now sold out. Contact the Queensland Government Bookshop <www.bookshop.qld.gov.au> for availability or the brassica product can be downloaded from Queensland, DEEDI Primary Industries website < http://www.dpi.qld.gov.au/26_14826.htm >

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