



Eggplant

Strategic Agrichemical Review Process
2011-2014

HAL Projects - MT10029 & VG12081

AgAware Consulting Pty Ltd
Checkbox 3D Pty Ltd

February 2014

Horticulture Australia project no:

MT10029 – Managing pesticide access in horticulture.
VG12081 - Review of vegetable SARP reports.

Contact:

Noelene Davis
Checkbox 3D Pty Ltd
PO Box 187 Beecroft NSW 2119
Ph: 0424 625 267 Email: ndavis@checkbox3d.com.au

Purpose of the report:

This report was funded by Horticulture Australia and the Australian vegetable industry to investigate the pest problem, agrichemical usage and pest management alternatives for the eggplant industry across Australia. The information in this report will assist the industry with its agrichemical selection and usage into the future.

Funding sources:

MT10029 - This project has been funded by HAL using the vegetable industry levy and across industry funds with matched funds from the Australian Government.

VG12081 - This project has been funded by HAL using the vegetable industry levy and matched funds from the Australian Government.

Date of report:

10 February 2014

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Horticulture Australia

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1. Media Summary

A Strategic Agrichemical Review Process (SARP) through the process of a desktop audit and industry liaison assesses the importance of the diseases, insects and weeds (plant pests) that can affect a horticultural industry; evaluates the availability and effectiveness of fungicides, insecticides and herbicides (pesticides) to control the plant pests; determines any 'gaps' in the pest control strategy and identifies suitable new or alternatives pesticides to address the 'gaps'.

Alternative pesticides should ideally be selected for benefits of:

- Integrated pest management (IPM) compatibility
- Improved scope for resistance management
- Sound biological profile
- Residue and trade acceptance domestically and for export

SARP workshops for eggplant were conducted in Queensland, Victoria and Western Australia as part of combined vegetable meetings in 2008, 2010 and 2011. The results of the process provide the eggplant industry with pesticide options for the future that the industry can pursue for registration with the manufacturer, or minor-use permits with the Australian Pesticides and Veterinary Medicines Association (APVMA).

DISEASE

Diseases identified as high priorities:

| Disease (common name) | Disease (scientific name) |
|------------------------------|----------------------------------|
| Bacterial wilt | <i>Ralstonia solanacearum</i> |
| Sclerotinia rot | <i>Sclerotinia</i> spp. |
| Verticillium wilt | <i>Verticillium dahlia</i> |

There are a range of products registered for disease control in eggplant. However, for three diseases named as high priorities there are few options. This is typical of the situation for minor crops. Industry resources are limited and the Agchem product registrants cannot justify the cost of development of products for minor crops.

INSECTS

Insects identified as high priorities:

| Insect (common name) | Insect (scientific name) |
|---|--|
| Eggfruit caterpillar | <i>Sceliodes cordalis</i> |
| Helioverpa | <i>Helicoverpa armigera</i> and <i>H. punctigera</i> |
| Whiteflies - including Silverleaf, Greenhouse | <i>Bemisia tabaci</i> , <i>Trialeurodes vaporariorum</i> |
| Two-spotted mite | <i>Tetranychus urticae</i> |
| Western flower thrips | <i>Frankliniella occidentalis</i> |

WEEDS

Overall there is a need for newer chemistry and increased options for control of weeds in eggplant. Non-chemical options should be considered in future SARPs.

Growers generally use a pre-plant weed control (general knockdown herbicides) to prepare the paddock. Growers then either alternate the herbicides used or use them in combination for effective weed control. Other than trifluralin (permit) all the herbicides registered are either pre-emergent knockdown herbicides or grass selective post-emergent herbicides.

Most weeds can be controlled with currently available herbicides.

Weeds identified as a high priority for control:

| Weed (common name) | Weed (scientific name) |
|-----------------------|-------------------------|
| Blackberry nightshade | <i>Solanum nigrum</i> |
| Pigweeds | <i>Portulaca</i> spp. |
| Marshmallow | <i>Malva parviflora</i> |

2. The Australian eggplant industry

The Australian eggplant industry is a small horticultural industry. Consumption of eggplant has risen in recent years with the growth in Asian, African, Middle Eastern and European cuisines.

Accurate statistics on eggplant production are not available, but it is known to be grown in reasonable quantities at:

- Bowen / Burdekin (Qld)
- Bundaberg (Qld)
- Perth Metro outer areas (WA)
- Sydney Basin (NSW)
- Sunraysia (Vic)
- Goulburn Valley (Vic)
- North Adelaide Plains (SA)
- Adelaide Hills (SA)

In 2011, Qld produced 38% of the national eggplant crop (3,091 t), WA 32% (2,603T), NSW 16% (1,302 t), Vic 8% (651 t), SA 4% (325T) and Tas 2% (163T). Total production was 8,134T in 2010/11 from an estimated 260 ha, worth ~\$22 million.

The most common grown commercial eggplant varieties are the large (10-15 cm long) teardrop dark purple varieties. There is also a range of niche market varieties grown.

Due to the variety of weather and growing conditions across Australia and the introduction of different varieties of eggplant, the Australian industry is now able to supply domestic and international markets with fresh eggplant throughout the year.

Although specific areas are unknown, some eggplants are grown in protected cropping structures; although most are field grown. There is expected to be a swing to protected cropping in coming years.

Eggplant exports are unknown.

3. Introduction

3.1. Background

Growers of some horticultural crops suffer from a lack of legal access to crop protection products (pesticides). The problem may be that whilst a relatively small crop area is valuable in an agricultural sense, it is not of sufficient size for agchem manufacturers to justify the expense of registering a product use on that crop. Alternately, the disease, pest, or weed problem may be regional or spasmodic, making agchem companies unwilling to bear the initial high cost of registering suitable pesticides. As an added complication some horticultural crops may be grown in protected cropping or hydroponic situations. These can have a significant impact on pesticide performance and residue outcomes, further increasing product development requirements and registration costs.

Growers may at times be in a situation where they face severe losses from diseases, pests and weeds if they do nothing to protect their crops, or face penalties if they use a product that is not registered or available via a permit. The eggplant industry is very aware of the possible consequences of the use of unregistered or non-permitted pesticides. These can include: produce with unauthorised pesticide residues; rejection at both local and export market levels; placing Australian export trading arrangements in jeopardy, and; fines and penalties.

Environmental concerns, consumer demands, and public opinion are also significant influences in the marketplace related to pest management practices. Industry/IPM Practitioners must strive to implement best management practices and tools to incorporate a pest management regime where strategies work in harmony with each other to achieve the desired effects while posing the least risks.

Pesticides have always been an important tool in the production of eggplant. They control the various diseases, insects and weeds that affect the crop and can cause severe economic loss in modern high intensity growing operations. Pesticides are utilized in seedling production, pre-plant, during plant establishment, through crop development and into crop maturity to maximise crop yield, quality and customer appeal.

From a pesticide access perspective, the APVMA classifies eggplant as a group as a minor crop. The crop fits within the APVMA crop group 012: Fruiting vegetables other than cucurbits.

As a consequence of the issues facing the eggplant industry regarding pesticide access, Horticulture Australia Ltd and the vegetable industry undertook a review of the pesticide requirements in eggplants via a Strategic Agrichemical Review Process (SARP). See Appendix 1 – the Strategic Agrichemical Review Process. The aim was to determine solutions (primarily pesticide) to current and future pest threats.

This SARP process identified diseases, insect pests and weeds of major concern to the eggplant industry. Against these threats available registered or permitted pesticides, along with non-pesticide solutions, were evaluated for overall suitability in terms of IPM, resistance, residues, withholding period, efficacy, trade, human safety and environmental issues. Where tools were unavailable or unsuitable the process aimed to identify potential future solutions.

This report is not a comprehensive assessment of all pests and control methods impacting on eggplant production in Australia but attempts to prioritise the major problems.

3.2. Minor use permits and registration

Eggplants are classified as minor by the APVMA. Therefore access to minor use permits can be relatively straight forward as long as a reasonable justification is provided. Possible justification for future permit applications could be based on:

- New disease, insect or weed identified as a cropping issue
- No pesticide available
- Current pesticides no longer work – resistance
- Current pesticides limiting trade
- IPM, environmental or operator issues
- Loss of pesticides due to removal from market
- New, effective pesticide registered in another crop
- Alternate pesticide has overseas registration or minor use permit

With each of these options, sound, scientific argument is required to justify any new registrations or permit applications.

Another option for the eggplant industry is for manufacturers to register new pesticides uses in the crop.

3.3. Methods

The SARP was conducted in Queensland, Victoria and Western Australia as part of combined vegetable meetings in 2008, 2010 and 2011. The meeting included leading growers, consultants, government agencies, agchem companies and agricultural reseller staff.

- Participants were given a comprehensive list of most major pests of eggplants and asked to prioritise them into high, moderate and low categories.
- Participants were then asked to list the main pesticides and or other control agents used for each pest.
- Mostly pesticide trade names were used and the list provided was certainly not comprehensive but a starting point for further assessment.
- Pesticides that are under review by the Australian Pesticides and Veterinary Medicines Authority (APVMA) were listed.
- Information was collated onto Excel spreadsheets for diseases, insects and weeds.
- The information was circulated to participants for any further comments to ensure the accuracy of the information.
- Each alternative pesticide was assessed for:
 - IPM compatibility
 - Improved scope for resistance management
 - Sound biological profile
 - Residue and trade acceptance domestically and for export

Final selections of proposed new pesticides for the eggplant industry to pursue were listed.

3.4. Results and discussions

Results and discussions are presented in the body of this document.

4. Pests and diseases of eggplant

4.1 Diseases of eggplant

| Common name | Scientific name |
|----------------------------|--|
| HIGH PRIORITY | |
| Bacterial wilt | <i>Ralstonia solanacearum</i> |
| Sclerotinia rot | <i>Sclerotinia</i> spp. |
| Verticillium wilt | <i>Verticillium dahlia</i> |
| MODERATE PRIORITY | |
| Anthracnose | <i>Colletotrichum</i> spp. |
| Fusarium rot | <i>Fusarium</i> spp. |
| Phomopsis Fruit rot | <i>Phomopsis</i> spp. |
| Powdery mildew | <i>Leveillula taurica</i> |
| Tomato spotted wilt virus | Tospovirus |
| LOW PRIORITY | |
| Bacterial spot | <i>Xanthomonas campestris</i> pv. <i>vesicatoria</i> |
| Cercospora leaf spot | <i>Cercospora</i> spp. |
| Damping off | <i>Pythium</i> spp., <i>Rhizoctonia solani</i> , <i>Phytophthora</i> spp. |
| Grey mould | <i>Botrytis cinerea</i> |
| Irish (Late) blight | <i>Phytophthora infestans</i> |
| Septoria | <i>Septoria</i> spp. |
| Target spot (Early blight) | <i>Alternaria solani</i> |
| Biosecurity risk | |
| None listed | |

4.1.1 High priority diseases

Bacterial wilt (*Ralstonia solanacearum*)



Bacterial wilt is a very common and destructive disease of eggplant and other solanaceous crops. The bacteria infect plants through roots, natural openings and wounds, often resulting in plant death. The disease is very destructive, and crop losses of 80% or more are not uncommon in areas in which the pathogen occurs. Bacterial wilt is difficult to control because it persists in the soil for years. Control by rotating crops. Avoid planting any solanaceous crops in contaminated ground.

- Bacterial wilt is considered a major problem in Qld and NT in certain locations, and a minor problem in other states.
 - Important and destructive foliar disease of eggplant.
- Chemicals **registered** for control of *Verticillium* wilt in eggplant are fumigants such as 1,3-dichloropropene + chloropicrin which has a general registration for soil borne diseases.

- No products are listed for bacterial wilt control in eggplant via **permits**.
- **Potential** options for bacterial wilt control in eggplant
 - Copper (various products) - Group M1 protectant fungicide
 - Registered for the control of other bacterial diseases in eggplant and can commonly be used 1-5 times per crop.
 - Trials have shown it to be efficacious.
 - Mancozeb (various) - Group M3 protectant fungicide
 - Registered for control of other diseases in eggplant.
 - Trials have shown it to be efficacious.
 - Alternate chemistry is needed but there has been nothing identified
 - Biocontrol of *Ralstonia solanacearum* by treatment with lytic bacteriophages has been reported in the literature. There is no phage product close to commercial availability but the industry should remain aware of developments in this area.

It must be noted that there will be regulatory hurdles associated with such products.

- Good crop rotation and cultivation practices limit damage.

Sclerotinia rot (*Sclerotinia* spp.)



Appears as a white threadlike growth that darkens over time. Plant may wilt and die rapidly.

On plants, it causes a dark, water soaked lesion on stems which then get girdled and die. Affected fruit are soft and rotted.

Favoured by cool humid conditions.

- Sclerotinia rot is considered a major-moderate problem in Qld.
- There are no fungicides **registered** for the control of Sclerotinia rot in eggplant.
- No fungicides are listed for Sclerotinia rot control in eggplant via **permits**.
- **Potential** fungicides for Sclerotinia rot control in eggplant.
 - Boscalid (various) – Group 7 protectant and curative fungicide
 - Registered for Alternaria / early blight in eggplant.
 - Registered for Sclerotinia rot in other vegetables.
 - Grower concern with the development of resistance in Sclerotinia resulting from overuse of Filian and limited options.
 - Penthiopyrad (FONTELIS[^]) Group 7 - Dupont could be approached with regard to development of this use. There are overseas registrations and an Australian label extension could be simple.
 - The product is registered for Sclerotinia rot in leafy vegetables.
 - Registered for other diseases in eggplant.
 - Cyprodinil + fludioxonil (SWITCH[^]) - Group 9 +12 protective and systemic fungicide
 - Australian registrations for Sclerotinia and other diseases in various crops.
 - Efficacy and residue data required.

Verticillium wilt (*Verticillium dahlia*)



<http://aciar.gov.au/files/mn-157/ff18.html>, accessed 14/02/14

First signs of this disease are wilting of the older leaves (picture shows early stages), then yellowing and finally death. The leaves will often have a V-shape of yellow. The whole plant may wilt and die. As with *Fusarium* wilt, there are no external markings on the stem, but if the stems of affected plants are split lengthwise, a brown discolouration of the vascular tissue is seen.

This disease is spread by contaminated soil, with the fungus entering the plant through the roots to the vascular system.

Cold weather favours the disease, which survives in the soil for long periods as sclerotia.

Yield impacts occur mainly when conditions of cool to mild temperatures and wet weather occur mid-season so plants don't have time to compensate. The disease may also be favoured by excessive use of nitrogen leading to late season growth and also by potassium deficiency.

- Fungicides **registered** for control of *Verticillium* wilt in eggplant are fumigants such as 1,3-dichloropropene + chloropicrin which has a general registration for soil borne diseases.
- There are no fungicides permitted for control of *Verticillium* wilt in eggplant.
- **Potential** fungicides for control of *Verticillium* wilt in eggplant.

Prochloraz is registered for treatment of mushrooms and carbendazim is registered for this use. The product is watered onto the soil/peat. These could be investigated for eggplant.

Note that there is no chemical that will control the disease once the plant is infected.

- **Management** options for *Verticillium* wilt in eggplant.
 - Balanced crop nutrition.
 - Avoidance of waterlogging.
 - Avoidance of late season maturation (in cooler, wet weather)
 - Crop rotation is not an easy option due to a broad crop and weed host range. Cereal and sorghum rotations are an option but this is not necessarily practical for horticultural farms.
 - Good farm hygiene.
 - Grafting of eggplant onto resistant tomato varieties (reported as an option in the USA <http://extension.psu.edu/plants/vegetable-fruit/news/2012/grafting-eggplant-for-verticillium-resistance>, accessed 14 Feb 2014)

Note that *Verticillium* wilt is a biosecurity / high priority disease of cotton and olives (Plant Health Australia, 2012).

The industry must keep abreast of and, where possible, participate in novel research into alternatives, such as bacteriophages: there is information in the literature on dramatic reductions of bacteria numbers when bacteriophage are introduced.

4.1.2 Summary

High Priority Diseases and control options

There are a range of products registered for disease control in eggplant. However, for three diseases named as high priorities there are few options. This is typical of the situation for minor crops. Industry resources are limited and the Agchem product registrants cannot justify the cost of development of products for minor crops.

| Disease | Control option |
|---|---|
| Bacterial wilt <i>(Ralstonia solanacearum)</i> | <p>Currently registered fungicides: Fumigants such as 1,3-dichloropropene + chloropicrin which has a general registration for soil borne diseases.</p> <p>Currently permitted fungicides: None</p> <p>Fungicide Gaps Alternates, preferably new, safer chemistry.</p> <p>Potential fungicide solutions Copper – registered for control of other diseases in eggplant. Mancozeb – registered for control of other diseases in eggplant.</p> <p>Non-chemical options</p> <ul style="list-style-type: none"> - Biocontrol options such as lytic bacteriophages have been suggested. - Crop rotation. - Various cultivation practices. |
| Sclerotinia rot | <p>Currently registered fungicides: None</p> <p>Currently permitted fungicides: None Phosphorous acid (various, PER11951, expires Mar 2015) – useful in rotations.</p> <p>Fungicide Gaps No fungicide options currently available.</p> <p>Potential fungicide solutions</p> <ul style="list-style-type: none"> - Boscalid (various) – Group 7 protectant and curative fungicide. Registered for Alternaria in eggplant and for Sclerotinia in other vegetables. - Penthiopyrad (FONTELIS[^]) Group 7 - Registered for Sclerotinia rot in leafy vegetables. Efficacy and residue data would be required. - Cyprodinil + fludioxonil (SWITCH[^]) - Group 9 +12 protective and systemic fungicide. Registered for Sclerotinia and other diseases in various crops. Efficacy and residue data required. <p>Non-chemical options Crop rotation. Good hygiene</p> |
| Verticillium wilt <i>(Verticillium dahlia)</i> | <p>Currently registered fungicides Fumigants such as 1,3-dichloropropene + chloropicrin which has a general registration for soil borne diseases.</p> <p>Permitted fungicides None</p> <p>Fungicide Gaps Alternates, preferably new, safer chemistry.</p> <p>Potential fungicide solutions Prochloraz and carbendazim have been suggested</p> <p>Non-chemical options</p> <ul style="list-style-type: none"> - Balanced crop nutrition. - Avoidance of waterlogging. - Avoidance of late season maturation (in cooler, wet weather). |

Currently available fungicides

| Disease Name | Active ingredient | WHP, days | Chemical group |
|---|---|------------|----------------|
| Alternaria leaf spots / early blight / target spot | boscalid | 14 | 7 |
| | clorothalonil (PER11451, expires Jun 2018) | 3(H), *(G) | M5 |
| | mancozeb | 7 | M3 |
| | metiram | 14 | M3 |
| | metiram+pyraclostrobin (AERO^) (not for greenhouse application) | 28 | 11, M3 |
| | penthiopyrad (FONTELIS^) | NR | 7 |
| | zineb | 7 | M3 |
| Anthracnose | mancozeb | 7 | M3 |
| | zineb (PER12862, expires Jul 2014) | 7 | M3 |
| Bacterial canker | copper (PER14038, expires Sep 2023) | NR | M1 |
| Bacterial spot | copper (PER14038, expires Sep 2023) | NR | M1 |
| Bactericide | iodine | NA | _ |
| Bean rust | sulphur | NR | _ |
| Downy mildew | clorothalonil (PER11451, expires Jun 2018) | 3(H), *(G) | M5 |
| | mancozeb | 7 | M3 |
| Fungi | iodine | NA | _ |
| Grey leaf spot | clorothalonil (PER11451, expires Jun 2018) | 3(H), *(G) | M5 |
| Grey mould | penthiopyrad (FONTELIS^) | NR | 7 |
| | iprodione (PER13517, expires Sep 2015) | 7 | 2 |
| | clorothalonil (PER11451, expires Jun 2018) | 3(H), *(G) | M5 |
| Late (Irish) blight | zineb | 7 | M3 |
| Phytophthora soil fungus | phosphorous acid (PER11778, expires Nov 2015) | 1 | |
| Powdery mildew | buprimate (PER14036, expires Mar 2018) | 1 | 8 |
| | hydrogen peroxide+peroxyacetic acid | 1 | M |
| | penthiopyrad (FONTELI^S) | NR | 7 |
| | sulphur | NR | _ |
| | triadimenol | 1 | 3 |
| Soil borne diseases incl Fusarium, Verticillium wilts, Rhizoctonia, Pythium | 1,3-dichloropropene + chloropicrin | _ | NR |
| Speck | copper (PER14038, expires Sep 2023) | NR | M1 |

4.2 Insects of Eggplant

| Common name | Scientific name |
|---|--|
| HIGH PRIORITY | |
| Eggfruit caterpillar | <i>Sceliodes cordalis</i> |
| Helioverpa | <i>Helicoverpa armigera</i> and <i>H. punctigera</i> |
| Whiteflies - including Silverleaf, Greenhouse. | <i>Bemisia tabaci</i> , <i>Trialeurodes vaporariorum</i> |
| Two-spotted mite | <i>Tetranychus urticae</i> |
| Western flower thrips | <i>Frankliniella occidentalis</i> |
| MODERATE PRIORITY | |
| Aphids - Green peach aphid | <i>Aphidae</i> - <i>Myzus persicae</i> |
| Cluster caterpillar | <i>Spodoptera litura</i> |
| Cutworms | <i>Agrotis</i> spp. |
| Fruit flies - Queensland fruit fly and Mediterranean fruit fly | <i>Bactrocera tryoni</i> , <i>Ceratitis capitata</i> |
| Green mirid | <i>Creontiades dilutus</i> |
| Potato moth (Leafminer) | <i>Phthorimaea operculella</i> |
| Thrips - Melon thrips & Onion thrips | <i>Thysanoptera</i> - <i>Thrips palmi</i> , <i>Thrips tabaci</i> |
| LOW PRIORITY | |
| Crickets - included Field and Mole | <i>Teleogryllus commodus</i> , <i>Gryllotalpa</i> spp. |
| Cucumber fly | <i>Bactrocera cucumis</i> |
| Grasshoppers | <i>Orthoptera</i> |
| Green vegetable bug | <i>Nezara viridula</i> |
| Leafhoppers - including Jassids | <i>Cicadellidae</i> |
| Looper caterpillars | <i>Chrysodeixis</i> spp. |
| Rutherglen bug | <i>Nysius vinitor</i> |
| Mites - including tomato russet, broad mite European red, rust | <i>Aculops lycopersici</i> , <i>Polyphagotarsonemus latus</i> , <i>Panonychus ulmi</i> , <i>Eriophyidae</i> |
| Vegetable weevil | <i>Listroderes difficilis</i> |
| 26 and 28-spotted ladybirds | <i>Henosepilachna</i> spp. |
| Biosecurity risk | |
| None listed | |

4.2.1 High priority insects

Eggfruit caterpillar (*Sceliodes cordalis*)



Eggfruit caterpillar moths have yellowish-brown patterned wings with a 25 mm wingspan. Eggs are laid mainly on the calyx, hatch in 4-5 days at 25°C. Larvae tunnel into the fruit and remain there until emerging to pupate. Eggfruit caterpillar is active all year in warm areas but has a winter diapause in cold climates. Larvae damage eggplant by feeding in the fruit, making extensive tunnels that are usually filled with their excreta.

Mature larvae leave a hole (3-4 mm diameter) as they exit the fruit to pupate. Damaged fruit will eventually break down and rot.

Cultural controls involve the removal of susceptible weeds such as thornapple and other solanaceous species and ploughing in of crop residues soon after harvest.

- Eggfruit caterpillars are considered a high-moderate problem in Qld.
 - Considered a major and sporadic pest.
 - Growers commented that insecticides generally not sprayed specifically for this pest. They are controlled with Helicoverpa sprays used.
 - Timing of spray application is critical as the larvae tunnel into fruit where they are protected. Therefore sprays need to be on the crops as larvae emerge.
- Insecticide registered for Eggfruit caterpillar control in eggplant:
 - Chlorantraniliprole (various, including CORAGEN[^]) - Group 28 contact and systemic insecticide
 - Controls all Lepidoptera.
 - Very effective.
 - IPM compatible - low impact on beneficial insects and mites.
- No insecticides are listed for eggfruit caterpillar control in eggplant via **permit**.
- Potential insecticides for control of eggfruit caterpillar in eggplant:
 - Insecticides effective against eggfruit caterpillar were identified in HAL project VG05052, Kay 2008. Spinosad, methoxyfenozide, flubendiamide and chlorantraniliprole were found to be suitable options, being selective with only low to moderate levels of impact on beneficial insects and mites.
 - The trial results were made available to the product registrants. At this time only chlorantraniliprole has the use registered.

Helicoverpa (*Helicoverpa armigera* and *Helicoverpa punctigera*)



This caterpillar varies in colour from green through yellow and brown to nearly black, with pale stripe down each side. They can grow to 40-50 mm and have hairs protruding from dark spots along the body.

The most obvious damage is caused by larvae that burrow directly into developing fruit causing holes and making them unsaleable. Smaller larvae may cause pinprick holes which can act as entry points

for disease. First stage larvae can damage flowers which decreases potential yield.

- Helicoverpa are considered a high priority problem in Qld and WA and a moderate problem in other states.
 - Parasites including Trichogramma wasps are key management tools.
 - Many soft options are available, but some are very expensive, restricting use.
 - Most insecticides used are narrow spectrum insecticides.
 - Growers would like insecticides registered on Helicoverpa registered for all Lepidoptera.
 - Insecticide resistance has made Helicoverpa difficult to control.

- Insecticides **registered** for Helicoverpa control in eggplant are:
 - Bacillus Thuringiensis (Bt) (various) - Group I16 contact insecticide
 - Btk is occasionally used.
 - Very effective on small grubs, but needs regular reapplication.
 - Minimal impact on all beneficial insects.
 - Chlorantraniliprole (various, including CORAGEN[^]) - Group 28 contact and systemic insecticide
 - Chlorantraniliprole + thiamethoxam (DURIVO[^]) - Group 28 +4A contact and systemic insecticide
 - Commonly used in some regions up to twice per crop.
 - Controls all lepidoptera.
 - Very effective.
 - IPM compatible - low impact on beneficial insects and mites.
 - Flubendiamide (BELT[^]) – Group 28 contact and systemic insecticide
 - Occasionally used in some regions.
 - Considered very effective but expensive.
 - Minimal impact on all beneficial insects.
 - Helicoverpa NPV (various) – a biological insecticide
 - Occasionally used.
 - Very effective on small grubs.
 - Minimal impact on all beneficial insects.
 - Indoxacarb (various) - Group 22A contact and systemic insecticide
 - Occasionally used in some regions.
 - Considered very effective but expensive.
 - Growers want registration for all lepidoptera.
 - Moderately harmful to some beneficial insects.
 - Methoxyfenozide (PRODIGY[^]) - Group 18 insect growth regulator
 - Field grown only (permit covers protected cropping).
 - Occasionally used in some regions.
 - Considered very effective but expensive.
 - Minimal impact on all beneficial insects.
 - Spinetoram (SUCCESS NEO[^]) - Group 5A contact and systemic insecticide
 - Commonly used in some regions.
 - Very effective on a range of pests, including thrips.
 - Moderately harmful to some beneficial insects.
 - Growers expressed concern that with a heavy reliance resistance may develop.
- Insecticides available for the control of Helioverpa in eggplant via **permit**:
 - Emamectin (various – PER13122, expires Sep 2016) – Group 6
 - For the control of Heliothis/Helicoverpa, Light brown apple moth and Cluster caterpillar.
 - Not IPM compatible.
 - Methomyl (PER13395, expires Sep 2017) – Group 1B
 - Field only.
 - Disruptive to beneficials but still used for ovacidal control.
 - Methoxyfenozide (PRODIGY[^]) - Group 18 insect growth regulator (PER12391, expires Sep 2017)
 - Protected crops
- Potential insecticides for the control of Helioverpa in eggplant:
 - Cyantraniliprole (BENEVIA[^]) – Group 28 contact and systemic insecticide
 - Registered in cotton for control of sucking insects – silverleaf whitefly, cotton aphid (suppression only) and for chewing insects – Helicoverpa.
 - Product being assessed at the APVMA. Residues studies, primarily from overseas, have been submitted for cucurbits, lettuce, peppers, tomatoes, melons, blueberries, pome and stone fruit, potatoes, beans, citrus, almonds, pecans, onion, leafy vegetables, brassica vegetables.
 - This is from the same group as Chlorantraniliprole so may have limited use for alternation.

- The initial target Australian use pattern is not known.
 - Dupont should be approached for consideration of minor crops in its development program.
 - IR4 projects for various crops/thrips, beetles, leafminer, psyllids, whitefly.
 - Similar comments to DURIVO with regard to resistance.
- Metaflumizone (New BASF active) - Group 22B
 - Activity against Lepidoptera, Coleoptera, Hemiptera, Hymenoptera, Isoptera, and Diptera.
 - At this stage an active ingredient approval is in review at the APVMA.
 - BASF could be approached for consideration of minor use crops in its development program. The Australian target use pattern is not known.
- Novaluron - Group 15. Farnoz and United Phosphorous have approvals of this active
 - The status of development of an end use product is unknown.
 - The active is the subject of IR4 project work: cabbage / diamondback moth, cabbage looper, Lepidoptera; cauliflower / lepidoptera

Whiteflies: Silverleaf (*Bemisia tabaci*), Greenhouse (*Trialeurodes vaporariorum*)



Silverleaf whitefly was first detected in Australia in 1994. Adults are approximately 1 mm long and are a narrow white wedge-shaped insect. When an infested plant is disturbed the whiteflies can be seen to flutter out and rapidly resettle.

Adults feed and lay their eggs on the undersides of young leaves and a female can lay up to 160 eggs during a 60 day lifespan. The eggs turn from white to brown as they get close to hatching.

Whiteflies damage eggplants by sucking enormous quantities of sap and covering plants with sticky honeydew. Black sooty mould grows over the honeydew.

Beneficial insects, play a very important role in the control of whitefly. Therefore any insecticide used in eggplant, needs to be compatible with these beneficial insects.

- Whiteflies are considered a major-moderate problem in NSW and Qld. Not a problem elsewhere.
 - Whitefly numbers can vary, but can be heavy.
 - Growers want new insecticides compatible with IPM strategies.
 - Growers commented that silverleaf whitefly are more difficult to kill than greenhouse whitefly. Growers report that some products are suffering from resistance issues.
- Insecticides **registered** for the control of whitefly in eggplant are:
 - Chlorantraniliprole + thiamethoxam (DURIVO[^]) - Group 4A/28 contact and systemic insecticide
 - Commonly used as a seedling drench or soil drench for control of aphids, lepidoptera, thrips and whitefly.
 - Adds significantly to the cost of seedlings from nurseries.
 - This product could be overused which may lead to resistance developing.
 - Very effective treatment method.
 - Harmful to many beneficial, particularly as it is a residual.
 - Imidacloprid (various) - Group 4A contact / systemic insecticide.
 - Silverleaf whitefly only.
 - Almost always used as a seedling drench or soil drench.
 - Adds significantly to the cost of seedlings from nurseries.
 - Very effective treatment method.
 - There are reports that it is overused and resistance is developing.
 - Harmful to many beneficial, particularly as it is a residual.
 - Emulsifiable botanical oil (various) - contact insecticide.
 - Greenhouse whitefly only.
 - Occasionally used - only when needed.

- Paraffinic oil (various) – contact insecticide
 - Silverleaf whitefly only.
 - Occasionally used, considered very effective.
 - Issues in hot/humid weather - phyto.
 - Also controls other pests.
 - Moderately harmful to some beneficial insects.
- Potassium salts (various) – contact biological insecticide
 - Occasionally used.
 - Very effective. Also controls some other pests.
 - Minimal impact on all beneficial insects.
- Pyrethrins+piperonyl butoxide (various) – Group 3A contact insecticide
 - Good knockdown.
 - Harmful to beneficials.
- Spirotetramat (MOVENTO[^]) – Group 23 contact and systemic insecticide
 - Occasionally used.
 - Varying reports of efficacy.
 - Moderately harmful to some beneficial insects.
- Insecticides listed for the control of whitefly in eggplant via **permit** are:
 - Bifenthrin (various, PER12947) - Group 3A contact / systemic insecticide
 - Occasionally used.
 - Mixed reports on efficacy. Also controls some mites.
 - Growers expressed concern that with a heavy reliance resistance may develop.
 - Harmful to many beneficial insects.
 - Expires 30-Apr-15. No manufacturer interest in registration.
 - Petroleum oil (various, PER12221, expires Nov 2017) – contact insecticide
 - Occasionally used.
 - Considered very effective.
 - Issues in hot/humid weather - phytotoxicity.
 - Also controls other pests.
 - Moderately harmful to some beneficial insects.
 - Pymetrozine (various, PER13111, expires May 2014) – Group 9B contact and systemic insecticide.
 - Occasionally used.
 - Mixed reports of efficacy.
 - Moderately harmful to some beneficial insects.
- **Potential** insecticides listed for the control of whitefly in eggplant:
Residue and efficacy data required. In some cases local and overseas data may be available.
 - Buprofezin (various) - Group 16 contact / systemic insecticide.
 - There is a whitefly / celery permit.
 - Cyantraniliprole (BENEVIA[^]) – Group 28 contact and systemic insecticide
 - Registered in cotton for control of sucking insects – silverleaf whitefly, cotton aphid (suppression only) and for chewing insects – Helicoverpa
 - Product being assessed at the APVMA. Residues studies, primarily from overseas, have been submitted for cucurbits, lettuce, peppers, tomatoes, melons, blueberries, pome and stone fruit, potatoes, beans, citrus, almonds, pecans, onion, leafy vegetables, brassica vegetables.
 - This is from the same group as Chlorantraniliprole so may have limited use for alternation.
 - The initial target Australian use pattern is not known
 - Dupont should be approached for consideration of minor crops in its development program
 - IR4 projects for various crops/thrips, beetles, leafminer, psyllids, whitefly
 - Flonicamid (new ISK/FMC product)– Group 9C
 - First registration application in assessment at APVMA.
 - IR4 project on peppers and eggplant / aphids, whiteflies, plant bugs, thrips

- Overseas registrations on aphids / brassica vegetables, root vegetables, tuberous and corn vegetables, cucurbit vegetables, hops, leafy vegetables, fruiting vegetables, pome fruit and stone fruit
- Metaflumizone (New BASF active) - Group 22B
 - Activity against Lepidoptera, Coleoptera, Hemiptera, Hymenoptera, Isoptera, and Diptera.
 - At this stage an active ingredient approval is in review at the APVMA.
 - BASF could be approached for consideration of minor use crops in its development program. The Australian target use pattern is not known.
- Novaluron - Group 15. Farmoz and United Phosphorous have approvals of this active. The status of development of an end use product is unknown. The active is the subject of IR4 project work: cucumber / whitefly. Efficacy and residue work would be required.
- Pyriproxyfen (various) - Group 7C contact / systemic insecticide.
 - There was a permit for this use, it was hoped Sumitomo would register the use.
 - Very effective. Also controls other pests.
 - Low harm to most beneficials.

Two-spotted mite (*Tetranychus urticae*)



Mites generally overwinter as adult females in protected places in the litter, trash, and weeds on the crop floor. The mites become active in early spring. Mites generally favour hot, dry conditions, and as the weather becomes warmer, they increase in numbers and move through the plant until the entire plant is infested. Their feeding causes leaf desiccation, leaf drop, disruption of fruit set, fruit deformation and yield loss. Mites are frequent pest of foliage, flowers and fruit.

- Two-spotted mites are considered a major pest of Vic and NSW, minor and infrequent pest of Qld, minor pest in other states.
 - Infestations are often patchy.
- Insecticides **registered** for the control of mites in eggplant are:
 - Abamectin (various) - Group 6 contact/systemic insecticide
 - Commonly used in Vic, SA, NSW and Qld.
 - Considered very effective, also controls western flower thrips (WA).
 - Moderately harmful to some beneficial insects.
 - Potassium salts of fatty acids (various) – contact biological insecticide
 - Occasionally used.
 - Effective.
 - Minimal impact on all beneficial insects.
 - Propargite (various) – Group 12 C
 - No comment from growers.
 - 21 day re-entry period is restrictive.
 - Sulphur (various) – insecticide
 - High selectivity.
 - Only short term impact on beneficials.
- Insecticides available for the control of mites in eggplant via **permit** are:
 - Bifenazate (PER12906, expires Mar 2018)
 - Selective.
 - Short term impact on beneficials.
 - Bifenthrin (various, PER12947, expires Apr 2015) - Group 3A contact and systemic insecticide
 - Occasionally used in some regions. Also controls whitefly.
 - Can be effective but there is resistance in many areas.
 - Moderately harmful to harmful to many beneficial insects.

- Phorate (various, PER8930, expires Jul 2016) - Group 1B contact and systemic insecticide
 - Permit in eggplant for mites. Controls many pests.
 - Rarely used in some regions.
 - Very effective.
 - Moderately harmful to harmful to many beneficial insects.

NOTE: In most regions miticides are applied 1-2 times per season. Growers alternate between insecticides to minimise the resistance risk.

Western flower thrips (*Frankliniella occidentalis*)



The adults are tiny insects, generally measuring only 1 to 2 mm in length. They have thin bodies and vary in colour from near black to straw coloured.

While thrips can cause direct damage to foliage and fruit, their role as vectors of tomato spotted wilt is of primary concern, especially in tomato and eggplant. They are weak fliers but are capable of infesting large areas of crop as they are easily blown by wind.

They cause most damage by discolouring, scaring and deforming leaves and fruit as they feed. WFT can cause damage to fruit at all stages of maturity. They are fast breeders when the weather is warm but not too hot and are capable of producing 12-15 generations per year with optimal conditions. Females live for up to 90 days and are capable of reproducing after approx 15-20 days.

- Western flower thrips are considered a major-moderate problem Vic, NSW and WA and a moderate problem in Queensland.
 - All insecticides used in alternation (3 spray strategy) due to rapid resistance development to many commonly used insecticides.
 - Potential for increase in incidence due to limited insecticides.
 - WFT develop resistance more easily than other thrips species.
 - Growers need several new 'soft' options and biological control.
- Insecticides **registered** for the control of Western flower thrips in eggplant are:
 - Abamectin (various) - Group 6 contact and systemic insecticide
 - Commonly used in Vic, SA, NSW and Qld.
 - Considered very effective, also controls mites.
 - Growers expressed concern that with heavy reliance resistance may develop.
 - Moderately harmful to harmful to many beneficial insects.
 - Chlorantraniliprole + thiamethoxam + (DURIVO) - Group 4A + 28 contact and systemic insecticide
 - Fairly new entrant to the market.
 - Effective but moderately harmful to some beneficial insects.
 - Potassium salts of fatty acids (various) – contact biological insecticide
 - Permit for use in greenhouse cucumber only.
 - Greenhouse and silverleaf whitefly.
 - Occasionally used.
 - Reported as effective, but only offers short term control.
 - Minimal impact on most beneficial insects.
 - Pyrethrins+piperonyl butoxide (various) – Group 3A contact insecticide
 - Good knockdown.
 - Harmful to beneficials.
 - Spinetoram (SUCCESS NEO[^]) - Group 5A contact and systemic insecticide
 - Commonly used in some regions.
 - Can be very effective but resistant for WFT in many parts of Australia.
 - Used for a range of pests, including heliothis.
 - Moderately harmful to some beneficial insects.
 - Growers expressed concern that with heavy reliance resistance may develop.
 - Used for Lepidoptera and WFT.

- Spirotetramat (MOVENTO[^]) – Group 23 contact and systemic
 - Occasionally used.
 - Very effective.
 - Reported as expensive.
 - Also controls other pests.
 - Moderately harmful to some beneficial insects.
- Thiamethoxam + chlorantraniliprole (DURIVO[^]) - Group 4A/28 contact and systemic insecticide
 - Commonly used as a seedling drench or soil drench for aphid control - also controls lepidoptera, whitefly and thrips.
 - Adds significantly to the cost of seedlings from nurseries.
 - Growers expressed concern that with a heavy reliance resistance may develop.
 - Very effective treatment method.
 - Moderately harmful to some beneficial insects
- Insecticides listed for control of Western flower thrips in eggplant via **permit** are:
 - Phorate (various, PER8930, expires Jul 2016) - Group 1B contact/systemic insecticide
 - 10 week WHP.
 - Rarely used.
 - Very effective.
 - Moderately harmful to harmful to many beneficial insects.
 - Spinetoram (SUCCESS NEO[^], PER14186, expires Sep 2018) - Group 5A contact and systemic insecticide
 - Commonly used in some regions.
 - Can be very effective but resistant for WFT in many parts of Australia.
 - Used for a range of pests, including heliothis.
 - Moderately harmful to some beneficial insects.
- **Potential** insecticides for control of Western flower thrips in eggplant:
 - Cyantraniliprole (BENEVIA[^]) – Group 28 contact and systemic insecticide
 - Registered in cotton for control of sucking insects – silverleaf whitefly, cotton aphid (suppression only) and for chewing insects – Helicoverpa.
 - Product being assessed at the APVMA. Residues studies, primarily from overseas, have been submitted for cucurbits, lettuce, peppers, tomatoes, melons, blueberries, pome and stone fruit, potatoes, beans, citrus, almonds, pecans, onion, leafy vegetables, brassica vegetables.
 - This is from the same group as Chlorantraniliprole so may have limited use for alternation.
 - The initial target Australian use pattern is not known.
 - Dupont should be approached for consideration of minor crops in its development program.
 - IR4 projects for various crops/thrips, beetles, leafminer, psyllids, whitefly.
 - Flonicamid (new ISK/FMC product)– Group 9C
 - First registration application in assessment at APVMA. Likely first registration on cucurbits.e
 - IR4 project on peppers and eggplant / aphids, whiteflies, plant bugs, thrips.
 - Overseas registrations on aphids / brassica vegetables, root vegetables, tuberous and corn vegetables, cucurbit vegetables, hops, leafy vegetables, fruiting vegetables, pome fruit and stone fruit.

4.2.2 Summary

High Priority Insects and control options

| Insect | Control option |
|---|--|
| Eggfruit caterpillar <i>(Sceliodes cordalis)</i> | <p>Currently registered insecticides Chlorantraniliprole (various, including CORAGEN[^]) - Group 28 – good efficacy and IPM compatibility</p> <p>Currently permitted insecticides None</p> <p>Insecticide Gaps Alternates with good IPM fit.</p> <p>Potential insecticide solutions Spinosad, methoxyfenozide, flubendiamide – selective, low to moderate levels of impact on beneficial insects and mites.</p> <p>Non-chemical options IPM practices</p> |
| Helicoverpa <i>Helicoverpa</i> spp. | <p>Currently registered insecticides</p> <ul style="list-style-type: none"> - Bacillus Thuringiensis (Bt) (various) - effective, IPM compatible. - Chlorantraniliprole (various, including CORAGEN[^]) - effective, IPM compatible. - Chlorantraniliprole + thiamethoxam (DURIVO[^]) - Group 28 +4A - effective, IPM compatible. - Flubendiamide (BELT[^]) - IPM fit. - Helicoverpa NPV (various) - effective on small grubs, IPM compatible. - Indoxacarb (various) - Group 22A – moderate harm to beneficials, growers want label extended to all Lepidoptera - Spinetoram (SUCCESS NEO[^]) - effective, common use, resistance issues. <p>Currently permitted insecticides</p> <ul style="list-style-type: none"> - Emamectin (various – PER13122) – Group 6 – not IPM compatible - Methomyl (PER13395) – Group 1B – field only, IPM disruptive but still used - Methoxyfenozide (PRODIGY[^]) - Group 18 good efficacy and IPM fit. <p>Insecticide Gaps Gaps closed somewhat in recent years with registration of new chemicals.</p> <p>Potential insecticide solutions Cyantraniliprole (BENEVIA[^]) – Group 28 – first registration in assessment at APVMA. Metaflumizone (New BASF active).- Group 22B – in development Novaluron - Group 15. Farmoz and United Phosphorous have approvals of this active.</p> <p>Non-chemical options IPM strategies to manage resistance. Parasites including Trichogramma wasps.</p> |
| Whiteflies: Silverleaf <i>(Bemisia tabaci)</i> , greenhouse <i>(Trialeurodes vaporariorum)</i> | <p>Currently registered insecticides</p> <ul style="list-style-type: none"> - Chlorantraniliprole + thiamethoxam (DURIVO[^]) - Group 4A/28 – good efficacy, care needed to prevent resistance - Imidacloprid (various) - Group 4A - very effective but moderately harmful to harmful to many beneficial insects. - Emulsifiable botanical oil – occasional use - Paraffinic oil / petroleum oil (various) – efficacious but moderately harmful to beneficials. - Potassium salts of fatty acids (various) - Potassium salts of fatty acids (various) – minimal impact on beneficials. - Pyrethrins+piperonyl butoxide |

| Insect | Control option |
|---|---|
| | <ul style="list-style-type: none"> - Spirotetramat (MOVENTO[^]) – Group 23 – use increasing, moderately harmful to some beneficial insects. <p>Currently permitted insecticides</p> <ul style="list-style-type: none"> - Bifenthrin (various, PER12947, expires Apr 2015) - Group 3A - Silverleaf whitefly, protected only. - Petroleum oil (various, PER12221, Expires Nov 2017) - offers short term suppression. - Pymetrozine (various, PER13111, expires May 2014) – Group 9B - very effective. <p>Insecticide Gaps Resistance in old chemistry, good alternation needed to minimise resistance in newer products.</p> <p>Potential insecticide solutions</p> <ul style="list-style-type: none"> - Buprofezin (various) - Group 16 - there is a whitefly / celery permit. - Cyantraniliprole (BENEVIA[^], not yet registered) – Group 28 – new product in assessment at APVMA. Same chemical group as Chlorantraniliprole. IR4 projects for various crops/thrips, beetles, leafminer, psyllids, whitefly. - Flonicamid (new ISK/FMC product)– Group 9C. First registration application in assessment at APVMA. IR4 project on peppers and eggplant / aphids, whiteflies, plant bugs, thrips. - Metaflumizone (New BASF active, not yet registered) - Group 22B - activity against Lepidoptera, Coleoptera, Hemiptera, Hymenoptera, Isoptera, and Diptera. - Novaluron - Group 15. Active approved but product not yet registered. IR4 project work: cucumber / whitefly. Efficacy and residue work would be required. - Pyriproxyfen (various) - Group 7C contact / systemic insecticide. Expired permit, growers would like to continue use, low harm to most beneficials. <p>Non-chemical options IPM strategies – required to manage resistance.</p> |
| Two-spotted mite (<i>Tetranychus urticae</i>) | <p>Currently registered insecticides</p> <ul style="list-style-type: none"> - Abamectin (various) - Group 6 – efficacious, moderately harmful to some beneficials. - Potassium salts of fatty acids (various) – efficacious, minimal impact on all beneficials. - Propargite (various) – Group 12 C - no comment from growers, 21 day re-entry. - Sulphur (various) – selective, no information on use. <p>Currently permitted insecticides</p> <ul style="list-style-type: none"> - Bifenazate (PER12906, expires Mar 2018). - Bifenthrin (various, PER12947, expires Apr 2015) - can be effective but there is resistance in many areas. moderately harmful to some beneficials. - Phorate (various, PER8930, expires Jul 2016) - Group 1B – efficacious but moderately harmful to harmful to many beneficial insects. <p>Insecticide Gaps Good alternation needed as mites quickly develop resistance to chemicals.</p> <p>Potential insecticide solutions None identified.</p> <p>Non-chemical options IPM strategies – required to manage resistance.</p> |

| Insect | Control option |
|---|---|
| Western flower thrips (<i>Frankliniella occidentalis</i>) | <p>Currently registered insecticides</p> <ul style="list-style-type: none"> - Abamectin (various) - Group 6 – efficacious, moderately harmful to beneficials. - Chlorantraniliprole + thiamethoxam + (DURIVO) - Group 4A + 28 – efficacious, moderately harmful to some beneficials. - Potassium salts of fatty acids (various) –effective, minimal impact on most beneficial. - Pyrethrins+piperonyl butoxide (various) – Group 3A - good knockdown, harmful to beneficials. - Spinetoram (SUCCESS NEO[^]) - Group 5A - can be very effective but resistant for WFT in many parts of Australia. - Spirotetramat (MOVENTO[^]) – Group 23 – good efficacy, moderately harmful to some beneficials. - Thiamethoxam + chlorantraniliprole (DURIVO[^]) - Group 4A/28 good efficacy, moderately harmful to some beneficials. <p>Currently permitted insecticides</p> <ul style="list-style-type: none"> - Phorate (various, PER8930, expires Jul 2016) - Group 1B – 10 wk WHP. <p>Insecticide Gaps Soft alternatives, more alternatives.</p> <p>Potential insecticide solutions</p> <ul style="list-style-type: none"> - Cyantraniliprole (BENEVIA[^], not yet registered) – Group 28 – new product in assessment at APVMA. Same chemical group as Chlorantraniliprole. IR4 projects for various crops/thrips, beetles, leafminer, psyllids, whitefly. - Flonicamid (new ISK/FMC product)– Group 9C. First registration application in assessment at APVMA. IR4 project on peppers and eggplant / aphids, whiteflies, plant bugs, thrips. <p>Non-chemical options IPM strategies.</p> |

Currently available insecticides

| Insect name | Active ingredient | WHP | Chemical group |
|--------------------------|--|-------------|----------------|
| Aphids | methidathion | 7 | 1B |
| | phorate (PER8930, expires Jul 2016) | 70 | 1B |
| | pirimicarb (PER13351, expires Mar 2016) | 2 | 1A |
| | potassium salts of fatty acids | NR | – |
| | pyrethrins+piperonyl butoxide | 1 | 3A |
| Aphid - brown sowthistle | chlorantraniliprole + thiamethoxam (DURIVO) | NR | 4A, 28 |
| Aphid - green peach | chlorantraniliprole + thiamethoxam (DURIVO) | NA | 4A, 28 |
| | imidacloprid | 7 | 4A |
| | spirotetramat | 1 | 23 |
| Armyworm | Bacillus thuringiensis kurstaki | NR | 11C |
| Australian plague locust | carbaryl, chlorpyrifos, diazinon, maldison | SL | 1A/1B |
| Black fungus gnats | Bacillus thuringiensis kurstaki | NA | 11 |
| Cabbage moth | Bacillus thuringiensis kurstaki | NR | 11C |
| Cabbage white butterfly | Bacillus thuringiensis kurstaki | NR | 11C |
| | methomyl (PER13395, expires Sep 2017) | 3 | 1B |
| | methoxyfenozide (PER12391, expires Sep 2017) | NR(H), *(G) | 18 |
| | chlorantraniliprole + thiamethoxam (DURIVO) | NR | 4A, 28 |
| Caterpillars | pyrethrins+piperonyl butoxide | 1 | 3A |

| Insect name | Active ingredient | WHP | Chemical group |
|---|--|----------------|----------------|
| Cluster caterpillar | methomyl (PER13395) | 3 | 1B |
| | methoxyfenozide (PER12391) | — | |
| Crickets | chlorpyrifos | NA | 1B |
| Cucumber moth | chlorantraniliprole (CORAGEN) | (H), 7(G) | 28 |
| | methomyl (PER13395, expires Sep 2017) | 3 | 1B |
| Cutworms | chlorpyrifos | NS | 1B |
| | diazinon | 14 | 1B |
| | trichlorfon | 2 | 1B |
| Eggfruit caterpillar | chlorantraniliprole (CORAGEN^) | (H), 7(G) | 28 |
| Fruit flies | fenthion | 7 | 1B |
| | trichlorfon (PER12442, expires May 2014) | 2 | 1B |
| Fungus gnats | Bacillus thuringiensis israelensis (PER11472, expires May 2014) | NR | 11 |
| Green mired | petroleum oil (PER12221, expires Nov 2017) | 1 | — |
| Green vegetable bug | trichlorfon | 2 | 1B |
| Grey cluster bug | petroleum oil (PER12221, expires Nov 2017) | 1 | — |
| Helicoverpa | flubendiamide (BELT) | 28 | 28 |
| | emamectin (PER13122, expires Sep 2016) | 3 | 6 |
| | methomyl (PER13395, expires Sep 2017) | 3 | 1B |
| <i>Helicoverpa armigera</i> (corn / cotton bollworm) | Bacillus thuringiensis kurstaki | NR | 11C |
| | chlorantraniliprole (CORAGEN) | (H), 7(G) | 28 |
| | chlorantraniliprole + thiamethoxam (DURIVO) | NR | 4A, 28 |
| | Helicoverpa NPV | NA | — |
| | indoxacarb | 3 | 22A |
| <i>Helicoverpa punctigera</i> (Native budworm) | methoxyfenozide (Label -field crops), (PER12391, expires Sep 2017) (protected crops) | NR(H), *(G) | 18 |
| | Bacillus thuringiensis kurstaki | NR | 11C |
| | chlorantraniliprole | 3 | 28 |
| | chlorantraniliprole (CORAGEN) | (H), 7(G) | 28 |
| | chlorantraniliprole + thiamethoxam (DURIVO) | NR | 4A, 28 |
| | Emamectin (PER13122, expires Sep 2016) | 3 | 6 |
| | flubendiamide (BELT) | 1 | 28 |
| | Helicoverpa NPV | NA | — |
| | indoxacarb | 3 | 22A |
| | methoxyfenozide (PRODIGY) | NR | 18 |
| Spinetoram (SUCCESS NEO^) | 1 | 5 | |
| Jassids | phorate (PER8930, expires Jul 2016) | 70 | 1B |
| Leafhoppers | methidathion | 7 | 1B |
| | pyrethrins+piperonyl butoxide | 1 | 3A |
| Lightbrown apple moth | Bacillus thuringiensis kurstaki | NR | 11C |
| Loopers | chlorantraniliprole + thiamethoxam (DURIVO) | NR | 4A, 28 |
| | Bacillus thuringiensis kurstaki | NR | 11C |
| | methidathion | 7 | 1B |
| Lucern leafroller | chlorantraniliprole + thiamethoxam (DURIVO) | NR | 4A, 28 |
| Mealybug | potassium salts of fatty acids | NR | — |
| Melon thrips | imidacloprid | 7 | 4A |
| | Spinetoram (SUCCESS NEO^) (PER14186, expires Sep 2018) | 1 | 5 |
| Mites | phorate (PER8930, expires Jul 2016) | 70 | 1B |
| Mite - blue oat | bifenthrin (PER12947, expires Apr 2015) | 1(H), 28(G) | 3A |
| Mite - redlegged earth mite | bifenthrin (PER12947, expires Apr 2015) | 1 | 3A |
| Mite – tomato russet | abamectin | 3 | 6 |

| Insect name | Active ingredient | WHP | Chemical group |
|---|---|-------------|----------------|
| Mite – two spotted (red spider) | bifenazate (PER12906, expires Mar 2018) | 1(H), *(G) | UN |
| | potassium salts of fatty acids | NR | – |
| | propargite (21 day re-entry) | 7 | 12C |
| | sulphur | NR | – |
| Potato moth / tomato leaf miner | Chlorantraniliprole (CORAGEN) | 3 (H), 7(G) | 28 |
| | chlorantraniliprole + thiamethoxam (DURIVO) | NR | 4A, 28 |
| | flubendiamide (BELT) | 1 | 28 |
| | indoxacarb | 3 | 22A |
| | Spinetoram (SUCCESS NEO^) | 1 | 5 |
| Rutherglen bug | methidathion (field) (PER14047, expires Jun 2018) | 7 | 1B |
| | petroleum oil (PER12221, expires Nov 2017) | 1 | – |
| | trichlorfon | 2 | 1B |
| Symphylans (garden centipedes) | 1,3-dichloropropene + chloropicrin | NR | 8B |
| Thrips | phorate (PER8930, expires Jul 2016) | 70 | 1B |
| | potassium salts of fatty acids | NR | – |
| | pyrethrins+piperonyl butoxide | 1 | 3A |
| Thrips - tomato | chlorantraniliprole + thiamethoxam (DURIVO) | NR | 4A, 28 |
| Thrips - WFT | abamectin | 3 | 6 |
| | chlorantraniliprole + thiamethoxam (DURIVO) | NR | 4A, 28 |
| | spinetoram | 1 | 5 |
| | spirotetramat (MOVENTO) | 1 | 23 |
| Thrips - melon | spinetoram (PER14186, expires Sep 2018) | 1 | 5 |
| Tomato grub | methoxyfenozide (PER12391, expires Sep 2017) | NR(H), *(G) | 18 |
| Vegetable leafhopper | chlorantraniliprole + thiamethoxam (DURIVO) | NR | 4A, 28 |
| Vegetable weevil | chlorpyrifos | NS | 1B |
| Vine moth | Bacillus thuringiensis kurstaki | NR | 11C |
| Whitefly - greenhouse, Bemisia tabaci species (Sweet potato, silverleaf B biotype and whitefly Q biotype) | petroleum (PER12221, expires Nov 2017) | 1 | – |
| | potassium salts of fatty acids | NR | – |
| | pyrethrins+piperonyl butoxide | 1 | 3A |
| Whitefly - greenhouse, silverleaf | chlorantraniliprole + thiamethoxam (DURIVO) | NR | 4A, 28 |
| Whitefly - greenhouse | emulsifiable botanical oil | NR | – |
| Whitefly - silverleaf | bifenthrin (PER12947, expires Apr 2015) | 1 | 3A |
| | imidacloprid | NA | 4A |
| | paraffinic oil | NR | – |
| | pymetrozine (PER13111, expires May 2014) | 3 | 9B |
| | spirotetramat | 1 | 23 |
| Wingless grasshopper | chlorpyrifos | NS | 1B |
| Wireworms | 1,3-dichloropropene + chloropicrin | NR | 8B |

(H)=Harvest

(G)= Grazing

NR= not required

*= do not graze or cut for stockfood

4.3 Herbicide use in eggplant

- Herbicides **registered** for use in eggplant are:
 - Glyphosate (various) – Group M pre-plant general knockdown herbicide
 - Commonly used.
 - Works well as a pre-crop spray.
 - Paraquat + diquat (various) - Group L pre-plant general knockdown herbicide
 - Occasionally used.
 - Works well as a pre-crop spray
- Herbicides listed for control of weeds in eggplant via **permit** are:
 - Clethodim (various, PER113307, expires Dec 2016) – Group A grass selective post-emergent herbicide
 - Commonly used.
 - Considered very effective.
 - It is used to spot spray grass weeds such as couch grass post-emergent. Some growers report that it does not control resistant ryegrass.
 - Controls most grass weeds.
 - Reported to control Winter grass.
 - Fusilade™ (fluazifop-p – PER 13394, expires Sep 2015) – Group A grass selective post emergent herbicide.
 - Good efficacy
 - 28 day WHP
 - Trifluralin (various, PER12823, expires Jun 2021) - Group D residual pre-emergent herbicide.
 - Occasionally used pre-planting (also under plastic mulch) to control annual broadleaf weeds.
 - Considered very effective.
 - Controls many weeds.
 - Permit expires 30-Jun-21. No manufacturer support for registering use.

High priority weeds and control options

Overall there is a need for newer chemistry and increased options for control of weeds in beetroot. Non-chemical options should be considered in future SARPs.

Growers generally use a pre-plant weed control (general knockdown herbicides) to prepare the paddock. Growers then either alternate the herbicides used or use them in combination for effective weed control. Other than trifluralin (permit) all the herbicides registered are either pre-emergent knockdown herbicides or grass selective post-emergent herbicides.

Most weeds can be controlled with currently available herbicides.

- Weeds identified as a high priority for control are:

| Weed (common name) | Weed (scientific name) | Herbicides available for control |
|---------------------------|-------------------------------|---|
| Blackberry nightshade | <i>Solanum nigrum</i> | Trifluralin |
| Pigweeds | <i>Portulaca spp.</i> | Trifluralin |
| Marshmallow | <i>Malva parviflora</i> | Glyphosate, paraquat + diquat |

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Images:

- Google images
- Infopest, Department of Primary Industries and Fisheries, Queensland Government, July 2012.

Acronyms

| | |
|-----------------|--|
| APVMA | Australian Pesticides and Veterinary Medicines Authority |
| DPI | Department of Primary Industries |
| HAL | Horticulture Australia Ltd |
| IPM | Integrated pest management |
| IR-4 | Interregional Research Program 4 (USA) |
| MRL | Maximum residue limit (mg/kg or ppm) |
| Plant pests .. | Diseases, insects, nematodes, viruses, weeds, etc |
| PMS | Pest Management Strategy |
| Pesticides | Plant protection products (fungicide, insecticide, herbicide, nematicides, etc). |
| SARP | Strategic Agrichemical Review Process |
| WFT | Western flower thrips |
| WHP | Withholding period |

Australian states and territories: NSW (New South Wales), NT (Northern Territory), Qld (Queensland), SA (South Australia), Tas (Tasmania), Vic (Victoria), WA (Western Australia)

Acknowledgement

APVMA: All staff especially Alan Norden

Government agencies: Each state DPI as excellent sources of information

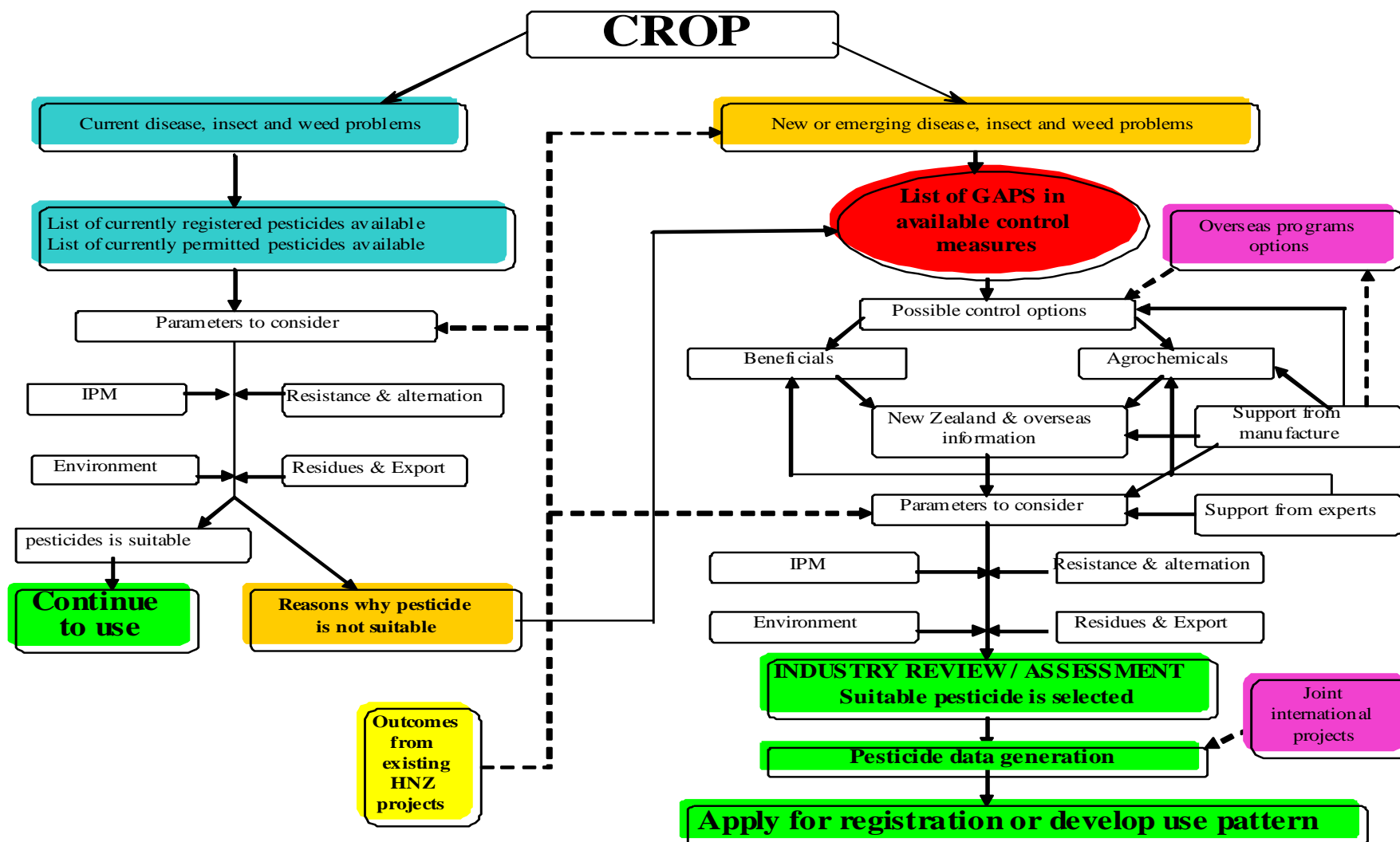
Industry development officers and associates

Thanks go to the many industry people who contributed information and collaborated on the review of this report.

^Trademark

6. Appendices

DIAGRAM 1: The Strategic Agrichemical Review Process



Appendix 2 – currently available fungicides in eggplant.

| Active ingredient | Disease Name | WHP, days | Chemical group |
|--|---|------------|----------------|
| 1,3-dichloropropene + chloropicrin | Soil borne diseases incl Fusarium, Verticillium wilts, Rhizoctonia, Pythium | – | NR |
| boscalid | Early blight (Target spot) | 14 | 7 |
| bupirimate (PER14036, expires Mar 2018) | Powdery mildew | 1 | 8 |
| clorothalonil (PER11451, expires Jun 2018) | Alternaria | 3(H), *(G) | M5 |
| | Downy mildew | 3(H), *(G) | M5 |
| | Grey leaf spot | 3(H), *(G) | M5 |
| | Grey mould | 3(H), *(G) | M5 |
| copper (PER14038, expires Sep 2023) | Bacterial spot | NR | M1 |
| | Canker | NR | M1 |
| | Speck | NR | M1 |
| hydrogen peroxide+peroxyacetic acid | Powdery mildew | 1 | M |
| iodine | Bactericide | NA | – |
| | Fungi | NA | – |
| iprodione (PER13517, expires Sep 2015) | Grey mould | 7 | 2 |
| mancozeb | Alternaria leaf spots / early blight / target spot | 7 | M3 |
| | Anthracoze | 7 | M3 |
| | Downy mildew | 7 | M3 |
| metiram | Alternaria leaf spots / early blight / target spot | 14 | M3 |
| metiram+pyraclostrobin (AERO) (not greenhouse) | Alternaria leaf spots / early blight / target spot | 28 | 11, M3 |
| penthiopyrad (FONTELIS) | Alternaria leaf spots / early blight / target spot | NR | 7 |
| | Grey mould | NR | 7 |
| | Powdery mildew | NR | 7 |
| Phosphorous acid (PER11778, expires Nov 2015) | Phytophthora soil fungus | 1 | |
| sulphur | Bean rust | NR | – |
| | Powdery mildew | NR | – |
| triadimenol | Powdery mildew | 1 | 3 |
| zineb | Early blight (Target spot) | 7 | M3 |
| | Late (Irish) blight | 7 | M3 |
| zineb (PER12862, expires Jul 2014) | Anthracoze | 7 | M3 |

Appendix 3 – currently available insecticides in eggplant.

| Active ingredient | Insect name | WHP | Chemical group |
|---|---|-------------|----------------|
| 1,3-dichloropropene + chloropicrin | Symphylans (garden centipedes) | NR | 8B |
| | Wireworms | | |
| abamectin | Mite – tomato russet | 3 | 6 |
| | Thrips - WFT | | |
| Bacillus thuringiensis israelensis (PER11472, expires May 2014) | Fungus gnats | NR | 11 |
| Bacillus thuringiensis kurstaki | Armyworm | NR | 11C |
| | Black fungus gnats | | |
| | Cabbage moth | | |
| | Cabbage white butterfly | | |
| | <i>Helicoverpa armigera</i> (Corn / cotton bollworm) | | |
| | <i>Helicoverpa punctigera</i> (Native budworm) | | |
| | Lightbrown apple moth | | |
| | Loopers | | |
| bifenazate (PER12906, expires Mar 2018) | Vine moth | 1(H), *(G) | UN |
| | Mites - two-spotted | | |
| bifenthrin (PER12947, expires Apr 2015) | Mite - blue oat | 1(H), 28(G) | 3A |
| | Mite - redlegged earth mite | | |
| | Whitefly - silverleaf | | |
| carbaryl, chlorpyrifos, diazinon, maldison | Australian plague locust | SL | 1A/1B |
| chlorantraniliprole (CORAGEN) | Cucumber moth (<i>Diaphania indica</i>) | (H), 7(G) | 28 |
| | Eggfruit caterpillar | | |
| | <i>Helicoverpa armigera</i> (Corn / cotton bollworm) | | |
| | <i>Helicoverpa punctigera</i> (Native budworm) | | |
| | Potato moth / | | |
| chlorantraniliprole + thiamethoxam (DURIVO) | Aphid - Lettuce (<i>Nasonovia ribis-nigri</i>) | NR | 4A, 28 |
| | Brown sowthistle aphid (<i>Uroleucon sonchi</i>) | | |
| | Cluster caterpillar (<i>Spodoptera litura</i>) | | |
| | Green peach aphid (<i>Myzus persicae</i>) | | |
| | <i>Helicoverpa armigera</i> (Corn / cotton bollworm) | | |
| | <i>Helicoverpa punctigera</i> (Native budworm) | | |
| | Looper (<i>Chrysodeixis</i> spp.) | | |
| | Lucern leafroller (<i>Merophyas divulsana</i>) | | |
| | Potato moth (<i>Phthorimaea operculella</i>) | | |
| | Thrips - tomato | | |
| | Thrips - WFT | | |
| | Vegetable leafhopper (<i>Austroasca viridigrisea</i>) | | |
| | Whitefly - greenhouse | | |
| | Whitefly - silverleaf | | |
| chlorpyrifos | Black field cricket | NS | 1B |
| | Cutworms | | |
| | Field crickets | | |
| | Mole crickets | | |
| | Vegetable weevil | | |
| | Wingless grasshopper | | |
| diazinon | Cutworms | 14 | 1B |

| Active ingredient | Insect name | WHP | Chemical group |
|---|---|-------------|----------------|
| emamectin (PER13122, expires Sep 2016) | Helicoverpa | 3 | 6 |
| emulsifiable botanical oil | Whitefly – greenhouse | NR | – |
| fenthion | Fruit flies | 7 | 1B |
| flubendiamide (BELT) | <i>Helicoverpa punctigera</i> (Native budworm) | 1 | 28 |
| | Potato moth (Leafminer) | | |
| | Helicoverpa | | |
| Helicoverpa NPV | <i>Helicoverpa armigera</i> (Corn earworm) | NA | – |
| | <i>Helicoverpa punctigera</i> (Native budworm) | | |
| imidacloprid | Aphid - green peach | 7 | 4A |
| | Melon thrips | | |
| | Whitefly – silverleaf | NA | 4A |
| indoxacarb | <i>Helicoverpa armigera</i> (cotton bollworm) | 3 | 22A |
| | <i>Helicoverpa punctigera</i> (Native budworm) | | |
| | Potato moth / tomato leaf miner | | |
| methidathion | Aphids | 7 | 1B |
| | Leafhoppers | | |
| | Loopers | | |
| | Thrips - WFT | | |
| methidathion (field) (PER14047, expires Jun 2018) | Rutherglen bug | 7 | 1B |
| methomyl (PER13395, expires Sep 2017) | Cluster caterpillar | 3 | 1B |
| | Cucumber moth, | | |
| | Helicoverpa, | | |
| methoxyfenozide (Field-label, protected - PER12391, expires Sep 2017) | Cluster caterpillar | NR(H), *(G) | 18 |
| | <i>Helicoverpa punctigera</i> | | |
| | Tomato grub | | |
| paraffinic oil | Whitefly - silverleaf | NR | – |
| petroleum (PER12221, expires Nov 2017) | Whitefly - greenhouse, Bemisia tabaci species (Sweet potato, silverleaf B biotype and whitefly Q biotype) | 1 | – |
| | Aphids | | |
| | Green mired | | |
| | Green vegetable bug | | |
| | Grey cluster bug | | |
| | Leafhoppers | | |
| | Mites | | |
| | Rutherglen bug | | |
| | Thrips | | |
| | phorate (PER8930, expires Jul 2016) | | |
| Jassids, | | | |
| Mites | | | |
| Thrips | | | |
| pirimicarb (PER13351, expires Mar 2016) | Aphids | 2 | 1A |
| potassium salts of fatty acids | Aphids | NR | – |
| | Mealybug | | |
| | Thrips | | |
| | Two spotted mite / spider mite | | |
| | Whitefly | | |
| propargite | Spider mites (21 day re-entry) | 7 | 12C |
| | Two spotted mite | | |

| Active ingredient | Insect name | WHP | Chemical group |
|--|--|-----|----------------|
| pymetrozine (PER13111, expires May 2014) | Whitefly - silverleaf | 3 | 9B |
| pyrethrins+piperonyl butoxide | Aphids | NR | – |
| | Mealybug | | |
| | Thrips | | |
| | Two spotted mite / spider mite | | |
| | Whitefly | | |
| spinetoram | <i>Helicoverpa punctigera</i> (Native budworm) | 1 | 5 |
| | Potato moth (Leafminer) | | |
| | Thrips - WFT | | |
| spinetoram (PER14186, expires Sep 2018) | Melon Thrips | 1 | 5 |
| spirotetramat | Aphid - green peach | 1 | 23 |
| | Whitefly – silverleaf | 1 | 23 |
| sulphur | Two spotted mite (red spider) | NR | – |
| trichlorfon | Cutworms | 2 | 1B |
| | Mediterranean fruit fly | | |
| | Queensland fruit fly | | |
| | Green vegetable bug | | |
| | Rutherglen bug | | |
| trichlorfon (PER12442, expires May 2014) | Fruit fly | 2 | 1B |

(H)=Harvest

(G)= Grazing

NR= not required

*= do not graze or cut for stockfood

Appendix 4 – currently available herbicides in eggplant.

| Active ingredient | Chemical group |
|--|----------------|
| Clethodim (PER13397, expires Dec 2016) | A |
| Fluazifop (PER13394, expires Sep 2015) | A |
| Glyphosate | M |
| Paraquat + diquat | L |
| Trifluralin (PER12823, expires Jun 2021) | D |