Lettuce 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 Lettuce - 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 lettuce 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; "Lettuce 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, "Pests, Beneficials, Diseases and Disorders in Lettuce – Field Identification Guide".

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:

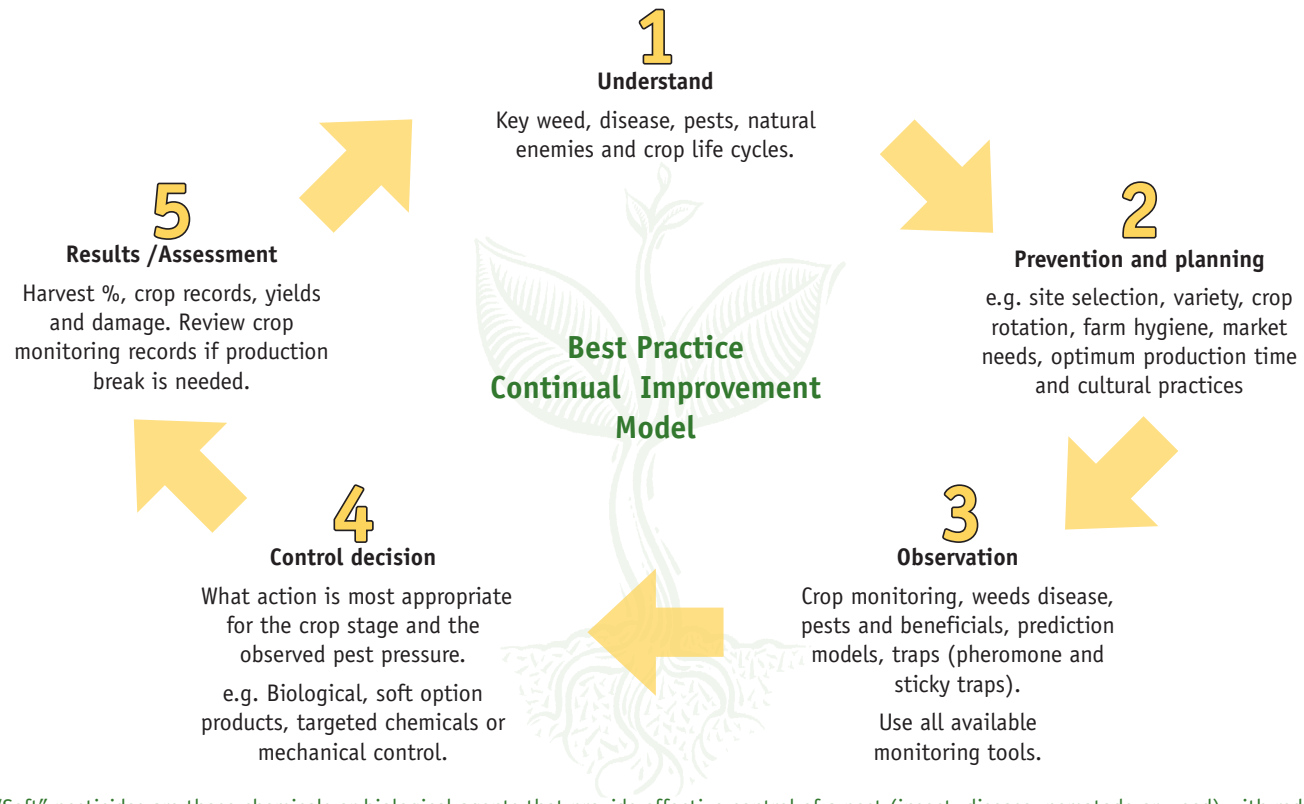
- crop rotation
- identification of your best production window
- efficient irrigation and drainage systems
- monitoring and pest thresholds
- beneficials and pests
- good farm hygiene
- available pest control techniques and products including their IPM rating.

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 Heliothis).
- 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 are being developed to assist in determining the likelihood of infection, once suitable conditions are met.

For example, there are a disease forecast models for Downy mildew disease, DownCast and BremCast predictive models are being evaluated. In the future 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.

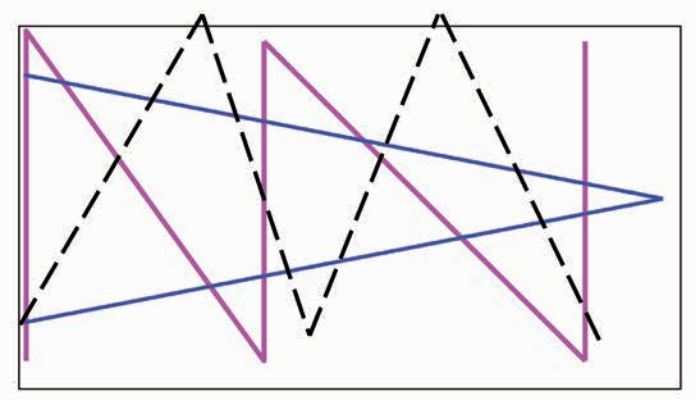


Diagram 1: A sample of some scouting patterns.

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 lettuce 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 other species excluding CLA

Including Brown thistle aphid (*Uroleucon sonchi*), Green sowthistle aphid (*Hyperomyzus lactucae*), Potato aphid (*Macrosiphum euphorbiae*), Green peach aphid (*Myzus persicae*), Foxglove aphid (*Aulacorthum solani*)

Effective IPM Rating √ √ √ √ √

Critical Comments: There are very good aphid specific and soft options available – seedling drenches will prevent IPM from being effective.

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**	
Mild weather. Spring and autumn plantings. Presence of sow thistles in or near crop greatly increases chances of sow thistle aphid feeding on lettuce and transmitting necrotic yellows virus.	Cool /cold weather. Good population of beneficials. Control weeds within crop and around crop – a range of weeds are hosts for both aphids and viruses (such as mosaic and necrotic yellows).	A control threshold is 1-2 aphids and no sign of beneficials on most seedlings checked. When scouting check for aphid "mummies" to indicate parasitoid activity. Monitor using yellow sticky traps to check pest levels.	**Predators:** · Spiders · Assassin bugs · Ladybird beetles · Lacewings · Damsel bugs (Nabids) · Hoverfly larvae Consider providing habitat for beneficial insects.	Plant with spacing that to allows for maximum air movement and spray coverage. Neighbouring crops can be a source of the aphid and the virus. Select a production period that will minimise pest pressure.	Aphids reproduce asexually most of the time so most are clones of each other. Once insecticide resistance develops it can progress quickly.	Range of targeted protectant and systemic chemicals available. Aphid specific and soft options are available and effective.	Range of IPM suitable and targeted chemicals available with good IPM Rating. Choose soft option products where additional control is necessary and rotate correctly.	Seedling drench application may have impact on the survival of some beneficial insects. Broad spectrum products reduce beneficial insect numbers. Because aphids are vectors for a range of viruses control is important.

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**	
			Parasitoids: · Aphid wasps (*Aphidiidae*) Naturally occurring fungi can also infect and control aphid colonies.	Aphids are generally not a problem during cooler weather once the crop is established CLA can still be active in cool weather.				Evaluate other pests present and beneficials when deciding on control.

Currant lettuce aphid (CLA)

Nasonovia ribis-nigri

Effective IPM Rating √ √ √ √ √

Critical Comments: Use of broad spectrum chemicals can result in increased pest levels – seedling drenches will prevent IPM from being effective.

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**	
Previous or nearby pest presence. Spring and autumn plantings. Hearting lettuce more susceptible as aphids colonise within the heart. Use of non-resistant varieties.	Colder weather and frosts may reduce occurrence. Resistant varieties are effective. Cos type lettuce. Presence of aphid predators: · Lacewings · Damsel flies · Ladybird beetles · Hoverfly larvae	Physical inspection and scouting is the preferred method of monitoring. Yellow sticky traps can also be used to monitor for presence for beneficials, however, less effective for CLA presence. Destructive monitoring is required once hearts formed.	**Predators** · Spiders · Assassin bugs · Ladybird beetles · Lacewings · Damsel bugs (Nabids) · Hoverfly larvae Consider providing habitat for beneficials adjacent to cropping areas.	Plant with spacing that allows maximum spray coverage. Assess likelihood of pest pressure prior to planting. Select a production period that will minimise pest pressure.	A seedling drench has been widely used as a preventative strategy for this pest to date. This is the main aphid that will infest the internal heart of lettuce.	A seedling drench based on one insecticide group is high risk for developing resistance. A soil / seedling drench, followed by a rotation with a foliar spray is now possible where aphids are observed.	Year-round production increases the risk of insecticide resistance. Seedling drench application may have a secondary impact on the survival and reproduction of some beneficial insects.	Broad spectrum seedling drench will prevent IPM from being effective. Other broad spectrum sprays can knock out beneficials. Seedlings that have been treated in a nursery may adversely affect beneficials for a few weeks.

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**	
	In spring, these may be moving about in relatively high numbers.	Cause for concern is 3-4 aphids and no sign of beneficials on most checked seedlings. Monitor beneficials that are present, as a small number can quickly clear up CLA outbreaks. Keep records of harvest volume, % damage as well as numbers of pests to fine tune thresholds.	Naturally occurring beneficial fungi can infect aphids.	CLA can still be problem during cooler weather periods. Control weeds particularly hosts such as Hawksbeard and Wild lettuce.	IPM techniques using natural predators as a control measure has been effective in a number of production sites.	A new highly systemic foliar spray from a new chemical group, will allow a more effective insecticide resistance management strategy. Effective systemic soft option aphicides are available.	Systemic soft option aphicides are available. Consider using targeted aphicides for open headed lettuce if necessary.	Use of broad spectrum insecticides can result in poorer control of the pest.

Cutworm

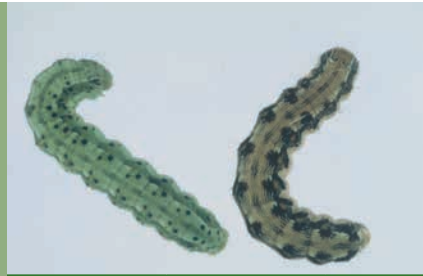
Agrotis spp.

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. Warm weather. Consider ground history. Increased risk if coming out of pasture rotation. Uncultivated or weedy ground.	At least one season free of lettuce crops. Normally not an issue in an established cropping area, though occasional infestations can occur. If the paddock is a known problem area, cultivate and have a fallow period before planting a crop.	Monitor newly transplanted seedlings for any sign of root or stem damage. Act quickly to control pest if it is observed. Active at night or early evening.	**Parasitoids** · *Trichogramma* **Predators** · Spiders · Assassin bugs · Ladybird beetles · Lacewings · Predatory beetles · Common brown earwig	Good soil preparation can significantly reduce numbers. Select a production period that will minimise pest pressure. Control important during seedling to hearting.	Soil-borne insect. Control as soon as crop damage detected. Ground dwelling pest so high water volume application essential (minimum 600L/Ha).	Chemical control still relies on broad spectrum products. These are not suited to IPM.	Good spray coverage is essential as this is a soil dwelling pest. High water volumes give best results. Late afternoon control applications tend to give best results.	Chemical control can be difficult to achieve as the pest hides in the soil. Management is best achieved with cultural 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**	
	Control weed growth.	Look for damage and curled up caterpillars in the first few centimetres of soil near plant stems.		Early detection and action required if the pest is present. Plough in crop residue.			Bt could be used late in the day if eggs are observed on plants but needs to be applied when eggs are hatching.	



Heliothis – Corn earworm or Native budworm
Helicoverpa armigera or *Helicoverpa punctigera*

Effective IPM Rating √ √ √ √ √

Critical Comments: Monitor crops and use pheromone traps to assess moth activity – need to consider if corn earworm or native budworm are present as corn earworm has resistance to some chemical groups and broad spectrum chemicals will not provide good 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 increases the rate and speed of hatching and the development of caterpillars. Pest pressure increases over summer.	At least one season free of host crops. Healthy beneficial insect population. Ploughing in crops after harvest – destroys pupae preventing emergence.	1 small caterpillar in 20 plants. 1 egg in 10 plants. Extreme heat will cause young hatched caterpillars to quickly move into the lettuce head. Moths will lay eggs in more sheltered areas of the plant.	**Parasitoids** · *Microplitis spp* · *Netelia spp* · *Cotesia spp* · *Hyposoter spp* · *Trichogramma spp* · *Telenomus spp* · *Tachinid* fly **Predators** · Spiders · Assassin bugs · Ladybird beetles · Lacewings · Predatory wasps · Predatory shield bugs · Birds	Ensure good spray coverage. Good soil preparation can significantly reduce overwintering pupae numbers. Select a production period that will minimise pest pressure. Control important during establishment to hearting.	Control easiest at small caterpillar stage. Avoid spraying at large caterpillar stage. Active at dusk and into the night. Caterpillars pupate in the soil.	There are registered insecticides and options with good IPM Rating. Biological options to assist control include: · *Nuclear Polyhedrosis Virus* (NPV) · *Bacillus thuringiensis* (Bt)	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 and how this might affect beneficial activity in the field.	If seedling drenches have been used these may affect beneficial control of this pest. NPV only affects Heliothis and no other caterpillar species. Resistance to broad spectrum chemicals has been recorded in corn earworm.

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**	
Vegetable, corn, sunflower, cotton or lucerne crops nearby or in rotation. Historical presence of the pest.		Use pheromone traps for both *H. armigera* and *H. punctigera* Important to commence regular monitoring soon after transplanting and prior to hearting. Look for eggs, small larvae, feeding damage, and beneficials	Consider providing habitat for beneficial insects.	Plough in crop residue to a depth of 10 cm immediately after harvest to destroy pupae.	Bt only works well against smaller caterpillars so apply it early in pest lifecycle. NPV (virus product) a very effective soft option in low to moderate pest pressure situations.	Hearting to harvest is the critical period to monitor and control. Hatching caterpillars will quickly tunnel into heads and are then uncontrollable. If spraying is required close to harvest use a product with a short withholding period.	Good spray coverage is more difficult to achieve on some varieties that tend to heart early. Bt and NPV do not affect beneficials. There are new chemistries much less disruptive to beneficials than older broad spectrum chemistry.	Bt stops caterpillar feeding but takes several days to kill. Apply Bt's or NPV after irrigation **not** before. Avoid the heat of the day.

Loopers and Cluster Caterpillar

Chysodeixis spp. and *Spodoptera litura*

Effective IPM Rating √ √ √ √ √

Critical Comments: Monitor crops and controls used for Heliothis will generally provide control of these species.

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. Spring though to autumn. Early season plantings are most at risk in QLD and WA.	Good farm and crop hygiene. Plough in all weed and crop residue quickly.	1 to 2 egg masses in 10 plants (wait for eggs to hatch before taking action). · Prefer outer and wrapper leaves. Monitor crops prior to hearting.	**Parasitoids** · *Microplitis spp* · *Netelia spp* · *Cotesia spp* · *Trichogramma spp* · *Telenomus spp* · *Tachinid* fly **Predators** · Spiders · Assassin bugs · Ladybird beetles · Lacewings · Predatory wasps · Predatory shield bugs · Birds	Plant with spacing that allows for maximum spray coverage. Rotate crops to minimise pest pressure. Select a production period that will minimise pest pressure.	Control easiest at small caterpillar stage. Avoid spraying at large caterpillar stage. Hearting to harvest is the critical period to monitor and control.	There are registered systemic and protectant insecticides and options with good IPM Rating. *Bacillus thuringiensis (Bt)* only works well against small caterpillars; apply it early in crop lifecycle.	Be aware of what chemicals have been applied to the seedlings in the nursery. Bt stops caterpillar feeding but takes several days to kill. Bt does not affect beneficials.	Apply Bt's after irrigation **not** before. Avoid the heat of the day. If seedling drenches have been used these may affect beneficial control of this pest.

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 providing habitat for beneficial insects, lizards, birds, frogs.	Encourage beneficial insects and provide insect refuge areas where possible. Plough in crop residue.		If spraying is required close to harvest use product with a short withholding period.	There are new chemistries that are less disruptive than older broad spectrum chemistry. Beneficials can impact on pest populations if crop managed correctly.	

Sucking pests

Thrips spp. (several species Onion thrips - *Thrips tabaci*, Tomato thrips - *Frankliniella schultzei*) and Rutherglen bug (RGB)- *Nysius vinitor*

Effective IPM Rating √ √ √ √ √

Critical Comments: Some chemicals are not suited to IPM. Choose chemicals carefully as not all species are controlled by soft products – RGB has no IPM suitable chemistry..

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 or Rutherglen bug.	Cool /cold weather. Control weeds. Consider the use of trap crops for RGB.	Yellow or blue sticky traps can be used to monitor thrips. Monitor for flights of migrating Rutherglen bug. Not all thrips are pest species. Pest species often move on prevailing winds in summer.	**Predators** · Spiders · Ladybird beetle · Lacewing larvae · Predatory thrips Some predatory mites and beetles RGB is not known to have any predators in lettuce.	Ensure good spray coverage. Select a production period that will minimise pest pressure. Consider using screening mesh in nursery area if pest pressure is high. Control important from seedling production to harvest.	Pests mainly migrate into the crop on prevailing winds. RGB moves to irrigated crops in very hot dry conditions. RGB does not breed in lettuce. Lifecycle is quicker in warm weather.	Rotate chemical groups to avoid resistance. For thrips range of chemicals available and some are a good IPM Rating. Choose soft option products where available.	Year-round production and poor product rotation increases the risk of insecticide resistance. Soft option products available for some thrips but not all species are controlled.	Onion thrips, tomato thrips can spread viruses such as Tomato Spotted Wilt Virus (TSWV). See entry for WFT Beneficial habitat may also host thrips.

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 providing habitat for beneficial insects.	Immediately after harvest, spray-off or cultivate and plough in lettuce to destroy crop residue.		For RGB control there are only broad spectrum chemicals available at this time though some of the newer systemic products may be effective.	Remove any virus infected plants / weeds to minimise re-infection potential.	RGB are very mobile and if chemical control is applied they can quickly re-infest a crop. Need to consider if control is actually required.

Western Flower Thrips (WFT)
Frankliniella occidentalis

Effective IPM Rating √ √ √ √ √

Critical Comments: Seedling drenches can affect beneficials and affect IPM. WFT is a critical vector for Tomato spotted wilt virus (TSWV) and where both are found, an integrated management approach is critical.

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 weather conditions and surrounding crops and weed hosts. Warm weather increases thrips numbers.	Nursery fully insect-screened (thrips-proof screen) and double doors prevent insect entry. Ensure transplants are free of pest. Control weeds in crop and headlands.	Yellow or blue sticky traps should be used in covered systems and can be useful in field crops. Visually monitor crop for thrips numbers and virus symptoms. Virus-infected plants should be physically removed and destroyed.	Important to ensure good spray coverage. Immediately after harvest spray off or cultivate and plough in lettuce to destroy crop residue.	Soil predatory mites · Predatory thrips · Some predatory beetles Beneficial predators are commercially available.	Lifecycle is quicker in warm weather. The full lifecycle can be completed in as little as 10 days at 20°C. Sprays only effective against certain lifecycle stages. Good hygiene in and around the crop minimises pest pressure.	The seedling drench for Currant lettuce aphid will control some thrips species but not WFT. Use a range of chemical groups to reduce the chance of resistance	Difficult to identify with the naked eye from other thrips. WFT has shown itself to be quick to develop insecticide resistance. Spinosad resistant populations exist in some production areas.	Can spread Tomato Spotted Wilt Virus (TSWV). Insecticidal seedling drenches can affect beneficial insects and affect an IPM 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**	
Surrounding weeds and other crops (e.g. tomato or flowering crops) can be a source of WFT and may increase the risk of a resident resistant population. Previous plant virus infection of crops may make control more critical.					Hygiene and end of crop clean-up critical.		Some new chemistry is claimed to be soft on beneficials.	

Whiteflies

Silverleaf whitefly (SLW) *Bemisia tabaci (*Biotype b), Glasshouse whitefly *Trialeurodes vaporariorum*

Effective IPM Rating √ √ √ √ √

Critical Comments: No chemicals registered for control in lettuce but some used for other sucking insects will provide control. Pest does not breed on Lettuce. The two Whitefly species look very similar.

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**	
Hot conditions. Nearby Whitefly host crops or weeds. Poor hygiene in protected cropping structures.	Screen nursery if necessary. Double doors on protected cropping structures. Keep crop area weed free. Effective monitoring.	Monitor for presence / damage. Yellow sticky traps can be used to monitor for Whitefly. 2-4 flies per leaf present on 40% of plants. Correctly identify the Whitefly to determine its potential impact.	Wasp parasitoids attack SLW nymphs. Generalist Predators. Consider providing habitat for beneficials.	Ensure good spray coverage. Select a production period that will minimise pest pressure. Harvesting of nearby susceptible crops may cause Whitefly to migrate to your crop. Spray oils and even wetters knock-down adults.	Whitefly does not breed on lettuce. Adult Whiteflies damage lettuce crops.	There are limited chemicals available for control.	Year-round production and poor product rotation increases the risk of insecticide resistance.	Crops that host SLW and are sprayed with broad spectrum insecticides will see a large population increase. Some chemical controls for other sucking insects on lettuce will 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**	
		Generally an issue to seedlings and transplants.						

Wireworm / False Wireworm

Elateridae 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**	
Stubble retention and trash from previous crop. A nearby crop or a weedy area could be a source of insect pests. Consider ground history. Increased risk if coming out of pasture or lucerne rotation.	If following pasture or known problem paddock cultivate several weeks before planting and consider period of fallow Normally not an issue in an established crop.	Monitor newly transplanted crop. Look for damaged (missing, wilted) seedlings and then search for damaged roots and wireworms in soil around the plant. Act quickly to control pest if it is observed.	· Common brown earwig · Predatory ground beetles Consider providing habitat for beneficials.	Good soil preparation can significantly reduce numbers. Control important during seedling establishment.	Soil-borne insect. Control as soon as crop damage detected. Ground dwelling pest so high water volume application essential (600L/Ha).	There are registered insecticides but not a suited to IPM. Chemical control still relies on broad spectrum products, which are not are not a good IPM Rating.	High water volumes give best results. 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.

Anthracnose

Microdochium panattonianum

Effective IPM Rating √ √ √ √ √

Critical Comments: Monitor crops to assess need for control and when conditions suitable for infection start protection program.

	Rotation Crop		Cultural Practices				Chemical Control		Conflicts / Issues
Resistant varieties available	**High Risk**	**Disease Break**	**Nutrition**	**Irrigation**	**Hygiene**	**Other**	**Chemical**	**IPM Issues**	
	If weather conditions favour disease, Anthracnose can cause high crop losses. Cool and wet conditions in autumns or especially late winter to early spring. Optimum temperature 18 ˚C - 20˚C.	Can survive in soil for up to 4 years. Host specific to lettuce so rotate with any other non-host crop. Avoid planting in paddocks with a history of the disease. Control host weeds.	Well-grown plants with a balanced nutrition program are less susceptible.	Minimise periods of extended leaf wetness. Use irrigation systems that reduce or eliminate leaf wetting. Water splash can spread the disease.	Only use disease-free seedlings.	Rotate with non-host crops to reduce levels of pathogen in soil. Symptoms can appear 4-8 days after infection. Spray off or plough in harvested areas as soon as possible after harvest.	A preventative monitoring and fungicidal program (protectants) should be employed to prevent early infection if a problem is expected. Systemic chemicals are available but prevention is more effective.	Infection may occur at the seedling production phase – do not over irrigate.	Monitor closely when conditions favour infection.

	Rotation Crop		Cultural Practices				Chemical Control		Conflicts / Issues
Resistant varieties available	**High Risk**	**Disease Break**	**Nutrition**	**Irrigation**	**Hygiene**	**Other**	**Chemical**	**IPM Issues**	
	Fields with a history of the disease. Cos (Romaine) lettuce cultivars appear to be more susceptible than iceberg or loose leaf varieties. Host weeds such as wild lettuce or prickly lettuce.			Irrigation timing important as 2-4 hours of leaf wetness can result in infection when the fungus is present.			Need to consider chemical resistance management. Protective copper fungicides will assist in disease prevention.		

Botrytis (grey mould)
Botrytis cinerea

Effective IPM Rating √ √ √ √ √

Critical Comments: Monitor crops to assess need for control.

	Rotation Crop		Cultural Practices				Chemical Control		Conflicts / Issues
Resistant varieties available	**High Risk**	**Disease Break**	**Nutrition**	**Irrigation**	**Hygiene**	**Other**	**Chemical**	**IPM Issues**	
	Damaged seedlings. Romaine types are very susceptible. High humidity. *Botrytis* is usually a minor problem.	Rotate out of lettuce as the fungus can survive in debris, soil and on alternative hosts. *Botrytis* has a wide host range. Often follows other diseases into a crop.	Seedlings can be killed if infected early in the season. Excess nitrogen (N) and low Calcium (Ca) favour the disease.	Free moisture is needed for infection. Avoid long periods of leaf wetness. Irrigate early in the day so foliage can dry as quickly as possible. Avoid overhead irrigation if possible. Maximise ventilation.	Minimize plant debris. Avoid planting oversize transplants as leaf damage may occur during the planting process and this may lead to infection. *Botrytis* infects damaged tissue.	Spread on air currents so plant up-wind of old crops. *Botrytis* does not infect healthy green tissue unless an injury or dead area is present. Always spray-off or plough in crop residue immediately after harvest.	Many fungicides are effective against gray mould. The fungicides are preventative and should be applied before infection occurs. Copper applications will have some preventative effect.		Need to balance risk and management for tipburn with risk of Botrytis. Night watering is preferred for tipburn control. In hot weather leaf wetness should not be a problem.

	Rotation Crop		Cultural Practices				Chemical Control		Conflicts / Issues
Resistant varieties available	**High Risk**	**Disease Break**	**Nutrition**	**Irrigation**	**Hygiene**	**Other**	**Chemical**	**IPM Issues**	
	If weather conditions are favourable for the pathogen then grey mould can cause substantial crop loss in both green house and field lettuce.				Minimise damage caused by seedling handling in nursery, cultural practices, and other pathogens and pests.		All fungicides used for *Sclerotinia* control are also effective against *Botrytis*. Rotate fungicide groups to avoid resistance.		If there is a conflict in disease and tipburn risk irrigate very early in the day.

Downy Mildew

Bremia latucae

Effective IPM Rating √ √ √ √ √

Critical Comments: Use resistant varieties and monitor crops closely and apply protective measures when conditions suitable for infection.

	Rotation Crop		Cultural Practices				Chemical Control		Conflicts / Issues
Resistant varieties available	**High Risk**	**Disease Break**	**Nutrition**	**Irrigation**	**Hygiene**	**Other**	**Chemical**	**IPM Issues**	
There are many types (or races) of this fungus. Some lettuce varieties claim resistance to some races	Cool, damp conditions. Free moisture on plant leaves. High risk following lettuce crops, near globe artichoke, endive, chicory and ornamental host plants.	Seed should be fungicide treated. Avoid planting near other lettuce fields as airborne spores can be dispersed from one crop to the other by the wind. Crop rotation is important.	Excessive Nitrogen may make lettuce more susceptible. Avoid high nitrogen levels.	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.	Use wider plant spacing to facilitate better air movement and leaf drying. Transplants should be protected with fungicides to avoid Downy mildew being introduced into the field.	Predictive models for downy mildew on lettuce are under evaluation world-wide. Align plant spacing that allows for maximum ventilation. Subsequent plantings should be up- wind of current crops.	Apply preventative fungicides before the disease develops based on weather conditions. Rotate with curative fungicides when conditions are ideal for infection.	Choose resistant varieties where possible.	More difficult to control as the plant ages and crop density increases. Control may conflict with optimum irrigation timing during the night for tipburn management.

	Rotation Crop		Cultural Practices				Chemical Control		Conflicts / Issues
Resistant varieties available	**High Risk**	**Disease Break**	**Nutrition**	**Irrigation**	**Hygiene**	**Other**	**Chemical**	**IPM Issues**	
	Wild lettuce is a host although it may not show symptoms. Spores carried over on crop debris.			Minimise leaf wetness eg. before 8.00 am when dew may normally be on the leaf and avoid watering in the evening. Trickle irrigated crops show less disease than overhead irrigated crops.		Grow seedlings outside the area of crop production to avoid cross contamination.	Rotate the appropriate registered fungicides. Copper is a general protectant fungicide. Fungicide resistance has been reported in some areas.		However in warm weather this will not be an issue as leaves will dry quickly.

Rhizoctonia (bottom rot)
Rhizoctonia solani

Effective IPM Rating √ √ √ √ √

Critical Comments: Monitor crops to assess the need for control and use good cultural practices.

	Rotation Crop		Cultural Practices				Chemical Control		Conflicts / Issues
Resistant varieties available	**High Risk**	**Disease Break**	**Nutrition**	**Irrigation**	**Hygiene**	**Other**	**Chemical**	**IPM Issues**	
None. Select varieties that have upright growth habits to reduce disease severity.	Hotter, humid production areas. Once infection is seen in an area it is likely to re-occur in future plantings if weather conditions are favourable.	Soil-borne pathogen that survives for a long period of time Repeated frequent cropping with lettuce may increase disease levels in the soil. Avoid fields with a history of bottom rot problems.		Plant in well drained soils. Drip irrigation will assist in disease reduction. Avoid over irrigation. Over watering creates wet stems and high humidity around the plant that can greatly increase disease severity.	Use a quality sterile seedling mix.	Do not plant back in fields with undecomposed residues from previous crop. All stages of the crop can be infected in conditions of high humidity. Greatest risk of infection is from heart formation through to harvest.	Ground with a history of Rhizoctonia disease may need to be treated with a fungicide prior to transplanting in order to reduce disease incidence. Apply appropriate chemicals to target the base of young plants.	None available yet. Consider planting on small hills to improve air circulation around plant base. Improve drainage.	More common in summer – hotter production regions. Can be a problem in glasshouse-grown lettuce. Direct seeded plants may be severely infected or killed by this disease before or just after emergence.

	Rotation Crop		Cultural Practices				Chemical Control		Conflicts / Issues
Resistant varieties available	**High Risk**	**Disease Break**	**Nutrition**	**Irrigation**	**Hygiene**	**Other**	**Chemical**	**IPM Issues**	
		Crop residues should be fully decomposed (broken down) before planting a new crop.				Spray-off or plough in harvested areas as soon as possible after harvest.	Preventative action required if you have a history of disease occurrence.		Good cultural practices and management provides best control. Rotate crops with non-hosts to reduce the inoculum but this disease has a wide host range.

Sclerotinia (lettuce drop)
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. Identification of the *Sclerotinia* pest is essential to determine the most effective control methods.

	Rotation Crop		Cultural Practices				Chemical Control		Conflicts / Issues
Resistant varieties available	**High Risk**	**Disease Break**	**Nutrition**	**Irrigation**	**Hygiene**	**Other**	**Chemical**	**IPM Issues**	
None available.	Cool, humid spring autumn weather. Wet soil. Following other susceptible crops.	The pathogen can survive as *Sclerotia* in soil for 5 years or more. Broad host range including some green manure or break crops. Cereals and grasses are non-host and thus good rotation crops.	Soil amendments with high Nitrogen such as poultry manure can reduce survival of *Sclerotia* in soil.	Improve soil structure to reduce water logging. Use raised beds if needed. Avoid both over and under watering to maintain consistent soil moisture levels. Effective irrigation scheduling is essential.	Minimise spread of disease by cleaning equipment after use in infected paddocks.	Devise a production systems that reduces the risk of Sclerotinia outbreaks by: · Using practical and cost-effective cultural practices. · Implementing a rotation program that includes non-host crops.	In fields with history of *S. minor* lettuce drop, protectant fungicides applied soon after transplanting can reduce disease incidence. Application must be to the base of seedlings and repeated before plants become too large.	Use good drainage, cultural practices and crop rotation. The biocontrol agent *C. minitans* can reduce infections caused by *F. sclerotiorum*.	An IPM approach is the best to manage *Sclerotinia*. Chemical control is not sustainable in the long-term. Control of lettuce drop caused by *S. sclerotiorum* is difficult because airborne spores can enter the lettuce fields at unpredictable times.

	Rotation Crop		Cultural Practices				Chemical Control		Conflicts / Issues
Resistant varieties available	**High Risk**	**Disease Break**	**Nutrition**	**Irrigation**	**Hygiene**	**Other**	**Chemical**	**IPM Issues**	
	Cultivars with low growth habit like Iceberg lettuce types can be more susceptible than those with upright growth like some Butter head or Cos types.	It is important to know which species is present for an effective control program. Crop residues from green manure biofumigant mustard crops (a brassica) show suppressive effects against *S. minor*.		Reduce free moisture by irrigating early in the day so that the crop canopy and soil surface dries quickly. Irrigate with drip irrigation or subsurface drip system so that the soil surface is drier.		· Improving overall soil health to reduce survival of sclerotia (eg. add biological control agents and increase organic matter). For *S. minor*, deep ploughing soil to bury sclerotia below root zone may reduce disease.	Fungicides alone do not provide absolute control and are not a sustainable control means. Important to consider water volume to be used as per canopy size and *Sclerotinia* species.		Need to balance risk and management for tipburn with risk of *sclerotinia*. Night watering is preferred for tipburn control. In hot weather leaf wetness should not be a problem.

Septoria spot

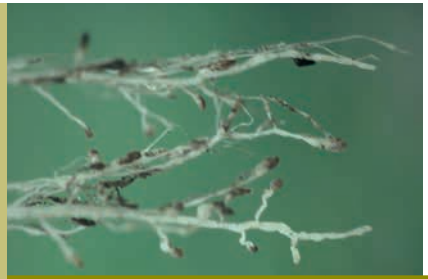
Septoria lactucae

Effective IPM Rating √ √ √ √ √

Critical Comments: Monitor crops to assess need for control and start protection program when conditions are suitable for infection.

	Rotation Crop		Cultural Practices				Chemical Control		Conflicts / Issues
Resistant varieties available	**High Risk**	**Disease Break**	**Nutrition**	**Irrigation**	**Hygiene**	**Other**	**Chemical**	**IPM Issues**	
	Prefers prolonged periods of high humidity and cool, wet windy conditions. Severe infection can render crops unmarketable. Fields with a history of the disease.	Avoid planting lettuce in fields with a history of disease. Control host weeds.	Crops under stress are more susceptible.	Water splash moves infection onto leaves. Minimise periods of extended leaf wetness. Use irrigation systems that reduce or eliminate leaf wetting.	Only use disease free seedlings. Keep seedlings disease free with protectant fungicides.	Disease normally appears on the older lower leaves first. Rotate with non-host crops to reduce levels of pathogen in soil. Spread by wet windy conditions, older leaves affected first.	A preventative monitoring and fungicidal program (protectants) should be employed if conditions are suitable to prevent early infection. Systemic chemicals are available but prevention is more effective.	Hygiene on farm is important, destroy old crop residues. Infected plants are a major source of new disease outbreaks.	Monitor closely when conditions favour infection.

	Rotation Crop		Cultural Practices				Chemical Control		Conflicts / Issues
Resistant varieties available	**High Risk**	**Disease Break**	**Nutrition**	**Irrigation**	**Hygiene**	**Other**	**Chemical**	**IPM Issues**	
	Host weeds such as wild lettuce or prickly lettuce.					Spray-off or plough in harvested areas as soon as possible after harvest.			



Nematodes

Meloidogyne spp. and *Pratylenchus spp.*

Effective IPM Rating √ √ √ √ √

Critical Comments: Effective long-term control will be 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.	Crop rotation with non-hosts of 1-2 years is generally sufficient to reduce RKN numbers to non-damaging levels. 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.	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 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**	
						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 lettuce in Australia. Of these the most important are Root knot nematode (RKN) (*Meloidogyne hapla*, *Meloidogyne javanica* and *Meloidogyne incognita*). RKN causes galling of lettuce roots and stunting of plants, often in distinct patches in the field. Species of Root lesion nematode (RLN) (P*ratylenchus spp.*) have been reported as parasites of lettuce in Australia.

Control needs to be 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, drain, dam or a weedy area or headlands could be a source of slugs and snails. Long grass in drains. Following a pasture crop. Minimum tillage. Wet weather.	A physical barrier of empty land between crops and waterways and drains helps slow pest movement to the crop. Good crop rotation. Keep crop blocks 3m - 4m away from drains and dams.	Check crop canopy and plant centres in areas adjacent to drains and wet spots, slugs and snail tend to appear there first. Larger plants are generally less affected but slugs and snails can be a contamination pest.	· Birds · Lizards · Other small vertebrates · Carabid beetles	Good soil preparation can significantly reduce numbers. Fallow periods. Improved drainage and improving soil quality assists control. Drip irrigation reduces occurrence. Plants are vulnerable when small.	Cool moist environments and areas favour pest survival and overwintering. Once established pest can survive in the soil between crops unless the life cycle is broken.	No registered chemicals available for control within the crop. Drains, damp areas that adjoin the crop can be baited. A protective border can be used to prevent pest movement into the crop.	Need to control in borders and headlands and bait those areas if a problem is likely. Baits or a barrier strip around the affected crop area.	Totally reliant on 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	
				Plough in crop residue. Remove debris that can be used as shelter areas and keep grass short.				

Virus

IPM Control - Pre Plant Planning.

Effective IPM Rating √ √ √ √ √

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

	Cucumber mosaic virus (CMV)	Lettuce mosaic virus (LMV)	Turnip mosaic virus (TuMV)	Lettuce necrotic yellows virus (LNYV)	Tomato spotted wilt virus (TSWV)	Lettuce big vein disease (LBVD). (Mirafiori lettuce virus/lettuce big vein virus)
How is it transmitted?	The virus is transmitted by more than 60 species of aphid, including: · *Acyrthosiphon pisum* · *Aphis crayccivora* and · *Myzus persicae* in a non-persistent** manner	Seed-borne in lettuce seed and most outbreaks can be traced to infected seed lots. Also spread by aphids (A*phis gosseii*, *Macrosiphum euphorbiae*, *Myzus persicae* in a non-persistent** manner).	The virus is transmitted by more than 50 species of aphid, including *Myzus persicae* and *Brevicoryne brassicae*, in a non-persistent** manner.	Transmitted by only one aphid species, the Sow thistle aphid (*Hyperomyzus lactucae*) in a persistent* manner.	Spread by several species of thrips: · *Thrips tabaci* · *Frankliniella schultzei* · *F. occidentalis* (Western Flower Thirps)	The viruses causing the disease are transmitted by the soil-borne fungus *Olpidium virulentus*. The virus survives in the fungal resting spore which can remain viable in soil for several years.
Host plants	A very wide host range including: · Lettuce · Vegetables · Weeds · Ornamental species.	The virus has a wide host range including the weeds, thistles (*Sonchus spp*) and Fat hen.	Wide host range including: · Lettuce · Vegetable brassicas · Canola · Brassica weeds · other weed species.	Both the virus and aphid have sow thistle as their major host.	A very wide host range among crop, weed and ornamental species. Lettuce often seriously affected.	The disease is favoured by cool weather and wet soils.

	Cucumber mosaic virus (CMV)	Lettuce mosaic virus (LMV)	Turnip mosaic virus (TuMV)	Lettuce necrotic yellows virus (LNYV)	Tomato spotted wilt virus (TSWV)	Lettuce big vein disease (LBVD). (Mirafiori lettuce virus/lettuce big vein virus)
Host plants *continued*			An occasional issue where lettuce is grown near infected brassica crops or near infected weeds, particularly weedy brassica species.			
Key control information	Remove old crops and weed control in and around the crop is essential. Insecticides may cause more harm than good as their application may encourage the aphid to move from plant to plant. Potentially, CMV will then be transmitted to each plant visited by the aphid.	Weed control around and in the crop is essential. It is critical to plant LMV-tested seed.	Weed control around and in the crop is essential. Incidence of TuMV may increase where lettuce is grown near infected brassica crops or weeds (particularly brassica species).	Weed control, particularly for Sow thistle, around and in the crop is essential.	Weed control around and in the crop is essential.	As the fungus is soil-borne the disease is difficult to control. It is important to plant healthy seedlings. Crop rotations can reduce the disease incidence.

* Persistent – Aphids need to feed for an extended period of time on each host to pick up and then transmit the virus from one host to another.
** Non- persistent – Aphids only need to feed for a very short period of time on each host to pick up and transmit the virus from one host to another.

Several of the above viruses produce similar symptoms in lettuce and are difficult to separate in the field. Laboratory tests are often necessary to determine which virus or viruses are present.

Virus minimisation strategy

Pre-plant	Rotations out of lettuce will help reduce big vein disease incidence. It is essential to control weeds in and around production areas. Collectively, the viruses infecting lettuce have a very wide range of potential hosts so a thorough weed management program is recommended, rather than selecting individual species which may be common hosts. Purchase seed and seedlings from reliable suppliers and ensure that it has been tested for Lettuce mosaic virus (LMV) freedom. Consider LBVD tolerant varieties when growing during cool weather in areas with a history of the disease. If aphid-transmitted viruses are an ongoing issue (CMV, LMV and TuMV) consider the use of permanent wind rows and strategic planting to maximise the distance between lettuce crops.
Nursery	Ensure nursery area is free of weeds. Control insect vectors-thrips, aphids. Where possible locate nursery in a district remote from production areas.
Transplant through to vegetative growth	Maintain weed control in and around production areas, especially of virus host plants. Monitor for and maintain good management of insect vectors. Avoid planting new crops near old crops, particularly where virus and other diseases have been prevalent. Remove any virus affected plants from the crop area to minimise virus spread. It is important to control the insect vectors (see control methods for insect vectors) before virus is observed in the field.

Transplant through to vegetative growth *continued*	Once virus is present in a crop, it is too late to eradicate the virus and **attempts to control aphid vectors at this point can further spread virus in the crop for diseases such as CMV and LMV**, due to the method of virus transmission. It is important to reduce virus spread to subsequent crops. Avoid planting near affected crops and plant upwind. Have non-host crops as alternate plantings.
Hearting through to harvest	Monitor crops closely for insect vectors and symptoms but if the virus is observed in the last stages of crop growth, there will be a minimal affect on yield. Destroy harvested crops promptly. Do not plant new crops close to old crops. Plan to have fallow land or non-susceptible crops as a means of separating plantings. Remove any virus-affected plants from the crop area to minimise virus spread to other plants, particularly younger plantings that are nearby. Plant upwind of affected crops if possible. Have non-host crops as part of your crop rotation.

Weeds
IPM Control

Effective IPM Rating √ √ √ √ √	**Critical Comments:** Weed control is an essential component of IPM for a range of pest issues. It is essential to consider the range of potential host plants for key diseases and their vectors as well as problem, insect pests.		
Method of control for a weed free seedbed	**How to do it**	**Negatives**	**Positives**
Pre-plant	Form beds well before planting and then irrigate to germinate an initial flush of weeds. Kill these weeds by spraying with a knockdown herbicide. Alternatively, kill weeds with a very shallow cultivation. For organic farming, flaming, steam or hot water treatments are alternatives to knockdown herbicides. Green manure crops can suppress weed growth.	Avoid moderate to deep cultivations because they will cause more weeds to germinate in the crop.	A range of techniques can be used to kill off the germinating weeds.
Bed formation before planting	Form beds just before planting, with a final cultivation to prepare the seedbed and kill any emerged weeds. If high weed numbers likely form beds well before planting and spray-off emerging weeds before planting or pre-plant herbicide application.	Not the preferred option in paddocks with substantial numbers of weeds.	Reduces weed numbers before planting.

Method of control for a weed free seedbed	How to do it	Negatives	Positives
Fumigation	Form beds before planting, then fumigate, (refer to fumigant labels for specific rates). Fumigating or "gassing" can produce variable results depending on a number of factors including soil type and temperature, moisture content, and exposure time. Contractors with specialist application equipment operate in many production areas.	Incorrect soil moisture will reduce the effectiveness of fumigation. Expensive and results can be variable. Fumigation will also kill off beneficial soil organisms.	This is not an IPM friendly practice. Fumigation has the additional benefit of controlling some diseases, nematodes and insect pests, depending on pest severity and the rates used.
Control using mulch	In combination with drip irrigation, lay plastic or paper mulch to control weeds and then transplant through this much layer. To make the most of the costs associated with this system growers usually try and replant these mulched beds with a second rotation crop. Plant based plastic type mulches claiming to be biodegradable are also now being developed and sold in some areas. It is too early to know how well these products perform in different environments, how well they break down and whether they are in fact more environmentally friendly than traditional plastic products.	Cannot be used with overheard irrigation. In summer production areas excess soil heat generated by plastic mulch can cause production issues. Can be expensive and more difficult to manage.	May increase soil temperature for an increased planting window.

Weeds
IPM Control

Weed management is a significant proportion (about 20%) of pre-harvest variable costs in lettuce production. Poorly managed or ineffective weed control can be even more costly as it impacts on disease severity, harvest weight, heart size and adds to weed potential in following crops.

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 are not a host to diseases or pests may help support a beneficial population.

Site selection and preparation

It is extremely difficult to grow lettuce in land with large weed seed banks; pre-planting management is the key to success. Land with at least a two-year history of effective weed control achieved by selective crop rotation and cover cropping is best.

Weed management in the lettuce crop starts with planting into a weed-free seedbed. There are a few possible options for achieving this.

Broadleaf weeds	Grass weeds
The most significant weed problem. Particularly the *Asteraceae* (daisy-type) family (Potato weed and Common sow thistle).	Seldom a problem. Most will be controlled by the same cultural practices used to manage broadleaf weeds.
Whilst late-emerging weeds may not affect lettuce yields they should still be managed. Species such as potato weed can grow dramatically in the last few weeks before harvest and interfere with cutting and packing processes. 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 in the lettuce crop can only be killed by cultivation or hand weeding.	There are pre-emergence herbicides to control many grass species before emergence. There are registered chemicals for post-emergence grass control in lettuce.

Weeds
Post harvest

Rotation Crop		Cultural Practices			Conflicts / Issues
High Risk	**Disease Break**	**Nutrition and Irrigation**	**Hygiene**	**Other**	
Areas with a previous history of weeds. Areas planted beside weedy areas. Troublesome weeds such as nut grass (*Cyperus rotundus*) or potato weed (*Galinsoga parviflora*), are difficult to control.	A consistent system of crop rotation and weed control between crops will minimise weed build up prior to planting. Because of residual activity, sensitive crops (e.g. beets) should not be sown immediately following a lettuce crop treated with some chemicals. Refer to the label for re-cropping intervals.	Some chemicals must be applied before transplanting.	Nursery and farm hygiene are important factors in both minimising weed population. Farm-based nursery production facilities should be kept weed-free and well drained.	To maintain an effective herbicide blanket, it is also important that cultural operations after herbicides are applied, e.g. while transplanting minimise soil surface disturbance. Whilst late-emerging weeds may not affect lettuce yields they should still be managed. Species such as potato weed can grow dramatically in the last few weeks before harvest and interfere with cutting and packing processes.	Take care on sandy soils, as the highest herbicide rates may cause crop stunting and yield reduction. The Queensland experience found in some circumstances (high temperatures and sandy soils), crop damage can occur. Growers unfamiliar with a product are strongly advised to only treat a small area at first, to determine product performance with local soils, climate and varieties.

Rotation Crop		Cultural Practices			Conflicts / Issues
High Risk	**Disease Break**	**Nutrition and Irrigation**	**Hygiene**	**Other**	
				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. Within one day of final harvest all weeds and crop residue should be destroyed.	

Part of the post-harvest activities are to review the impacts of various control activities on the yield and "pack out" to improve and pest and weed control for subsequent seasons. A key part of the IPM process is to record percentage crop damage and "pack out" rate, crop residue management, migration of beneficial insects and insect pests, rotation – length, break crops and follow on crops.

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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 lettuce product can be downloaded from <http://era.deedi.qld.gov.au/1660/>

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