



# Brassica leafy vegetables

Strategic Agrichemical Review Process  
2011-2014

HAL Projects - MT10029 & VG12081

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**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 brassica leafy vegetable industry across Australia. The information in this report will assist the industry with its agrichemical selection and usage into the future.

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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 brassica leafy vegetables were conducted in New South Wales, Queensland, South Australia and Victoria as part of combined vegetable meetings in 2008, 2010 and 2011. The results of the process provide the brassica leafy vegetables 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**

The diseases identified as a high priority are:

<b>Disease (common name)</b>	<b>Disease (scientific name)</b>
Downy mildew	<i>Hyaloperonospora parasitica</i>
White blister	<i>Albugo candida</i>

Registrations for control of diseases are primarily for old chemistry. Growers want additional, "safer" options and more choice to reduce risk of resistance. New fungicide chemistry has entered the market and registrants should be approached to consider product development in minor crops.

### **INSECTICIDES**

The insects identified as a high priority are:

<b>Insect (common name)</b>	<b>Insect (scientific name)</b>
Diamondback moth	<i>Plutella xylostella</i>
Helicoverpa	<i>Helicoverpa</i> spp.
Rutherglen bug	<i>Nysius vinitor</i>

Although there are registrations and permits for a range of pests, a problem can be that there is a restriction on the maximum number of sprays that can be applied in a season. This is a major reason for requests for additional permitted uses.

There are no chemicals permitted for a number of low priority uses. Growers must rely on control by other chemicals already being used in the crop. This can be difficult when the management strategy is not targeted to the problem.

A range of pests, including: Helicoverpa, cabbage aphid, diamondback moth, green peach aphid, loopers, cabbage cluster caterpillar, cabbage white butterfly, cabbage centre grub; are all controllable with a range of chemicals, and therefore are not major issues to be addressed even though their control is necessary to maintain crop quality and marketable yield.

### **WEEDS**

Most weeds can be controlled with currently available herbicides. There were no weeds identified as a high priority for control.

Although some growers use a pre-plant weed control (general knockdown herbicides) to prepare the paddock, quick reworking of the soil means that this step is not part of the strategy for many others

Growers will either alternate herbicides or use them in combination for effective weed control. All those available are either pre-emergent or early post-emergent herbicides.

## **2. The Australian brassica leafy vegetable industry**

The Australian brassica leafy vegetable industry is fast growing, innovative and resourceful. Consumption of brassica leafy vegetables has risen in recent years with the move to Asian cooking.

Crops in the brassica leafy vegetable group include:

<b>Name</b>	<b>Scientific name</b>	<b>Common aliases</b>
Bok choy, Baby bok choy	<i>B. rapa</i> (Chinensis group)	Bok choy, Chinese white cabbage, Chinese chard,
Choy sum, Baby choy sum	<i>B. rapa</i> (Parachinensis group)	Chinese flowering cabbage
Gai choy	<i>B. juncea</i> (many varieties)	Chinese mustard, Mustard cabbage, Swatow mustard, Mustard greens, Amsoi
Gai lan	<i>B. oleraceae</i> subsp. alboglabra	Chinese broccoli, Kailan, Gai lum
Kale	<i>B. oleracea</i> (Acephala group)	Kale, Collard greens
<i>Mibuna</i>	<i>B. rapa</i> subsp. <i>nipposinica</i> var. <i>laciniata</i>	
Mizuna	<i>B. rapa</i> subsp. <i>nipposinica</i>	
Pak choy	<i>B. rapa</i> subsp. <i>chinensis</i> (green stemmed variety)	Baby buk choy, Shanghai buk choy
Rutabaga leaves	<i>B. napus</i> subsp. <i>napobrassica</i>	
Siberian kale	<i>B. napus</i> subsp. <i>pabularia</i>	Hanover salad
Tatsoi	<i>B. rapa</i> (Narinosa group)	Rosette pak choi, Chinese flat cabbage, Komatsuna
Turnip greens	<i>B. rapa</i> var. <i>rapa</i>	
Wombok	<i>B. rapa</i> subsp. <i>pekinensis</i>	Chinese cabbage, Napa cabbage, Wong bok

Brassica leafy vegetables are grown across Australia with the main growing regions being areas close to major population centres:

- Sydney Basin (NSW)
- Melbourne Metro area (Vic)
- Brisbane Metro ,Sunshine coast, Stanthorpe, Lockyer Valley (Qld)
- Perth Metro outer areas (WA)
- North Adelaide Plains (SA)

In 2010, NSW accounted for 25% of brassica leafy vegetable production, Vic 25% and Qld 20%.

The area planted to brassica leafy vegetable in 2008/09 was 1,196 ha by 418 growers. The total brassica leafy vegetable production in Australia in that period was 20,209 tonnes with a gross value of \$16.9 mill. Production has been steadily increasing since 2005 with the industry now approaching a stable volume.

Hydroponic production is a significant contributor to total production volume due to the quick maturity time of this crop group.

Due to Australia's varying weather conditions and growing regions, and the increased production of different varieties of brassica leafy vegetable, the Australian industry is now able to fully supply the domestic brassica leafy vegetable market throughout the year.

Australian brassica leafy vegetables are also exported from the Northern Territory to Asian countries including: Singapore, Indonesia, Malaysia, Hong Kong and Asian countries. In 2010, 1,759 tonnes of Australian product was sold into this market. (Ausveg 2010)

### **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 brassica leafy vegetable 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 brassica leafy vegetables. 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 brassica leafy vegetables as a minor crop. The crop fits within the APVMA crop group 013: Leafy vegetables (including brassica leafy vegetables).

As a consequence of the issues facing the brassica leafy vegetable industry regarding pesticide access, Horticulture Australia Ltd and the vegetable industry undertook a review of the pesticide requirements in brassica leafy vegetables 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 brassica leafy vegetable 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 brassica leafy vegetable production in Australia but attempts to prioritise the major problems.

### **3.2. Minor use permits and registration**

Brassica leafy vegetables 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 brassica leafy vegetable industry is for manufacturers to register new pesticides uses in the crop.

### **3.3. Methods**

The SARP was conducted in New South Wales, Queensland, South Australia and Victoria 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 brassica leafy vegetables 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 (AVPMA) 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 brassica leafy vegetable 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 brassica leafy vegetables

### 4.1 Diseases of brassica leafy vegetables

Common name	Scientific name
<b>HIGH PRIORITY</b>	
Downy mildew	<i>Hyaloperonospora parasitica</i>
White blister	<i>Albugo candida</i>
<b>MODERATE PRIORITY</b>	
Alternaria leaf spot	<i>Alternaria brassicicola</i>
Cercospora leaf spot	<i>Cercospora</i> spp.
Damping off	<i>Pythium</i> spp., <i>Phytophthora</i> spp. <i>Fusarium</i> spp., <i>Rhizoctonia</i> spp.
Peppery leaf spot	<i>Pseudomonas syringae</i> pv. <i>maculicola</i>
Septoria leaf spot	<i>Septoria apiicola</i>
Sclerotinia rot	<i>Sclerotinia</i> spp.
<b>LOW PRIORITY</b>	
Black rot	<i>Xanthomonas campestris</i> pv. <i>campestris</i>
Ring spot	<i>Mycosphaerella brassicicola</i>
<b>Biosecurity risk</b>	
None listed	

Opinion on the priority of diseases can vary across the industry. As an example, Phoma diseases (*Leptosphaeria maculans* and *Leptosphaeria biglobosa*; asexual stage *Phoma lingam*), also known as blackleg, is a concern for some growers, in particular as there are no products registered or permitted for control. In circumstances where a disease is a low priority for obtaining a permit or registration, growers must rely on incidental control by products used to control other diseases in the crop.

#### **4.1.1 High priority diseases**

##### **Downy mildew (*Hyaloperonospora parasitica*)**



Downy mildew is a fungal disease which can affect all brassica leafy vegetable varieties both as seedlings and mature plants. The first signs of the disease usually appear on the older leaves. First symptoms are yellow or light green blotchy areas appearing on the upper sides of the leaves. White downy spores then appears on the underside of the leaf if the infection is not treated rapidly at this stage the infected area of the leaf will soon turn brown and die.

- Downy mildew is considered a major-moderate problem in Vic, NSW and SA and a moderate problem in Qld.
  - Growers alternate the use of different fungicides.
  - Growers are in need of other protective/curative fungicides to allow effective alternation.
- Fungicides **registered** for the control of Downy mildew in brassica leafy vegetable are:
  - Copper (as copper ammonium complex) - Group M1 protectant fungicide:
    - Commonly used as a protectant.
    - Also offers some control of White blister.
    - It is not effective in high pressure situations.  
Has some effect on beneficial insects.



- Metalaxyl-M + mancozeb (RIDOMIL<sup>^</sup> GOLD MZ) - Groups 4 + M3 systemic and protective, curative fungicide
  - Commonly used.
  - Used as a protectant / curative fungicide.
  - Also control White blister.
  - It is very effective.
  - Number of applications is limited.
  - Considered expensive.
- Fungicides listed for the control of Downy mildew in brassica leafy vegetable via **permits** are:
  - Copper (various, PER14038, expires Sept 2023)- Groups M1 protective
    - May not be effective in high pressure situations.
    - Moderately harmful to some beneficial insects.
    - Has a 1 day WHP - favourable.
  - Phosphorous acid (various, PER14184, expires Jun 2017) - Group 33 protective and systemic fungicide - enhances plants natural defence mechanisms.
    - Occasionally used as a protectant.
    - It is effective when it is used in rotation with other fungicides.
    - No manufacturers interested in registering use.
  - Zineb (ZINEB<sup>^</sup>, PER10845, expires Mar 2015) - Group M3 protectant fungicide
    - Occasionally used as a protectant.
    - It is not effective in high pressure situations.
    - Has some effect on beneficial insects.
    - No manufacturers interested in registering use.
- **Potential** fungicides listed for the control of Downy mildew in brassica leafy vegetable
  - Cyazofamid (likely to be called RANMAN<sup>^</sup>?, new ISK/FMC Fungicide) – FRAC code 21 – contact and residual fungicide
    - Application for registration with the APVMA, for potatoes, brassicas and possibly brassica leafy
    - Inhibits oomycetes fungal development
    - Overseas registration on brassica leafy for white rust (*Albugo occidentalis*), downy mildew, pythium damping-off, club root (*Plasmodiophora brassicae*)
    - Resistance management tool
    - The registrant should be approached for interest in developing the product on minor crops
  - Ametoctradin + dimethomorph (ZAMPRO<sup>^</sup>) – FRAC code 21+ Group 40 – contact and residual fungicide
    - Controls late blight and downy mildew on potatoes and other crops, including vines. Overseas work on bulb vegetables, brassica vegetables, fruiting vegetables, leafy vegetables, celery and hops has been reported.
    - BASF should be approached for interest in developing the product on minor crops
  - Fluopicolide is a new Bayer active in the FRAC group 43. This would be a novel group in Australia. It is a systemic fungicide affecting oomycetes. Bayer CropScience has applied for approval of the active in Australia but registration of a registered product will take some time. There is overseas registration on leafy vegetables / *Peronospora farinose*. It would be sensible to approach Bayer to discuss development opportunities.

## White blister (*Albugo candida*)



*Albugo* infects the leaves causing distinctive white, raised pustules to form underneath the plant epidermis. These blister-like pustules sometimes result in twisted, deformed growth of the stem, leaves, or flowers. When mature, the epidermis covering the pustule will rupture, releasing powdery white sporangia (a type of spore) that can be carried by winds or splashing water onto neighbouring host plants. Severely infected leaves can wither and die.

Economic losses result from the leaf marking caused by this disease

Because *Albugo* is dependent on cool, wet conditions, the disease is often more severe during winter and early spring months, though with major outbreaks still a possibility in mid-summer with the right conditions

- White blister is considered a major-moderate problem in all states
  - Where possible growers try to alternate the use of different fungicides.
  - Growers would like other protective/curative fungicides for alternation.
  - Growers are concerned at resistance developing to current fungicides.
  - Reported as relatively hard to control but not normally a problem
- Fungicides **registered** for the control of white blister in brassica leafy vegetable are:
  - Metalaxyl-M + mancozeb (RIDOMIL<sup>®</sup> GOLD MZ) - Groups 4 + M3 systemic and protective, curative fungicide
    - Commonly used.
    - Used as a protectant / curative fungicide.
    - Reported as efficacious in some areas but not in others.
    - Number of applications is limited.
    - Considered expensive.
- Fungicides listed for the control of White blister in brassica leafy vegetable via **permits** are:
  - Azoxystrobin (various, PER13123, expires Mar 2014) – Group 11 protectant and curative fungicide:
    - Occasionally used.
    - Used as a protectant / curative fungicide.
    - Also control Downy mildew.
    - Reported as effective in some areas, but ineffective in other.
    - Permit not to be renewed as Syngenta reportedly registering the use.
- **Potential** fungicides used for the control of White blister are:
  - Cyazofamid (likely to be called RANMAN<sup>®</sup>?, new ISK/FMC Fungicide) – FRAC code 21 – contact and residual fungicide
    - Application for registration with the APVMA, for potatoes, brassicas and possibly brassica leafy
    - Inhibits oomycetes fungal development
    - Overseas registration on brassica leafy for white rust (*Albugo occidentalis*), downy mildew, pythium damping-off, club root (*Plasmodiophora brassicae*)
    - Resistance management tool
    - The registrant should be approached for interest in developing the product on minor crops
  - Pyraclostrobin (CABRIO<sup>®</sup>) – Group 11 protectant and curative fungicide
    - A previous permit for the use was not renewed
    - Nufarm / BASF unsure if use will be registered.
    - Growers report good efficacy

## **Ring spot (*Mycosphaerella brassicicola*)**

- Ring spot is the most consistent problem in southern Victoria although classified as a low priority overall in the SARP assessment.
  - Growers would like alternate chemistry.
- Fungicides **registered** for the control of ring spot in brassica leafy vegetable are:
  - Copper (as copper ammonium complex) - Group M1 protectant fungicide:
    - Has some effect on beneficial insects.
    - Growers want additional chemistry
- **Potential** fungicides for the control of ring spot in brassica leafy vegetable are:
  - triadimenol (BAYFIDAN<sup>^</sup>) - Group 3 systemic fungicide:
    - Registered for brassicas and expected to be efficacious in brassica leafy vegetables
    - Growers would like this use permitted or registered

### **4.1.2 Biosecurity risk diseases**

None identified

### 4.1.3 Summary

#### High Priority Diseases and control options

Registrations for control of diseases are primarily for old chemistry. Growers want additional, "safer" options and more choice to reduce risk of resistance. New fungicide chemistry has entered the market and registrants should be approached to consider product development in minor crops.

Disease	Control option
<p>Downy mildew (<i>Peronospora farinosa</i>)</p>	<p><b>Currently registered fungicides</b> Copper (as copper ammonium complex) – moderately harmful to beneficials, reduced efficacy under high pressure. Metalaxyl-M + mancozeb (RIDOMIL<sup>^</sup> GOLD MZ)– common use, good efficacy.</p> <p><b>Currently permitted fungicides</b> Copper (various, PER14038, expires Sept 2023) – moderately harmful to beneficials, reduced efficacy under high pressure. Phosphorous acid (various, PER14184, expires Jun 2017) – useful in rotations. Zineb (ZINEB<sup>^</sup>, PER10845, expires Mar 2015) – occasional use, moderate harm to beneficials.</p> <p><b>Fungicide Gaps</b> New chemistry with IPM fit.</p> <p><b>Potential fungicide solutions</b> Cyazofamid (likely to be called RANMAN<sup>^</sup>?, new ISK/FMC Fungicide) – first new product registration under assessment at the APVMA. Fluopicolide, a new Bayer fungicide being assessed for first registration by the APVMA. Ametoctradin + dimethomorph (ZAMPRO<sup>^</sup>) – new BASF chemistry registered for downy mildew in other crops.</p> <p><b>Non-chemical options</b> Crop rotation. Plant spacing to improve air flow and spray penetration. Resistant varieties.</p>
<p>White blister (<i>Albugo candida</i>)</p>	<p><b>Currently registered fungicides</b> Metalaxyl-M + mancozeb (RIDOMIL<sup>^</sup> GOLD MZ)– common use, good efficacy.</p> <p><b>Currently permitted fungicides</b> Azoxystrobin (various, PER13123, expires Mar 2014) – occasional use, varying efficacy.</p> <p><b>Fungicide Gaps</b> New chemistry with IPM fit</p> <p><b>Potential fungicide solutions</b> Cyazofamid (likely to be called RANMAN<sup>^</sup>?, new ISK/FMC Fungicide) – first new product registration under assessment at the APVMA. Pyraclostrobin (CABRIO<sup>^</sup>) – good efficacy, previous permit not renewed</p> <p><b>Non-chemical options</b> None identified. This should be discussed in future SARPs</p>

## Currently available fungicides

Active ingredient	Disease	Crops	WHP (H) days	WHP (G) days	Chemical Group
Azoxystrobin (PER13123, expires Mar 2014)	Alternaria leaf spot	Brassica leafy (listed)	7	1	11
	White blister				
Boscalid (PER13897, expires Jun 2014, now on label)	Sclerotinia rot	Brassica leafy (listed)	7	14 **	3
Copper (PER14038, expires Sept 2023)	Downy mildew	Brassica leafy	1	-	M1
Copper (as oxychloride)	Rust and leaf spot diseases	Vegetables			
	Alternaria leaf spot	Brassicas			
	Downy mildew				
	Ring spot ( <i>Mycosphaerella brassicicola</i> )				
	Peppery leaf spot ( <i>Pseudomonas syringae pv. Maculicola</i> ) (Bacterial disease)				
	Black spot ( <i>Xanthomonas campestris</i> ) (bacterial disease)				
Copper (as copper ammonium complex)	Downy mildew	Brassica leafy			
	Ring spot ( <i>Mycosphaerella brassicicola</i> )				
	Peppery leaf spot ( <i>Pseudomonas syringae pv. Maculicola</i> ) (Bacterial disease)				
	Black rot ( <i>Xanthomonas campestris pv. Campestris</i> ) (Bacterial disease)				
Cyprodinil + fludioxonil (switch)	Sclerotinia	Brassica leafy	7	-	9+12
Copper + metalaxyl – RIDOMIL GOLD PLUS	White blister ( <i>Albugo candida</i> )	Brassica leafy	14	-	M3 + 4
	Downy mildew				
Iprodione	Sclerotinia	Brassica leafy (listed)	7	7	7
	Grey mould ( <i>Botrytis</i> )				
	Alternaria leaf spot				
Mancozeb (PER12016, expires Mar2015)	Anthracnose	Brassica leafy (listed)	14	-	M3
	Septoria				
Penthiopyrad (FONTELIS^)	Sclerotinia stem rot / white mould ( <i>Sclerotinia</i> spp.)	Brassica leafy	-	-	7
	Grey mould ( <i>Botrytis cinerea</i> )	Leafy vegetables			
	Powdery mildew ( <i>Erysiphe cichoracearum</i> )				
Phosphorous (PER14184)	Damping off	Brassica leafy (listed)	-	-	33
	Downy mildew				
Potassium bicarbonate	Powdery mildew (PER13695, exp 09/17)	Brassica leafy (listed)	-	-	M2
Propiconazole (PER14479, expires Oct 2017)	Cercospora leaf spot	Brassica leafy, field grown	28	-	3
	Rust				
	Septoria leaf spot				
Zineb (PER10845, expires Mar 2015)	Cercospora leaf spot	Brassica leafy (listed)	10	-	M3
	Downy mildew				

\*Do not graze or cut for stock food      \*\*export

## 4.2 Insects of brassica leafy vegetable

Common name	Scientific name
<b>HIGH PRIORITY</b>	
Diamondback moth	<i>Plutella xylostella</i>
Helicoverpa	<i>Helicoverpa</i> spp.
Rutherglen bug	<i>Nysius vinitor</i>
<b>MODERATE PRIORITY</b>	
Cabbage aphid	<i>Brevicoryne brassicae</i>
Green peach aphid	<i>Myzus persicae</i>
Green vegetable bug	<i>Nezara viridula</i>
Looper caterpillars	<i>Chrysodeixis</i> spp.
Plague thrips	<i>Thrips imaginis</i>
Silverleaf whitefly	<i>Bemisia tabaci</i>
<b>LOW PRIORITY</b>	
Cabbage cluster caterpillar	<i>Crociodolomia pavonana</i>
Cabbage white butterfly	<i>Pieris rapae</i>
Cabbage-centre grub	<i>Hellula hydralis</i>
Redlegged earth mite	<i>Halotydeus destructor</i>
Two-spotted mite	<i>Tetranychus urticae</i>
Western flower thrips	<i>Frankliniella occidentalis</i>
<b>Biosecurity risk</b>	
None listed	

### 4.2.1 High priority insects

#### Helicoverpa (*H. armigera* and *H. punctigera*)



This caterpillar varies greatly in appearance. They can reach lengths of 50 mm. It is generally initially pale green, sometimes with black dots, and a pattern of thin dark lines running along the body, the lines being darker around the second and third segments. Later the dark lines become less conspicuous, and the black spots develop red areas around them. There is a lot of variation in colour in this species. Some have white spots instead of black.

Helicoverpa species feed prolifically on leaves and are capable of causing large amounts of damage.

- Helicoverpa are considered a high priority in all areas in terms of damage. However as there are many control options available they are not a high priority for action on new chemistry if IPM is utilised to keep resistance at bay.
  - Many soft options are available
  - Insecticide resistance especially in *Helicoverpa armigera*, has made this species a particularly difficult pest when insecticides are totally relied upon for control.
- Insecticides **registered** for Helicoverpa control in brassica leafy vegetable are:
  - Alpha-cypermethrin (various) - Group 3A contact and systemic insecticide
    - Not listed for all brassica leafy vegetables.
    - Commonly used in some regions.
    - Considered effective.
    - Controls all lepidoptera.
    - This treatment is highly disruptive to beneficial insects in an IPM situation.

- *Bacillus Thuringiensis* (Bt) (various) - Group 11C contact insecticide
  - Bt is commonly used.
  - Controls all lepidoptera.
  - Very effective on small grubs, but needs regular reapplication.
  - IPM compatible - low impact on beneficial insects and mites.
- Chlorantraniliprole (various, including CORAGEN<sup>^</sup>) - Group 28 contact and systemic insecticide
- Chlorantraniliprole + thiamethoxam (DURIVO<sup>^</sup>) - 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.
- Cypermethrin (various) - Group 3A contact and systemic insecticide
  - Not listed for all brassica leafy vegetables.
  - Occasionally used in some regions.
  - Considered effective.
  - Controls all lepidoptera.
  - This treatment is highly disruptive to beneficial insects in an IPM situation.
- Flubendiamide (BELT<sup>^</sup>) – Group 28 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.
- Helicoverpa NPV (various) – is a biological insecticide:
  - Occasionally used but highly rated for efficacy and IPM compatibility.
  - Very effective on small grubs.
  - IPM compatible.
- Indoxacarb (various) - Group 22A contact and systemic insecticide
  - Occasionally used in some regions.
  - Controls all lepidoptera.
  - Considered effective.
  - IPM compatible - variable impact on beneficial insects and mites.
- Prothiofos (TOKUTHION<sup>^</sup>) - Group 1B contact and systemic insecticide
  - No information on use of this chemical
- Spinetoram (SUCCESS NEO<sup>^</sup>) - Group 5A contact and systemic insecticide
  - Commonly used in some regions.
  - Very effective on a range of pests, including thrips. Controls all lepidoptera.
  - IPM compatible.
  - Growers concerned of overuse - resistance.
  - IPM compatible - variable impact on beneficial insects and mites.

Resistance to some insecticides is an important issue. Growers are trying to manage resistance with the selective use of insecticides and IPM.

- Insecticides used for the control of *Helicoverpa* in brassica leafy vegetable via **permits** are:
  - Chlorfenapyr (PER14292, Expires March 2016) - Group 13A insecticide
    - Growers requested this use.
    - Issued in late 2013.
    - Field grown only
  - Emamectin (various, PER11994, expires May 2014) - Group 6 contact and systemic insecticide
    - Occasionally used.
    - Considered effective.
    - Controls all lepidoptera.
    - IPM compatible - variable impact on beneficial insects and mites.

## Rutherglen bug (*Nysius vinitor*)



Rutherglen bugs are common native insects that attack a wide range of crops. Adults are 3-4 mm long and grey-brown in colour with clear wings folded flat on their back. Nymphs are wingless and have a dark red, pear-shaped body. Rutherglen bugs are usually a problem in spring, but can also be a pest of crops in autumn. They are regarded as opportunistic, nomadic and can reach plague proportions in drought periods.

Rutherglen bugs feed like aphids, by sucking sap from plant foliage including leaves. They also impact brassica leafy vegetable crops by contaminating packed product

- The Rutherglen bug is considered a high-moderate priority in Qld and all south eastern states and a moderate priority in WA.
  - Rarely causes significant crop damage.
  - Contamination is a major issue for supermarket rejections when there is zero tolerance to live insects.
  - Local management will have little impact in seasons when there are major influxes of bugs from outside the cropping region in spring. As RGB also feed on weeds, managing weeds in and around paddocks prior to sowing can reduce the likelihood of bugs moving from dying weeds onto emerging seedlings.
  - Have increased as a pest problem with the reduced use of broad spectrum insecticides.
  - RGB generally succumb to fungal attack as humidity rises after Christmas and become much less of an issue.
  - Growers currently rely on incidental control from insecticides being used to control other pests
  - Chemistry with an IPM fit is required
- No insecticides are **registered or permitted** for the control of Rutherglen bug in brassica leafy vegetable.

## Diamondback moth (*Plutella xylostella*)



The moths are small, about 10 - 12 mm long. The patterning of the male is most distinct, being dark brown with three white diamonds on its back. The female is tan coloured with less obvious diamonds. Caterpillars are grey-green with a dark head in the first three stages and green with a green-brown head in the last growth stage. Caterpillars grow to approximately 12 mm in length. Caterpillars eat many holes in the leaves and also cause contamination by pupating inside heads.

<http://www.dpi.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects/ag0512-diamondback-moth>, accessed 14/02/2014

- Diamondback moth is considered a high priority for many growers as the damage they causes impacts the marketability of the produce.
- Insecticides **registered** for diamondback moth control in brassica leafy vegetable are:
  - Chlorantraniliprole (various, including CORAGEN<sup>^</sup>) - Group 28 contact and systemic insecticide
  - Chlorantraniliprole +thiamethoxam (DURIVO<sup>^</sup>) - Group 28 +4A contact and systemic insecticide
    - Commonly used in some regions up to twice per crop.
    - Very effective.
    - IPM compatible - low impact on beneficial insects and mites.
  - Flubendiamide (BELT<sup>^</sup>) – Group 28 contact and systemic insecticide
    - Commonly used in some regions up to twice per crop.
    - Very effective.
    - IPM compatible - low impact on beneficial insects and mites.



- Spinetoram (SUCCESS NEO) - Group 5A contact/systemic insecticide
  - Commonly used in some regions.
  - Very effective.
  - Some impact in an IPM situation.
- Insecticides approved for the control of diamondback moth in brassica leafy vegetable via **permits** are:
  - Chlorfenapyr (PER14292, Expires March 2016)- Group 13A insecticide
    - Growers requested this use.
    - Issued in late 2013.
    - Field grown only
  - Emamectin (various, PER11994, expires May 2014) - Group 6 contact and systemic insecticide
    - Occasionally used.
    - Considered effective.
    - Controls all lepidoptera.
    - IPM compatible - variable impact on beneficial insects and mites.
- **Potential** insecticides for control of Lepidoptera pests:
  - Methoxyfenozide (various) - Group 18 insect growth regulator
    - Controls a range of Lepidoptera pests.
    - Registrations and permits to control Lepidoptera pests in various vegetables including fruiting vegetables and lettuce.
    - IPM compatible - low impact on beneficial insects and mites.
  - Metaflumizone (New BASF active) - Group 22B
    - Metaflumizone is a new active ingredient under development by BASF, which in research studies has demonstrated significant activity against important Lepidoptera, Coleoptera, Hemiptera, Hymenoptera, Isoptera, and Diptera. Metaflumizone belongs to a new chemical class of insecticides, the semicarbazones, which block the voltage-dependent Na<sup>+</sup> channel of susceptible insects.
    - At this stage an active ingredient approval is in review at the APVMA
    - BASF should be approached for consideration of minor use crops in its development program. The Australian target use pattern is not known
    - There may be the possibility of collaboration with an IR4 / chinese cabbage / diamondback moth project
  - 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

#### **4.2.2 Biosecurity risk insects**

None identified

#### **4.2.3 Summary**

##### **High Priority Insects and control options**

Although there are registrations and permits for a range of pests, a problem can be that there is a restriction on the maximum number of sprays that can be applied in a season. This is a major reason for requests for additional permitted uses.

There are no chemicals permitted for a number of low priority uses. Growers must rely on control by other chemicals already being used in the crop. This can be difficult when the management strategy is not targeted to the problem.

A range of pests, including: Helicoverpa, cabbage aphid, diamondback moth, green peach aphid, loopers, cabbage cluster caterpillar, cabbage white butterfly, cabbage centre grub; are all controllable with a

range of chemicals, and therefore are not major issues to be addressed even though their control is necessary to maintain crop quality and marketable yield.

Disease	Control option
<p>Helicoverpa (<i>Helicoverpa</i> spp.)</p>	<p><b>Currently registered insecticides</b>            Most chemistry registered for Helicoverpa also controls Lepidoptera more broadly.            Alpha-cypermethrin (various) – efficacious, disruptive to beneficials.            Bacillus Thuringiensis (Bt) (various) - effective, IPM compatible.            Chlorantraniliprole (various, including CORAGEN<sup>^</sup>) - effective, IPM compatible..            Chlorantraniliprole + thiamethoxam (DURIVO<sup>^</sup>) - effective, IPM compatible            Cypermethrin (various) – efficacious, disruptive to beneficials.            Flubendiamide (BELT) - IPM fit.            Helicoverpa NPV (various) - effective on small grubs, IPM compatible.            Indoxacarb (various) – occasional use, IPM fit.            Prothiofos (TOKUTHION<sup>^</sup>).            Spinetoram (SUCCESS NEO) - effective, common use, resistance issues.</p> <p><b>Currently permitted insecticides</b>            Chlorfenapyr (PER14292, Expires March 2016) – field only.            Emamectin (various - PER13122) - not IPM compatible.</p> <p><b>Insecticide Gaps</b>            Helicoverpa resistance to many chemicals.</p> <p><b>Potential insecticide solutions:</b> None identified</p> <p><b>Non-chemical options</b>            IPM strategies – required to manage resistance.</p>
<p>Rutherglen bug (<i>Nysius vinitor</i>)</p>	<p><b>Currently registered insecticides:</b> None</p> <p><b>Currently permitted insecticides:</b> None</p> <p><b>Insecticides Gaps</b>            Registrations and permits required, although chemistry registered to control other insects will incidentally control Rutherglen bug.</p> <p><b>Potential insecticides solutions</b>            None specifically requested by growers.</p> <p><b>Non-chemical options</b>            Weed control around crops – this pest feeds on weeds then moves to the crop as weeds die.            Management of the Retail / supermarket zero tolerance of live insects.</p>
<p>Diamondback moth (<i>Plutella</i> <i>xylostella</i>)</p>	<p><b>Currently registered insecticides</b>            Chlorantraniliprole (various, including CORAGEN) - effective, IPM compatible.            Chlorantraniliprole + thiamethoxam (DURIVO<sup>^</sup>) - effective, IPM compatible.            Flubendiamide (BELT) - IPM fit.            Spinetoram (SUCCESS NEO) - effective, common use, resistance issues.</p> <p><b>Currently permitted insecticides</b>            Chlorfenapyr (PER14292, Expires March 2016) – field only.            Emamectin (various - PER13122) - not IPM compatible.</p> <p><b>Insecticides Gaps</b>            Resistance developments</p> <p><b>Potential insecticides solutions</b>            Efficacy and residue work required:            Methoxyfenozide (various) - Group 18 insect growth regulator. A range of Lepidoptera registrations and permits in other vegetable situations. Low impact on beneficial insects and mites.            Metaflumizone – Group 22B – BASF development molecule            Novaluron – Group 15 – unsure of development status</p> <p><b>Non-chemical options</b>            Management of the Retail / supermarket expectation for zero/low damage</p>

## Currently available insecticides

Active ingredient	Crop	Insect	WHP (H) Days	WHP (G) Days	Chemical Group
Abamectin	Brassica leafy	Western flower thrips ( <i>Frankiniella occidentalis</i> )	3	-	6
Alpha-cypermethrin	Chinese cabbage, kale	Cabbage moth ( <i>Plutella xylostella</i> )	1	-	3A
		Cabbage white butterfly ( <i>Pieris rapae</i> )			
		Cluster caterpillar ( <i>Spodoptera litura</i> )			
		<i>Helicoverpa armigera</i>			
Alpha-cypermethrin (PER13090, expires May 2015)	Brassica leafy (listed)	Redlegged earth mite	1	-	3A
		Plague thrips			
Bacillus thuringiensis	Vegetables	Armyworm ( <i>Spodoptera</i> spp.)	-	-	11C
		<i>Helicoverpa</i> spp.			
		Cabbage moth			
		Cabbage white butterfly			
		Loopers			
		Light brown apple moth			
		Vine moth			
Bifenthrin (PER13700, not for general use)	Brassica leafy	Budworm ( <i>Helicoverpa</i> )	**	-	3A
		Two spotted mite			
Chlorantraniliprole	Brassica leafy	Cabbage centre grub ( <i>Hellula hydralis</i> )	3	-	28
		Cabbage cluster caterpillar ( <i>crocidolomia pavonana</i> )			
		Cabbage leafminer ( <i>Liriomyza brassicae</i> )			
		Cabbage white butterfly			
		Cluster caterpillar ( <i>Spodoptera litura</i> )			
		Cotton bollworm ( <i>Helicoverpa armigera</i> )			
		Diamondback moth ( <i>Plutella xylostella</i> )			
		Native budworm ( <i>helicoverpa puntigera</i> )			
		Soybean looper ( <i>Thysanoplusia orichalcea</i> )			
		Chlorfenapyr (per14292, expires march 2016)			
Cabbage white butterfly					
<i>Helicoverpa</i> spp.					
Two-spotted mite					
Chlorpyrifos	Cole crops	Cabbage moth	5	-	1B
		Cabbage white butterfly			
		Cabbage aphid ( <i>Brevicoryne brassicae</i> )			
		Cluster caterpillar			
		Cabbage cluster caterpillar			
		<i>Helicoverpa</i> spp			
Chlorpyrifos (PER14583, expires Mar 2019)	Brassica leafy	African black beetle	-	-	1B
		False wireworms, wireworms			
Cypermethrin	Chinese cabbage, kale	Cabbage moth	1	-	3A
		Cabbage white butterfly			
		<i>Helicoverpa</i> spp.			
		Cluster caterpillar			
Emamectin - proclain (per11994,	Brassica leafy (listed)	Diamondback moth	3	*	6
		<i>Helicoverpa</i> spp.			

Active ingredient	Crop	Insect	WHP (H) Days	WHP (G) Days	Chemical Group
expires May 2014)					
Flubendiamide	Brassica leafy, field and protected	Diamondback moth	1	-	28
		Cabbage white butterfly			
		Cluster caterpillar			
		<i>Helicoverpa</i> spp.			
		Soybean looper			
Helicoverpa NPV	Brassica leafy	<i>Helicoverpa</i> spp.	-	-	Biological
Imidacloprid (PER14584, expires Mar 2019)	Brassica leafy (listed)	Aphids	3	-	4A
		Whitefly			
		Thrips (not WFT)			
Indoxacarb	Chinese leafy vegetables (bok choy, choy sum, chinese cabbage)	<i>Helicoverpa</i> spp.	7	*	22a
Paraffinic oil and petroleum oil (see permit PER12221, exp11/17)	Brassica leafy vegetables, listed	Aphids	1	-	-
		Green mirid			
		Green vegetable bug			
		Grey cluster bug			
		Leafhoppers			
		Mites			
		Rutherglen Bug			
Pirimicarb	Chinese cabbage, kale	Cabbage aphid	2	-	1A
		Green peach aphid ( <i>Myzus persicae</i> )			
Prothiofos	Chinese cabbage, kale	Cabbage centre grub	7	-	1B
		Cabbage moth			
		Cabbage white butterfly			
		Cluster caterpillar			
		<i>Helicoverpa</i> spp.			
Spinetoram (SUCCESS NEO)	Brassica leafy (listed)	Diamondback moth	3	-	5
		Cabbage white butterfly			
		Cabbage cluster caterpillar			
		Cabbage centre grub			
		Loopers			
		<i>Helicoverpa</i> spp.			
		Cluster caterpillar			
		Western flower thrip			
Spirotetramat	Brassica leafy (listed)	Green peach aphid	3	-	23
		Grey cabbage aphid			
		Silverleaf whitefly			
Sulfoxaflor	Asian greens	Aphids	3	-	4C
		Greenhouse whitefly	3	-	4C
Chlorantraniliprole + thiamethoxam	All	Cabbage white butterfly	28	-	4A + 28
		Diamondback moth			
		<i>Helicoverpa armigera</i>			
		<i>Helicoverpa punctigera</i>			
		Cabbage centre grub			
		Cabbage cluster caterpillar			
		Soybean looper			
		Cabbage aphid			
		Green peach aphid			
		Silverleaf whitefly ( <i>Bemisia tabaci</i> )			
		Greenhouse whitefly ( <i>Trialeurodes vaporariorum</i> )			
		Western flower thrips			

Active ingredient	Crop	Insect	WHP (H) Days	WHP (G) Days	Chemical Group
		Tomato thrips ( <i>Frankiniella schultzei</i> )			
Methyl bromide PER11092, PER10145 (not for persons generally)	All food crops	Thrips	3	-	8A

\*Do not graze or cut for stock food

## **4.3 Herbicide use in brassica leafy vegetable**

### **4.3.1. High priority weeds**

No weeds have been identified as high priorities

- Herbicides **registered** and used in brassica leafy vegetable:
  - Chlorthal-dimethyl (various) – Group D general knockdown and residual herbicide
    - pre-plant.
    - Occasionally used.
    - Some crop phyto issues in some situations.
    - Considered effective.
    - Controls many broadleaf and some grass weeds.
  - Metolachlor (various) - Group K pre-plant residual herbicide
    - Only registered in Chinese cabbage.
    - Rarely used.
    - Some crop phyto issues in some situations.
    - Considered effective.
    - Controls many broadleaf and some grass weeds.
  - 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
- The herbicides listed for control of weeds in brassica leafy vegetable via **permits** are:
  - Clethodim (various) – Group A grass selective post-emergent herbicide
    - Commonly used.
    - Considered very effective.
    - Controls most grass weeds including Winter grass (*Poa annua*).
  - Fluazifop-P as butyl (various, PER12017, expires Jun 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.
    - Controls most grass weeds. Does not control Winter grass (*Poa annua*).
  - S-Metolachlor (various, PER13154, expires Mar 2017) - Group K pre-plant residual herbicide.
    - Permit for all brassica leafy vegetable.
    - Occasionally used.
    - Some crop phyto issues in some situations.
    - Considered effective.
    - Controls many broadleaf and some grass weeds.
    - Permit expires 31-Mar-17.
  - Propachlor (RAMROD, PER12008) - Group H selective post-emergent herbicide
    - Commonly used.
    - Considered very effective.
    - Controls many weeds.
    - Permit expires 30-Sep-15. No manufacturer interested in registering use.

### 4.3.2. Summary

It was identified in the SARP that there were no weeds identified as a high priority for control and that most weeds can be controlled with currently available herbicides.

Although some growers use a pre-plant weed control (general knockdown herbicides) to prepare the paddock, quick reworking of the soil means that this step is not part of the strategy for many others

Growers will either alternate herbicides or use them in combination for effective weed control. All those available are either pre-emergent or early post-emergent herbicides.

Active ingredient	Crops	Weed	WHP (H) days	WHP (G) days	Chemical group
Chlorthal-dimethyl	Brassica leafy	Various grass and broadleaf	-	*	D
Clethodim (PER11848, expires Sept 2015)	Brassica leafy (listed)	Grass weeds	28	-	A
Pendimethalin (PER14127, expires Aug 2018)	Brassica leafy (listed)	Various grass and broadleaf	-	-	D
Fluazifop-P-butyl (PER12017, expires Jun 2016)	Brassica leafy (listed)	Grass weeds on product label	28	*	A
Metolachlor	Chinese cabbage	Various grass and broadleaf	-	*	K
S-metolachlor (PER13154, expires Mar 2017)	Brassica leafy (listed)	Various grass and broadleaf	-	-	K
Propachlor (PER12008, expires Sept 2015)	Brassica leafy (listed)	Grass and broadleaf weeds on product label	-	-	K

\*Do not graze or cut for stock food

## **5. References and information**

- Australasian Biological Control website.
- Australian Bureau of Statistics, Agricultural Commodities website.
- Australian Horticultural Statistics Handbook.
- Australian Pesticide and Veterinary Medicines Authority website.
- Ausveg 'Domestic Vegetable Industry Snapshot' (2009) website.
- Ausveg 'Fresh Vegetable Exports' (2011) website.
- Biobest website.
- Codex MRL database website.
- Cornell University website.
- Diseases of Vegetable Crops. Department of Primary Industries Queensland, 1994.
- Infopest, Department of Primary Industries and Fisheries, Queensland Government, July 2012.
- IPM Technologies final report. Project: Pesticide effects on beneficial insects and mites in vegetables.
- IR-4 Project website.<http://ir4.rutgers.edu/index.html>
- Managing Insects and Mites in horticultural crops, QLD DPI, 1994.
- McMaugh, 'What garden pest or disease is that?' published 1989.
- New South Wales Department of Primary Industries websites.
- Pest management strategy documents for Queensland's fruit and vegetable industries, Queensland Fruit and Vegetable growers, 2003 & 2008.
- USA Foreign Ag Service website.
- Vegetable IPM Coordinator draft report 2011. Sandra McDougall NSW DPI.

Images:

- Google images

## ***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
Pesticides .....	Plant protection products (fungicide, insecticide, herbicide, nematicides, etc).
SARP .....	Strategic Agrichemical Review Process
WHP .....	Withholding period

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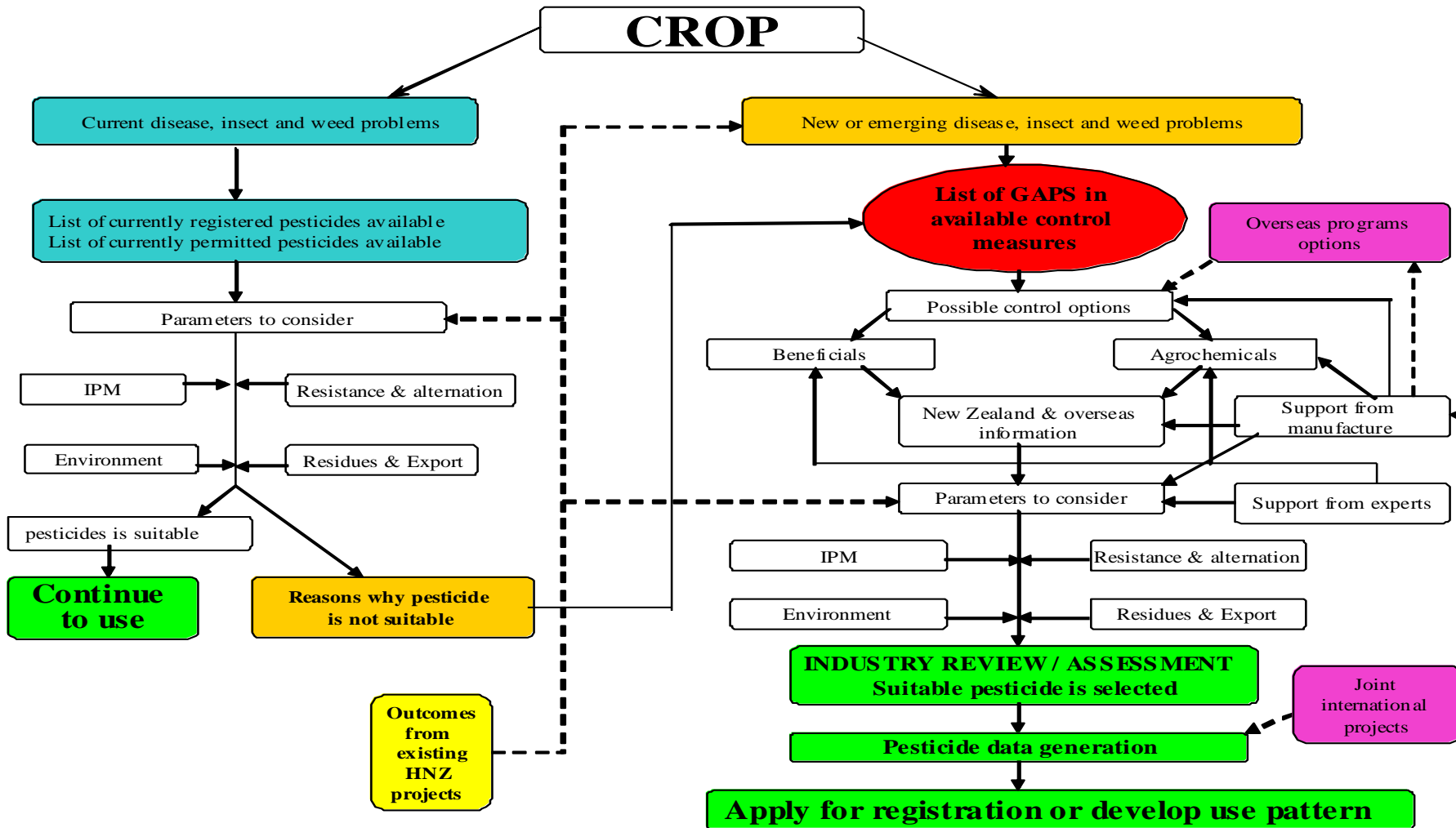
Thanks go to the many industry people who contributed information and collaborated on the review of this report.

^Trademark



## 6. Appendices

**DIAGRAM 1:** The Strategic Agrichemical Review Process



**Appendix 2 – currently available fungicides in brassica leafy vegetable.**

Disease	Crops	Active ingredient	WHP (H) days	WHP (G) days	Chemical Group
Alternaria leaf spot	Brassica leafy (listed)	Azoxystrobin (PER13123, expires Mar 2014)	7	1	11
	Brassica leafy (listed)	iprodione	7	7	7
Anthracnose	Brassica leafy (listed)	Mancozeb (PER12016, expires Mar2015)	14	-	M3
Black rot (Xanthomonas campestris pv. Campestris) (Bacterial disease)	Brassica leafy	Copper (as copper ammonium complex)	1	-	M1
Cercospora leaf spot	Brassica leafy, field grown	Propiconazole (PER14479, expires Oct 2017)	28	-	3
	Brassica leafy (listed)	Zineb (PER10845, expires Mar 2015)	10	-	M3
Damping off	Brassica leafy (listed)	Phosphorous (PER14184)	-	-	33
Downy mildew	Brassica leafy	Copper (as copper ammonium complex)	1	-	M1
	Brassica leafy	Copper (PER14038, expires Sept 2023)	1	-	M1
	Brassica leafy	copper + metalaxyl – RIDOMIL GOLD PLUS	14	-	M3 + 4
	Brassica leafy (listed)	Phosphorous (PER14184)	-	-	M3
	Brassica leafy (listed)	Zineb (PER10845, expires Mar 2015)	10	-	M3
Grey mould (Botrytis)	Brassica leafy (listed)	iprodione	7	7	7
	Leafy vegetables	Penthiopyrad (FONTELIS)	-	-	7
Peppery leaf spot ( <i>Pseudomonas syringae</i> pv. <i>Maculicola</i> ) (Bacterial disease)	Brassica leafy	Copper (as copper ammonium complex)	1	-	M1
Powdery mildew	Leafy vegetables	Penthiopyrad (FONTELIS)	-	-	7
	Brassica leafy (listed)	potassium bicarbonate (PER13695, exp 09/17)	-	-	M2
Ring spot ( <i>Mycosphaerella brassicicola</i> )	Brassica leafy	Copper (as copper ammonium complex)	1	-	M1
Rust	Vegetables	Copper (as oxychloride)	1	-	M1
	Brassica leafy, field grown	Propiconazole (PER12054, expires Aug 2014)	28	-	3
Sclerotinia	Brassica leafy	Cyprodinil + Fludioxonil (SWITCH)	7	-	9+12
	Brassica leafy (listed)	iprodione	7	7	7
	Brassica leafy (listed)	Boscalid (PER13897, expires Jun 2014, now on label)	7	14 **	3
	Brassica leafy	Penthiopyrad (FONTELIS)	-	-	7
Septoria	Brassica leafy (listed)	Mancozeb (PER12016, expires Mar2015)	14	-	M3
	Brassica leafy, field grown	Propiconazole (PER14479, expires Oct 2017)	28	-	3
White blister	Brassica leafy (listed)	Azoxystrobin (PER13123, expires Mar 2014)	7	1	11
	Brassica leafy	copper + metalaxyl – RIDOMIL GOLD PLUS	14	-	M3 + 4

\*Do not graze or cut for stock food \*\*export

**Appendix 3 – currently available insecticides in brassica leafy vegetable.**

<b>Insect</b>	<b>Crop</b>	<b>Active ingredient</b>	<b>WHP (H) Days</b>	<b>WHP (G) Days</b>	<b>Chemical Group</b>
African black beetle	Brassica leafy	Chlorpyrifos (PER14583, expires Mar 2019)	-	-	1B
Aphids	Brassica leafy (listed)	Paraffinic oil and petroleum oil (see permit PER12221, exp11/17)	1	-	1
		Imidacloprid (PER14584, expires Mar 2019)	3	-	4A
	Asian greens	Sulfoxaflor (TRANSFORM)	3	-	4c
Armyworm ( <i>Spodoptera</i> spp.)	Vegetables	Bacillus thuringiensis	-	-	11C
Budworm ( <i>Helicoverpa</i> )	Brassica leafy	Bifenthrin (PER13700, not for general use)	**	-	3A
Cabbage aphid ( <i>Brevicoryne brassicae</i> )	All	Chlorantraniliprole + thiamethoxam (DURIVO)	28	-	4A + 28
	Cole crops	Chlorpyrifos	5	-	1B
	Chinese cabbage	Pirimicarb	2	-	1A
Cabbage centre grub ( <i>Hellula hydralis</i> )	Chinese cabbage	Prothiofos	7	-	1B
	Brassica leafy (listed)	Spinetoram (SUCCESS NEO)	3	-	5
	Brassica leafy	Chlorantraniliprole	3	-	28
	All	Chlorantraniliprole + thiamethoxam (DURIVO)	28	-	4A + 28
Cabbage cluster caterpillar ( <i>Crociodolomia pavonana</i> )	Cole crops	Chlorpyrifos	5	-	1B
	Brassica leafy	Chlorantraniliprole	3	-	28
	All	Chlorantraniliprole + thiamethoxam (DURIVO)	28	-	4A + 28
	Brassica leafy (listed)	Spinetoram (SUCCESS NEO)	3	-	5
Cabbage leafminer ( <i>Liriomyza brassicae</i> )	Brassica leafy	Chlorantraniliprole	3	-	28
Cabbage moth ( <i>Plutella xylostella</i> )	Chinese cabbage, kale	Alpha-cypermethrin	1	-	3A
	Vegetables	Bacillus thuringiensis	-	-	11C
	Cole crops	Chlorpyrifos	5	-	1B
	Chinese cabbage	Cypermethrin	1	-	3A
	Chinese cabbage	Prothiofos	7	-	1B
Cabbage white butterfly ( <i>Pieris rapae</i> )	Chinese cabbage, kale	Alpha-cypermethrin	1	-	3A
	Vegetables	Bacillus thuringiensis	-	-	11C
	Brassica leafy	Chlorantraniliprole	3	-	28
	All	Chlorantraniliprole + thiamethoxam (DURIVO)	28	-	4A + 28
	Field grown brassica leafy (listed)	Chlorfenapyr (per14292, expires march 2016)			13a
	Cole crops	Chlorpyrifos	5	-	1B
	Chinese cabbage	Cypermethrin	1	-	3A
	Brassica leafy, field and protected	Flubendiamide	1	-	28
Chinese cabbage	Prothiofos	7	-	1B	

Insect	Crop	Active ingredient	WHP (H) Days	WHP (G) Days	Chemical Group
	Brassica leafy (listed)	Spinetoram (SUCCESS NEO)	3	-	5
Cluster caterpillar ( <i>Spodoptera litura</i> )	Chinese cabbage, kale	Alpha-cypermethrin	1	-	3A
	Cole crops	Chlorpyrifos	5	-	1B
	Chinese cabbage	Prothiofos	7	-	1B
	Brassica leafy (listed)	Spinetoram (SUCCESS NEO)	3	-	5
	Brassica leafy	Chlorantraniliprole	3	-	28
	Chinese cabbage	Cypermethrin	1	-	3A
	Brassica leafy, field and protected	Flubendiamide	1	-	28
Cotton bollworm ( <i>Helicoverpa armigera</i> )	Brassica leafy	Chlorantraniliprole	3	-	28
Diamondback moth ( <i>Plutella xylostella</i> )	Brassica leafy	Chlorantraniliprole	3	-	28
	All	Chlorantraniliprole + thiamethoxam (DURIVO)	28	-	4A + 28
	Brassica leafy (listed)	Emamectin - proclaim (per11994, expires may 2014)	3	*	6
	Brassica leafy, field and protected	Flubendiamide	1	-	28
	Field grown brassica leafy (listed)	Chlorfenapyr (per14292, expires march 2016)	14	*	13a
	Brassica leafy (listed)	Spinetoram (SUCCESS NEO)	3	-	5
False wireworms, wireworms	Brassica leafy	Chlorpyrifos (PER14583, expires Mar 2019)	-	-	1B
Green peach aphid ( <i>Myzus persicae</i> )	Chinese cabbage	Pirimicarb	2	-	1A
	Brassica leafy (listed)	Spirotetramat (MOVENTO)	3	-	23
	All	Chlorantraniliprole + thiamethoxam (DURIVO)	28	-	4A + 28
Greenhouse whitefly ( <i>Trialeurodes vaporariorum</i> )	All	Chlorantraniliprole + thiamethoxam (DURIVO)	28	-	4A + 28
Green mirid	Brassica leafy (listed)	Paraffinic oil and petroleum oil (see permit PER12221, exp11/17)	1	-	1
Green vegetable bug	Brassica leafy (listed)	Paraffinic oil and petroleum oil (see permit PER12221, exp11/17)	1	-	1
Grey cabbage aphid	Brassica leafy (listed)	Spirotetramat (MOVENTO)	3	-	23
Grey cluster bug	Brassica leafy (listed)	Paraffinic oil and petroleum oil (see permit PER12221, exp11/17)	1	-	1
Helicoverpa	Chinese cabbage, kale	Alpha-cypermethrin	1	-	3A
	Vegetables	Bacillus thuringiensis	-	-	11C
	Brassica leafy	Chlorantraniliprole	3	-	28
	All	Chlorantraniliprole + thiamethoxam (DURIVO)+	28	-	4A + 28
	Field grown brassica	Chlorfenapyr (per14292,			13a

Insect	Crop	Active ingredient	WHP (H) Days	WHP (G) Days	Chemical Group
	leafy (listed)	expires march 2016)			
	Chinese cabbage	Cypermethrin	1	-	3A
	Brassica leafy (listed)	Emamectin - PROCLAIM (PER11994, expires May 2014)	3	*	6
	Brassica leafy, field and protected	Flubendiamide	1	-	28
	Brassica leafy	Helicoverpa NPV	-	-	Biological
	Chinese leafy vegetables (bok choy, choy sum, chinese cabbage)	Indoxacarb	7	*	22a
	Chinese cabbage	Prothiofos	7	-	1B
	Brassica leafy (listed)	Spinetoram (SUCCESS NEO)	3	-	5
Leaf hoppers	Brassica leafy (listed)	Paraffinic oil and petroleum oil (see permit PER12221, exp11/17)	1	-	1
Light brown apple moth	Vegetables	Bacillus thuringiensis	-	-	11C
Loopers	Vegetables	Bacillus thuringiensis	-	-	11C
	Brassica leafy (listed)	Spinetoram (SUCCESS NEO)	3	-	5
Mites	Brassica leafy (listed)	Paraffinic oil and petroleum oil (see permit PER12221, exp11/17)	1	-	1
Plague thrips	Brassica leafy (listed)	Alpha-cypermethrin (PER13090, expires May 2015, PER14433, exp Jun 2017)	1	-	3A
Redlegged earth mite	Brassica leafy (listed)	Alpha-cypermethrin (PER13090, expires May 2015, PER14433, exp Jun 2017)	1	-	3A
Rutherglen bug	Brassica leafy (listed)	Paraffinic oil and petroleum oil (see permit PER12221, exp11/17)	1	-	1
Silverleaf whitefly ( <i>Bemisia tabaci</i> )	Brassica leafy (listed)	Spirotetramat (MOVENTO)	3	-	23
	All	Chlorantraniliprole + thiamethoxam (DURIVO)	28	-	4A + 28
Soybean looper ( <i>Thysanoplusia orichalcea</i> )	Brassica leafy	Chlorantraniliprole	3	-	28
	All	Chlorantraniliprole + thiamethoxam (DURIVO)	28	-	4A + 28
	Brassica leafy, field and protected	Flubendiamide	1	-	28
Thrips	All food crops	Methyl bromide PER11092, PER10145 (not for persons generally)	3	-	8A
Thrips (not WFT)	Brassica leafy (listed)	Imidacloprid (PER14584, expires Mar 2019)	3	-	4A
Tomato thrips ( <i>Frankiniella schultzei</i> )	All	Chlorantraniliprole + thiamethoxam (DURIVO)	28	-	4A + 28
Two spotted mite	Brassica leafy	Bifenthrin (PER13700, not for general use)	**	-	3A
	Field grown brassica leafy (listed)	Chlorfenapyr (per14292, expires march 2016)			13a

<b>Insect</b>	<b>Crop</b>	<b>Active ingredient</b>	<b>WHP (H) Days</b>	<b>WHP (G) Days</b>	<b>Chemical Group</b>
Vine moth	Vegetables	Bacillus thuringiensis	-	-	11C
Western flower thrips ( <i>Frankiniella occidentalis</i> )	Brassica leafy (listed)	Spinetoram (SUCCESS NEO)	3	-	5
	Brassica leafy	Abamectin	3	-	6
	All	Chlorantraniliprole + thiamethoxam (DURIVO)	28	-	4A + 28
Whitefly	Brassica leafy (listed)	Imidacloprid (PER14584, expires Mar 2019)	3	-	4A
Greenhouse whitefly	Asian greens	Sulfoxaflor (TRANSFORM)	3	-	4c

\*Do not graze or cut for stock food

\*\*permit for seed crops only

**Appendix 5 – currently available herbicides in brassica leafy vegetable.**

<b>Weed</b>	<b>Crops</b>	<b>Active ingredient</b>	<b>WHP (H) days</b>	<b>WHP (G) days</b>	<b>Chemical group</b>
Grass weeds	Brassica leafy (listed)	Clethodim (PER11848, expires Sept 2015)	28	-	A
Grass weeds on product label	Brassica leafy (listed)	Fluazifop-P-butyl (PER12017, expires Jun 2016)	28	*	A
Various grass and broadleaf	Brassica leafy	Chlorthal-dimethyl	-	*	D
Various grass and broadleaf	Chinese cabbage	Metolachlor	-	*	K
Various grass and broadleaf	Brassica leafy (listed)	S-metolachlor (PER13154, expires Mar 2017)	-	-	K
Various grass and broadleaf	Brassica leafy (listed)	Pendimethalin (PER14127, expires Aug 2018)	-	-	D
Grass and broadleaf weeds on product label	Brassica leafy (listed)	Propachlor (PER12008, expires Sept 2015)	-	-	K

\*Do not graze or cut for stock food