Brassica Vegetables

Strategic Agrichemical Review Process
2011-2014

HAL Projects - MT10029 & VG12081

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February 2014

Horticulture Australia project no:
MT10029 – Managing pesticide access in horticulture.
VG12081 - Review of vegetable SARP reports.

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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 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:
15 February 2014

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Contents

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 brassicas were conducted in Queensland, South Australia, Tasmania, Victoria and Western Australia as part of combined vegetable meetings in 2008, 2010 and 2011. The results of the process provide the brassica 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 soft rot	*Pseudomonas* spp., *Erwinia caratovora*
Downy mildew	*Hyaloperonospora parasitica*
White blister	*Albugo candida*

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.

INSECTS

Insects identified as high priorities:

Insect (common name)	**Insect (scientific name)**
Aphids	*Brevicoryne brassicae, Myzus persicae, Lipaphis pseudobrassicae*
Cabbage-centre grub	*Hellula hydralis*
Diamondback moth	*Plutella xylostella*

As a generalisation there is a need for different chemistry to be used for alternation, in particular to reduce resistance risks. However for some pests, such as aphids, control can be simple if IPM is used. This reduces the priority of the pest for action on new insecticides.

For Lepidoptera pests, there are many registered options already available, but resistance is associated with some product groups. Potential new chemistry from different groups has been identified for some pests. Efficacy and residues need to be evaluated before pursuing. Any insecticides selected need to fit in with IPM, with insecticide resistance management strategies, and need to be considered for trade impacts.

WEEDS

Most weeds can be controlled with currently available herbicides but growers would welcome inclusion of brassicas in new chemical registrations.
There were no weeds identified as a high priority for control during the SARP meetings but some growers have mentioned wild radish (*Raphanus raphanistrum*) and wild turnip (*Brassica tournefortii*), as weeds of concern due to spread and difficulty in control in WA.

Some growers use a combination of pre plant herbicides followed by post plant herbicides. Growers express concerned regarding build-up of herbicides in soils under these circumstances.

Growing weed resistance is a problem. For example wild radish populations have developed resistance to herbicides in the mode-of-action (MOA) Groups B, C, F and I. Group B resistance is the most common, followed by Group F.

Growers should be mindful of current and developing resistance management strategies. Some strategies to consider are use of sequences that avoid use of the same product twice in a growing season, accuracy in timing and application rates, targeted treatment, treatment of small weeds and the use of cultivation techniques to reduce herbicide use.

2. The Australian brassica vegetable industry

The Australian brassica vegetable industry is a mature, innovative and resourceful horticultural industry. Consumption of brassica vegetables has risen in recent years with promotion of health benefits.

Crops included in the brassica vegetables group include:

Name	**Scientific name**
Broccoli	*Brassica oleracea var. italica*
Brussels Sprouts	*Brassica oleracea* var. *gemmifera*
Cabbages	*Brassica oleracea* var. *capitata*
Cauliflower	*Brassica oleracea* var. *botrytis*

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

- Sydney Basin, Riverina and Bathurst (NSW)
- Melbourne Metro area and Bairnsdale (Vic)
- Granite Belt, Lockyer Valley, Fassifern Valley, Darling Downs and Mareeba (Qld)
- Perth Metro outer areas and Manjimup (WA)
- North Adelaide Plains (SA)
- Devonport (Tas)

Crops statics for the brassica vegetables group are:

Name	**Plantings**	**Production**	**Value**
Broccoli	7090 ha (2011)	46112 T (2011)	$104.6 m (2011)
Brussels Sprouts	189 ha (2009)	3534 T (2009)	
Cabbages	2060 ha (2009)	78075 T (2009)	$44.2 m (2009)
Cauliflower	3118 ha (2011)	66932 T (2011)	$42.9 m (2011)

(Ausveg website 2013: www.ausveg.com.au)

Due to Australia's diverse weather conditions and the introduction of different varieties of brassica vegetable, the Australian industry is now able to supply the domestic market with fresh brassica vegetables throughout the year.

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 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. 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 as a major crop. The crop fits within the APVMA crop group 010: Brassica vegetables.

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

3.2. Minor use permits and registration

Brassicas are classified as a major crop by the APVMA. Therefore access to minor use permits can be difficult, and will only be granted for limited uses within the crop. 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 industry is for manufacturers to register new pesticides uses in the crop.

3.3. Methods

The SARP was conducted in Queensland, South Australia, Tasmania, 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 brassicas 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 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

4.1 Diseases of brassica vegetables

Common name	Scientific name
HIGH PRIORITY	
Bacterial soft rot	*Pseudomonas* spp., *Erwinia caratovora*
Downy mildew	*Hyaloperonospora parasitica*
White blister	*Albugo candida*
MODERATE PRIORITY	
Base rot or Rhizoctonia rot or Wirestem	*Rhizoctonia solani*
Black rot	*Xanthomonas campestris pv. campestris*
Club root	*Plasmodiophora brassicae*
Grey mould	*Botrytis cinerea*
Peppery leaf spot	*Pseudomonas syringae pv. maculicola*
Ring spot	*Mycosphaerella brassicicola*
LOW PRIORITY	
Alternaria leaf spot	*Alternaria brassicicola*
Anthracnose	*Colletotrichum / Glomerella* spp.
Cercospora leaf spot	*Cercospora* spp.
Damping off	*Pythium* spp., *Phytophthora* spp., *Fusarium* spp., *Rhizoctonia* spp.
Sclerotinia rot	*Sclerotinia* spp.
Biosecurity risk	
None listed	

Opinion on the priority of diseases can vary across the industry. As an example, Rhizoctonia rot / wirestem was considered a moderate priority in the SARP meetings but is consider by Victorian and South Australian growers as a high priority in winter months. A number of products are registered for Rhizoctonia (chlorothalonil, mancozeb, iprodione, hydrogen peroxide + peroxyacetic acid (PERATEC PLUS^).

Alternaria leaf spot was ranked as a low priority but is reported to cause significant issues in Baby broccoli crops (bunching broccoli or broccolini types in southern areas during coooler seasons. Chlorothalonil, copper, mancozeb and zineb are registered to control Alternaria, but not all across the entire brassica group.

Similarly, Club root was a moderate priority for most growers but can cause major crop losses in some cases. Fluazinam is registered for control of this disease.

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

Bacterial soft rot (*Pseudomonas* spp., *Erwinia caratovora*)

Bacterial soft rots are predominantly caused by the bacteria, *Pseudomonas* spp. and *Erwinia caratovora*, but other oft rot bacteria may also be involved. The bacteria produce enzymes which destroy the 'cementing' material between cells resulting in a watery, slimy rot.
Conditions favourable to soft rot development are high humidity, abundant rainfall or irrigation, poor drying conditions and warm temperatures. They are secondary invaders following infection by other pathogens or through tissue damage by insects or weather conditions.

- Bacterial soft rot is considered a major-moderate problem in Qld and WA and a moderate problem in Vic and Tas.

- There are no products **registered** or **permitted** for the control of Bacterial soft rot in brassica vegetables. However copper products are registered for *Pseudomonas syringae* in brassicas.

    - Copper (various products) - Group M1 protectant fungicide
        - Registered for the control of other diseases in brassicas and can commonly be used 1-5 times per crop.
        - Not used specifically for this disease, but controlled when product used for other disease control.
        - Reported as sometimes effective.

Downy mildew (*Hyaloperonospora parasitica*)

Downy mildew causes yellow-green spots on leaves with a white fungal growth on the underside. *Hyaloperonospora* requires cool, moist weather for infection and disease development to take place. The pathogen survives between crops on weed hosts or as resilient oospores in crop residue. The spores produced are carried by the wind or by rain splash contaminating new areas of the crop.

This disease is most serious on young seedlings; if cotyledons and the first true leaves are severely infected, the young plant may die.

There are many varieties of brassica vegetables available that are resistant to downy mildew.

- Downy mildew is considered a major-moderate problem in Vic and Tas (mainly in nurseries and a moderate problem in Qld and WA.
    - Growers alternate the use of different fungicides.
    - Growers are in need of other protective/curative fungicides to allow effective product alternation.

- Fungicides **registered** for the control of Downy mildew in brassica vegetables are:
    - Copper (various) - Group M1 protectant fungicide
        - Used in all brassicas.
        - Effective as a protectant in moderate pressure.
        - Also provides some control of White blister.
        - Moderately harmful to beneficial insects.

- Mancozeb (various) - Group M3 protectant fungicide
  - Commonly used 1-5 times per crop.
  - Used in all brassicas.
  - Effective as a protectant under moderate pressure.
  - Not effective in Vic & Tas under high pressure.
  - Has some effect on beneficial insects.
- Metalaxyl + copper as hydroxide (RIDOMIL^ GOLD PLUS) – Group 4 + M3 systemic, protective and curative fungicide
  - For use in brassica vegetables, including brassica leafy vegetables.
  - Commonly used 0-2 times per crop, in some cases primarily for white blister.
  - Used as a protectant / curative fungicide.
  - Used in all brassicas.
  - Used in pressure situations.
  - Reported as very effective.
  - There are restrictions in the number of applications.
  - Growers concerned about resistance to metalaxyl developing.
- Metiram (POLYRAM^) - Group M3 protectant fungicide
  - Occasionally used 0-2 times per crop.
  - Used in all brassicas.
  - Effective as a protectant in moderate pressure.
  - Minimal effect on beneficial insects.
- Hydrogen peroxide + peroxyacetic acid (PERATEC PLUS^) - Group M fungicide
  - Maximum 5 sprays per crop
  - Controls both downy mildew and white blister
  - 1 day witholding period
- Zineb (ZINEB^) - Group M3 protectant fungicide
  - Not used.

- Fungicides listed for the control of Downy mildew in brassica vegetables via **permits** are:
  - Metalaxyl-M + mancozeb (RIDOMIL GOLD MZ, PER14045) - Groups 4 + M3 systemic, protective and curative fungicide
    - For use in broccoli, cauliflower and Brussels sprout only at higher than label rate.
    - Expires 31-Mar-18.
  - Phosphorous acid (various, PER11951) - Group 33 protective and systemic fungicide - enhances plants natural defence mechanisms
    - Protective and systemic fungicide - enhances plants natural defence mechanisms.
    - When used, commonly applied 1-5 times per crop.
    - For use in broccoli, cauliflower and Brussels sprout only.
    - Mixed reports of efficacy. A number of growers find the product ineffective while others find regular use provides satisfactory efficacy.
    - Expires 31-Mar-15. Growers want the permit to continue.

- **Potential** fungicides for control of Downy mildew in brassicas:
  - Azoxystrobin (various) – Group 11 protectant and curative fungicide
    - Permit expiration March 2014, unlikely to be renewed
    - Registered or Downy mildew control in cucurbits, grapes, leeks, poppies & ornamentals. Permit in brassica leafy vegetables for White blister.
    - Registered overseas for Downy mildew control in various vegetables.
    - Syngenta may be registering this use however there is concern in the industry about development of resistance to this group of fungicides

  Several chemicals are registered for downy mildew control in grapes. These may be efficacious; however different organisms cause the disease in different crops. Therefore the use would need to be tested.
  - Captan (various) – Group M4 protectant/curative fungicide
    - Registered in Aust for Downy mildew control in grapes
    - Registered overseas for Downy mildew control in various vegetables.
    - Possible option as a different chemical group.
    - Need to check for efficacy and residues before pursuing.

- Chlorothalonil (various) – Group M5 protectant fungicide
  - Registered in Aust for Downy mildew control in various vegetables.
  - Registered overseas for Downy mildew control in various vegetables.
  - Possible option as a different chemical group.
  - Need to check for efficacy and residues before pursuing.
- Mandipropamid (REVUS^) – Group 40 protectant fungicide
  - Registered in Aust for Downy mildew control in grapes.
  - Registered overseas for Downy mildew control in various crops.
  - Possible option as a different chemical group.
  - Need to check for efficacy and residues before pursuing.
  - Project to investigate this use proposed to HAL.

Chemistry that is new to Australia and offers potential down mildew control in brassicas:

- Ametoctradin + dimethomorph (ZAMPRO^) – FRAC code 21+ Group 40 – contact and residual fungicide
  - New BASF chemistry registered for downy mildew in other crops.
  - 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

- Cyazofamid (likely to be called RANMAN^?, new ISK/FMC fungicide) – Group 21 fungicide – first new product registration under assessment at the APVMA studies on potatoes, spinach, mustard greens, broccoli for downy mildew and white blister,
  - Approved for use on potatoes, tomatoes, cucurbits, cauliflower, cabbage, broccoli, carrots and many other vegetables.
  - Contact and residual activity
  - Some IR4 project work underway

- 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 leaves and floral parts, 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 spores that can be carried by winds or splashing water onto neighbouring host plants. Severely infected leaves can wither and die.

Albugo only affects Brassica species, with significant economic damage in crops in which the leaves and floral parts are marketed.

As White blister is dependent on cool, wet conditions, it is consistently more severe during winter and early spring months.

- White blister is considered a major problem in all states.
  - Growers would like other protective/curative fungicides for alternation.
  - Growers are concerned at resistance developing to current fungicides.
  - Current fungicide control options are limited
  - Varietal tolerance varies.

- Fungicides **registered** for the control of White blister in brassica vegetables are:
  - Hydrogen peroxide + peroxyacetic acid (PERATEC PLUS^) - Group M fungicide

        - Maximum 5 sprays per crop
        - Controls both downy mildew and white blister
        - 1 day witholding period

    - Metalaxyl + copper as hydroxide (RIDOMIL^ GOLD PLUS) – Group 4 + M3 systemic, protective and curative fungicide
        - For use in brassica vegetables, including brassica leafy vegetables.
        - Used as a protectant / curative fungicide.
        - Used in all brassicas.
        - Used in pressure situations.
        - Reported as very effective.
        - A maximum of 2 applications are allowed per year, as part of a resistance management strategy.
        - Growers concerned about the potential of development of resistance to metalaxyl.

- Fungicides listed for the control of White blister in brassica vegetables via **permit** are:

    - Metalaxyl-M + mancozeb (RIDOMIL GOLD MZ, PER14045) - Groups 4 + M3 systemic, protective and curative fungicide
        - For use in broccoli, cauliflower and Brussels sprout only at higher than label rate.
        - Expires 31-Mar-18.

- **Potential** fungicides for the control of White blister in brassicas:

    - Cyazofamid (likely to be called RANMAN^?, 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

    - Azoxystrobin (various) – Group 11 protectant and curative fungicide
        - Permit expiration March 2014, unlikely to be renewed
        - Registered or Downy mildew control in cucurbits, grapes, leeks, poppies & ornamentals. Permit in brassica leafy vegetables for White blister.
        - Registered overseas for Downy mildew control in various vegetables.
        - Syngenta may be registering this use however there is concern in the industry about development of resistance to this group of fungicides

    - Pyraclostrobin (CABRIO^) – Group 11 protectant and curative fungicide
        - A previous permit expired in 2012.
        - The active was reported as more efficacious than azoxystrobin. It was used 0-2 times per crop as a protectant / curative fungicide.
        - Nufarm/BASF do not seem to be registering the use
        - Resistance concerns limit the potential of the product

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
Bacterial soft rot *(Pseudomonas* spp*., Erwinia caratovora)*	**Currently registered fungicides:** None **Currently permitted fungicides:** None **Fungicide Gaps** New chemistry with IPM fit. **Potential fungicide solutions** Copper – registered for control of other *Pseudomonos* species in brassicas **Non-chemical options** Good crop rotation and cultivation practices limit damage: Choose tolerant varieties – these tend to have domed and tight heads where water runs off. Don't grow susceptible crops on infected areas for two years. Avoiding harvesting in wet conditions. Minimise plant damage. Destroy infected plants
Downy mildew *(Peronospora farinosa)*	**Currently registered fungicides** Copper (various) – moderately harmful to beneficials, reduced efficacy under high pressure. Hydrogen peroxide + peroxyacetic acid (PERATEC PLUS^) – 1 day WHP period advantageous. Mancozeb – efficacy various with disease pressure, moderately harmful to beneficials. Metalaxyl-M + mancozeb (RIDOMIL^ GOLD MZ)– common use, good efficacy. Metiram – Effective, minimal effect on beneficials. Zineb – not reported to be used. **Currently permitted fungicides** Phosphorous acid (various, PER11951, expires Mar 2015) – useful in rotations. **Fungicide Gaps** New chemistry with IPM fit and short WHP. Some registrations are not for all members of the crop group – there may be potential for extrapolation to the whole group in some cases. **Potential fungicide solutions** Efficacy and residues need to be evaluated. Cyazofamid (likely to be called RANMAN^?, 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^) – new BASF chemistry registered for downy mildew in other crops. Captan (various) - new use, efficacy and residues to be evaluated before pursuing. Chlorothalonil) - new use, efficacy and residues to be evaluated before pursuing. Mandipropamid (REVUS^) - new use, efficacy and residues to be evaluated before pursuing. **Non-chemical options** Crop rotation. Plant spacing to improve air flow and spray penetration.

Disease	Control option
White blister *(Albugo candida)*	**Currently registered and permitted fungicides** Metalaxyl-M + mancozeb (RIDOMIL^ GOLD MZ)– common use, good efficacy. **Fungicide Gaps** New chemistry for alternation and with IPM fit and short WHP. **Potential fungicide solutions** Efficacy and residues need to be evaluated. Cyazofamid (likely to be called RANMAN^?, new ISK/FMC Fungicide) – first new product registration under assessment at the APVMA. Hydrogen peroxide + peroxyacetic acid (PERATEC PLUS^) – 1 day WHP period advantageous. Pyraclostrobin (CABRIO^) – good efficacy, previous permit not renewed. **Non-chemical options** None identified. This should be discussed in future SARPs

Currently available herbicides

See Appendix 2

4.2 Insects of brassica vegetables

Common name	Scientific name
HIGH PRIORITY	
Aphids	*Brevicoryne brassicae, Myzus persicae, Lipaphis pseudobrassicae*
Cabbage-centre grub	*Hellula hydralis*
Diamondback moth	*Plutella xylostella*
MODERATE PRIORITY	
Cabbage white butterfly	*Pieris rapae*
Cluster caterpillar	*Spodoptera litura*
Cotton whitefly	*Bemisia tabaci*
Helicoverpa	*Helicoverpa spp.*
Rutherglen bug	*Nysius vinitor*
Silverleaf whitefly	*Bemisia tabaci*
Thrips	*Thrips* spp.
LOW PRIORITY	
African black beetle	*Heteronychus arator*
Australian cabbage looper	*Chrysodeixis subsidens*
Black field and Mole cricket	*Teleogryllus commodus, Gryllotalpidae*
Cabbage cluster caterpillar	*Crocidolomia pavonana*
Earwigs	*Dermaptera*
Green vegetable bug	*Nezara viridula*
Looper caterpillars	*Chrysodeixis* spp.
Redlegged earth mite	*Halotydeus destructor*
Staphylinid beetle	*Staphylinidae*
Vegetable weevil	*Listroderes difficilis*
Western flower thrips	*Frankliniella occidentalis*
Biosecurity risk	
None listed	

4.2.1 High priority insects

Aphids - Cabbage aphid (*Brevicoryne brassicae*), Green peach aphid (*Myzus persicae*) & Turnip aphid (*Lipaphis pseudobrassicae*)

Green peach aphids are a yellow-green aphid with prominent tubercles at the base of the antennae and are the most common aphid pest of brassicas. Green peach aphid and turnip aphid tend to be more randomly dispersed around the plants than the dense colonies of the cabbage aphid.
When populations are heavy, green peach aphid can stunt seedlings. Economic damage rarely occurs on older plants because green peach aphids tend to feed on older leaves and rarely enter heads of broccoli, cauliflower, cabbage, or Brussels sprouts.

- Aphids are overall considered a moderate-major problem, although some Victorian growers do not consider aphids a priority pest

- Insecticides **registered** for the control of aphids in brassicas are:
  - Acephate (various products) – Group 1B contact/systemic insecticide
    - No current reports of its use.
    - Insecticide under review by APVMA.
  - Chlorpyrifos (various) – Group 1B contact and systemic insecticide
    - Not used for this pest.
    - Insecticide under review by APVMA.
  - Diazinon (various) – Group 1B contact and systemic insecticide
    - Rarely used.
    - Not used specifically for this pest, but provides control when used for other pests sprayed - Qld only.
    - Effective.
    - Not IPM compatible.
    - Insecticide under review by APVMA.
  - Imidacloprid (various) - Group 4A contact and systemic insecticide
    - Commonly used, up to twice per crop for the control of all aphids.
    - Reported to be very effective.
    - Some growers claim that it is disruptive to IPM.
  - Maldison (various) – Group 1B contact and systemic insecticide
    - Rarely used.
    - Not used specifically for this pest, but provides control when used for other pests sprayed.
    - Effective.
    - Not IPM compatible.
    - Insecticide under review by APVMA.
    - Only cabbage and cauliflower are listed on the label
  - Phorate (various) - Group 1B contact and systemic insecticide
    - Not used.
  - Pirimicarb (various) - Group 1A contact and systemic insecticide
    - Commonly used, up to twice per crop for the control of all aphids. Not effective against Green Peach Aphid.
    - Reported to be very effective.
    - Reported as having good compatibility with many beneficial insects but has a significant impact on wasp populations.
    - Some reports of resistance.
  - Pymetrozine (various) – Group 9B contact and systemic insecticide
    - Commonly used, up to twice per crop for the control of all aphids.
    - Reported to be very effective, but only if applied under ideal application conditions, poor results reported when applied at slightly sub optimal conditions. Much care needs to be taken to achieve fully efficacy.
    - Reported as having good compatibility with beneficial insects.
  - Spirotetramat (MOVENTO^) – Group 23 contact and systemic insecticide
    - Occasionally used once per crop for the control of all aphids.
    - Reported to be very effective.
    - Reported as having good compatibility with beneficial insects.
  - Sulfoxaflor (TRANSFORM^) – Group 4C insecticide
    - Field situations only.
    - May have adverse effects on parasitic wasps in IPM situations.

- Insecticides are listed for control of aphids in brassica vegetables via **permit**.
  - Petroleum (PER12221)
    - Controls a broad range of insects.

- **Potential** product for use on aphids:
  - Flonicamid (new ISK/FMC product)– Group 9C
    - First registration application in assessment at APVMA. Likely first registration on cucurbits
    - Aphicide
    - IR4 projects on brassica leafy vegetables / aphids, harlequin bug
    - Overseas registrations on aphids / brassica vegetables, root vegetables, tuberous and corm vegetables, cucurbit vegetables, hops, leafy vegetables, fruiting vegetables, pome fruit and stone fruit
    - Efficacy and residue data required

Lepidoptera - Cabbage-centre grub (*Hellula hydralis*) & Diamondback moth (*Plutella xylostella*)

Lepidoptera larvae mature in 10 to 14 days and spin a loose cocoon on leaves or stems for pupation. Adult moths lay their tiny, roundish eggs singly on the undersides of leaves; eggs are difficult to find. Although they may occur all year round, especially in coastal areas, diamondback moths are often abundant in spring and early summer, and populations may rise again in autumn.

Lepidoptera larvae infestations can damage the crowns or growing points of young plants; in the maturing plant the centre, hearts, buds, developing buttons/heads and under developed heads, and; leaves of both young and established plants. Economic loss results from slowed growth and damage to and contamination of the saleable item.

- The Lepidoptera pests Cabbage-centre grub and Diamondback moth are considered a high priority, though with some differences across the country: Cabbage centre grub is less of an issue in Qld and Diamondback moth is the major issue in Victoria.
- Resistance to some insect groups has reduced control options despite there being a range of actives registered. Additionally, not all actives have broad registrations across Lepidoptera.

- Insecticides **registered** for Lepidoptera pest control in brassica vegetables are:
  - Acephate (various products) – Group 1B contact/systemic insecticide
    - Occasionally used in some regions up to twice per crop.
    - Considered effective, but some level of resistance in some regions.
    - Controls a range of Lepidoptera.
    - IPM disruptive - high impact on beneficial insects and mites.

  - Alpha-cypermethrin (various) - Group 3A contact and systemic insecticide
    - Occasionally used in some regions up to twice per crop.
    - Considered effective, but some level of resistance in some regions.
    - Controls a range of Lepidoptera although not always with good efficacy on plutella.
    - IPM disruptive - high impact on beneficial insects and mites - use with caution.
  - Betacyfluthrin (various) - Group 3A contact and systemic insecticide
    - Occasionally used in some regions once per crop.
    - Considered effective, but some level of resistance in some regions.
    - Controls a range of Lepidoptera.
    - IPM disruptive - high impact on beneficial insects and mites.

  - Bacillus Thuringiensis var Kurstaki (Btk) (various) - Group 11C contact insecticide
    - Bt is commonly used.
    - Controls all Lepidoptera.
    - Very effective on small grubs, but needs regular reapplication.
    - UV sensitive.
    - IPM compatible - low impact on beneficial insects and mites.

- Chlorantraniliprole (various, including CORAGEN^) - Group 28 contact and systemic insecticide
  - Occasionally used in some regions up to twice per crop.
  - Controls all Lepidoptera.
  - Very effective.
  - IPM compatible - low impact on beneficial insects and mites.

- Chlorantraniliprole + thiamethoxam (DURIVO^) - Group 28 +4A contact and systemic insecticide
  - Latest released insecticide
  - Controls a range of Lepidoptera
  - Grower concerns about potential for resistance developing
  - Commonly used
  - One application per cop usually in nursery prior to farmer collection
  - IPM compatible – minimal impact on beneficial insects

- Chlorfenapyr (various) - Group 13 contact and systemic insecticide
  - Occasionally used in some regions up to twice per crop.
  - Considered effective.
  - Controls a range of Lepidoptera.
  - IPM disruptive - high impact on beneficial insects and mites.

- Cypermethrin (various) - Group 3A contact and systemic insecticide
  - Occasionally used in some regions 0-2 times per crop.
  - Considered effective, but some level of resistance in some regions.
  - Controls a range of Lepidoptera.
  - IPM disruptive - high impact on beneficial insects and mites.
  -
- Deltamethrin (various) - Group 3A contact and systemic insecticide
  - Occasionally used in some regions 0-2 times per crop.
  - Considered effective, but some level of resistance in some regions.
  - Controls a range of Lepidoptera.
  - IPM disruptive - high impact on beneficial insects and mites - use with caution.

- Emamectin (various) – Group 6 contact and systemic insecticide
  - Occasionally used in some regions 0-2 times per crop.
  - Reported as very effective.
  - Controls a range of Lepidoptera.
  - IPM compatible – low/moderate impact on beneficial insects and mites.
  - Resistance is now an issue in some areas.

- Fipronil (various) - Group 2B contact/systemic insecticide
  - Rarely used.
  - Considered effective.
  - Controls a range of Lepidoptera.
  - IPM disruptive - high impact on beneficial insects and mites.

- Flubendiamide (BELT^) – Group 28 contact and systemic insecticide
  - Commonly used in some regions up to twice per crop.
  - Controls all Lepidoptera.
  - Usually very effective. Some cases of irregular efficacy have been observed.
  - IPM compatible - low impact on beneficial insects and mites.

- Indoxacarb (various) - Group 22A contact and systemic insecticide
  - Occasionally used in some regions up to twice per crop.
  - Controls all Lepidoptera.
  - Very effective.
  - IPM compatible - variable impact on beneficial insects and mites.

- Lambda-cyhalothrin (various) - Group 3A contact and systemic insecticide
  - Occasionally used in some regions 0-1 x per crop.
  - Considered effective, but some level of resistance in some regions.
  - Controls a range of Lepidoptera.
  - IPM disruptive - high impact on beneficial insects and mites - use with caution.

- Maldison (various) – Group 1B contact and systemic insecticide
  - Occasionally used in some regions up to twice per crop.
  - Not IPM compatible.
  - IPM disruptive - high impact on beneficial insects and mites - use with caution.
  - Insecticide under review by APVMA.
  - Only cabbage and cauliflower are listed on the label

- Methomyl (various) - Group 1A contact and systemic insecticide
  - Only registered for Cabbage-centre grub.
  - Occasionally used in some regions up to twice per crop.
  - IPM disruptive - high impact on beneficial insects and mites - use with caution.

- Permethrin (various) - Group 3A contact and systemic insecticide
  - Rarely used.
  - Considered effective, but some level of resistance in some regions.
  - Controls a range of Lepidoptera.
  - IPM disruptive - high impact on beneficial insects and mites - use with caution.
  -
- Spinetoram (SUCCESS NEO^) - Group 5A contact and systemic insecticide
  - Commonly used in some regions up to four times per crop.
  - Very effective on a range of pests, including thrips. Controls all Lepidoptera.
  - IPM compatible.
  - Growers concerned with overuse - resistance.
  - IPM compatible - variable impact on beneficial insects and mites.

- No insecticides are available for the control of Lepidoptera pests in brassica vegetables via **permit.**

- **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+ 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. 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: 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

As a generalisation there is a need for different chemistry to be used for alternation, in particular to reduce resistance risks. However for some pests, such as aphids, control can be simple if IPM is used. This reduces the priority of the pest for action on new insecticides.

For Lepidoptera pests, there are many registered options already available, but resistance is associated with some product groups. Potential new chemistry from different groups has been identified for some pests. Efficacy and residues need to be evaluated before pursuing. Any insecticides selected need to fit in with IPM, with insecticide resistance management strategies, and need to be considered for trade impacts.

Disease	Control option
Aphids - Cabbage aphid (*Brevicoryne brassicae*), Green peach aphid (*Myzus persicae*) & Turnip aphid (*Lipaphis pseudobrassicae*)	**Currently registered insecticides** Acephate (various products) – Group 1B – no reports of use. Chlorpyrifos (various) – Group 1B – no reports of use. Diazinon (various) – Group 1B – provides control when used for other pests, not IPM compatible. Imidacloprid (various) - Group 4A – commonly used and efficacious. Maldison (various) – Group 1B – rarely used but efficacious, not IPM compatible. Phorate (various) - Group 1B – no reports of use. Pirimicarb (various) - Group 1A – commonly used, not efficacious on all aphids, variable impact on beneficials. Pymetrozine (various) – Group 9B – commonly used, requires careful application for efficacy, good IPM compatibility. Spirotetramat (MOVENTO^) – Group 23 - occasional use, efficacious, good beneficial compatibility. Sulfoxaflor (TRANSFORM^) – Group 4C insecticide - field situations only. **Currently permitted insecticides** Petroleum (PER12221) - broad efficacy **Insecticide Gaps** Resistance in some commonly used insecticides. New chemistry with IPM fit. **Potential insecticide solutions** Flonicamid (new ISK/FMC product)– Group 9C – efficacy and residue data required. **Non-chemical options** Weed control will assist management as aphids can live and breed in weeds adjacent to crops. Having a good IPM program will also help as beneficials such as wasps and ladybird can predate or parasitise aphids and reduce numbers.

Disease	Control option
Lepidoptera - Cabbage-centre grub (*Hellula hydralis*) & Diamondback moth (*Plutella xylostella*)	**Currently registered Lepidoptera insecticides** Acephate (various products) – Group 1B - occasional use, broad efficacy but some resistance, IPM disruptive. Alpha-cypermethrin (various) - Group 3A - occasional use, broad efficacy, though not always on Plutella, some resistance, IPM disruptive. Betacyfluthrin (various) - occasional use, broad efficacy but some resistance, IPM disruptive. Bacillus Thuringiensis var Kurstaki (Btk) (various) – commonly used, effective, IPM compatible. Chlorantraniliprole (various, including CORAGEN) Group 28 – growing use, effective, IPM compatible. Chlorantraniliprole + thiamethoxam (DURIVO^) Group 28+4A- growing use, effective, IPM compatible. Chlorfenapyr (various) - Group 13 - occasional use, broad efficacy, IPM disruptive. Cypermethrin (various) - Group 3A - occasional use, efficacious, disruptive to beneficials. Deltamethrin (various) - Group 3A - occasional use, broad efficacy but some resistance, IPM disruptive. Emamectin (various) - Group 6 - occasional use, broad efficacy but some resistance, IPM disruptive. Fipronil (various) - Group 2B – rarely used, effective, IPM disruptive. Flubendiamide (BELT) - commonly used, broad efficacy, IPM fit. Indoxacarb (various) - Group 22A - occasional use, broad efficacy, IPM compatible. Lambda-cyhalothrin (various) - Group 3A - occasional use, broad efficacy but some resistance, IPM disruptive. Maldison (various) - Group 1B - occasional use, occasional use, effective, IPM disruptive. Methomyl (various) - Group 1A - occasional use, occasional use, not IPM compatible. Permethrin (various) - Group 3A – rarely used, broad efficacy, some resistance, IPM disruptive. Spinetoram (SUCCESS NEO^) - Group 5A – commonly used, broad efficacy, IPM fit. **Currently permitted insecticides** None. **Insecticide Gaps** Concerns over overuse and potential for resistance developing in newer chemicals. **Potential insecticide solutions** 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 **Non-chemical options** IPM strategies – required to manage resistance.

Currently available insecticides

See Appendix 3

4.3 Weeds of brassica vegetable

Herbicides **registered** and used in brassica vegetables:

- Chlorthal-dimethyl (various) – Group D general knockdown and residual herbicide
  - Occasionally used - once per crop.
  - Effective in controlling most broadleaf weeds pre-emergent.
  - Some weeds need high rates for control, but not able to use as causes crop damage on lighter soils.

- Fluazifop-P as butyl (various) – Group A grass selective post-emergent herbicide
  - Commonly used - 0-2 times per crop.
  - Effective in controlling most annual summer and winter grass weeds post-emergent. Resistance in ryegrass an issue.
  - Controls most grass weeds. Does not control Winter grass (Poa annum).
  - Growers used high rates to spot spray for couch.

- Glufosinate-ammonium (various) – Group N pre-plant broad spectrum herbicide
  - Commonly used - 0-1 times per yr.
  - Used as a pre-plant total weed control. Very effective.

- Glyphosate (various) – Group M pre-plant general knockdown herbicide
  - Commonly used - 0-2 times per yr.
  - Works well as a pre-crop spray.

- Metolachlor (various) - Group K pre-plant residual herbicide
  - Occasionally used - once per crop.
  - Warning on label that crop retardation may occur on soils with low organic matter levels and in some Qld soils. Not registered in WA due to light soils - requested by growers.
  - Effective on a range of broadleaf weeds when used post-transplant.

- S-Metolachlor (various) - Group K pre-emergent residual herbicide.
  - Occasionally used - once per crop.
  - Applied immediately after transplanting
  - Warning on label that crop retardation may occur on soils with low organic matter levels and in some Qld soils.
  - Not registered in WA due to light soils - requested by growers.
  - Effective on a range of broadleaf weeds when used post-transplant.

- Oxyfluorfen (various) – Group G pre or post-emergent herbicide.
  - Commonly used - 0-1 times per crop.
  - Effective on a range of broadleaf weeds when used pre-plant.
  - Only used in transplanted broccoli, cabbage and cauliflower.
  - Some use in-crop against selected broadleaf weeds.
  - Crop burning can be a problem, possibly due to wetter use in nursery growing environments or soft leaves near growing parts of plants.

- Paraquat + diquat (various) - Group L pre-plant general knockdown herbicide
  - Occasionally used - 1-2 times per yr.
  - Used as a pre-plant total weed control. Very effective.
  - Herbicides under review by APVMA.

- Pendimethalin (various) - Group D residual herbicide
  - Occasionally used - 0-1 times per crop.
  - Effective on a range of broadleaf weeds when used pre-plant.
  - Only used in transplanted broccoli, cabbage and cauliflower.

- Propachlor (RAMROD^) - Group H selective post-emergent herbicide
  - Occasionally used - 0-1 times per crop.
  - Effective on a range of weeds when used post-transplant.
  - Only used in transplanted brassicas.

- Quizalofop-P-ethyl (various) - Group A grass selective post-emergent herbicide

        - Occasionally used - 0-1 times per crop.
        - Effective in controlling annual grass weeds post-emergent.
        - Does not control all grass weeds.

    - Sethoxydim (various) - Group A grass selective post-emergent herbicide
        - Occasionally used - 0-1 times per crop.
        - Effective in controlling annual grass weeds post-emergent.

    - Trifluralin (various) - Group D residual pre-emergent herbicide
        - Commonly used - 0-1 times per crop.
        - Effective on a range of broadleaf weeds when used pre-plant.
        - Some issues with crop retardation when high rates used on light soils.

- Herbicides available for the control of weeds in brassica vegetables via **permit** are:
    - Clopyralid (various, PER13147) - Group I post-emergent hercicide
        - For the control of capeweed and clover in cauliflower in WA only.
        - Occasionally used once per crop.
        - Very effective but early weed timing critical.
        - Long WHP is a disadvantage
        - Expires 31-Sep-16.

Some growers use a combination of pre plant herbicides followed by post plant herbicides. Growers express concerned regarding build-up of herbicides in soils under these circumstances.

Most weeds can be controlled with currently available herbicides but growers would welcome inclusion of brassicas in new chemical registrations.

There were no weeds identified as a high priority for control during the SARP meetings but some growers have mentioned wild radish (*Raphanus raphanistrum*) and wild turnip (*Brassica tournefortii*), as weeds of concern due to spread and difficulty in control in WA. Isoxaflutole (various products, Group H) has registrations for these weeds and could be considered for a permit, although residue work would be required.

Growing weed resistance is a problem. For example wild radish populations have developed resistance to herbicides in the mode-of-action (MOA) Groups B, C, F and I. Group B resistance is the most common, followed by Group F.

Growers should be mindful of current and developing resistance management strategies. Some strategies to consider are use of sequences that avoid use of the same product twice in a growing season, accuracy in timing and application rates, targeted treatment, treatment of small weeds and the use of cultivation techniques to reduce herbicide use.

Some **potential** development options:

- Isoxaflutole (various)
    - residue data required
    - efficacy on broadleaf weeds and grasses
- Pyroxasulfone – (SAKURA) –
    - residue data required
    - grass weed efficacy
    - IR4 projects on crop safety, no residue projects
- Clomazone (various) – Group G
    - residue data required
    - Broadleaf weed fungicide
    - IR4 project on annual weeds – possible opportunities for collaboration
- Flumioxazin (PLEDGE^, VALOR^) – Group G
    - residue data required
    - grass and broadleaf herbicide
    - IR4 projects – possible opportunities for collaboration

Currently available herbcides

- See Appendix 4

5. References

Information:

- Australasian Biological Control 2008 (http://www.goodbugs.org.au/)
- Australian Bureau of Statistics, Agricultural Commodities website.
- Australian Horticultural Statistics Handbook.
- Australian Pesticide and Veterinary Medicines Authority website. Website: www.apvma.gov.au
- Ausveg 'Domestic Vegetable Industry Snapshot' (2009) website: http://www.ausveg.com.au
- Ausveg 'Fresh Vegetable Exports' (2011) website: http://www.ausveg.com.au
- Biobest 2008 http://207.5.17.151/biobest/en/nieuws/scanivital.htm
- Codex MRL database
- Cornell university- http://plantclinic.cornell.edu/FactSheets.htm
- Diseases of Vegetable Crops. Department of Primary Industries Queensland, 1994.
- Infopest, Department of Primary Industries and Fisheries, Queensland Government, Nov 2012.
- Integrated Pest Management for crops and pastures (2008) Paul Horne and Jessica Page
- 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.
- New Zealand Horticulture and AgAware: Brassica vegetabless SARP report 2008.
- Pest management strategy documents for Queensland's fruit and vegetable industries, Queensland Fruit and Vegetable growers, 2003 & 2008.
- USA Foreign Ag Service- www.mrldatabase.com
- Vegetable IPM Coordinator draft report 2011. Sandra McDougall NSW DPI.

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

Acknowledgement

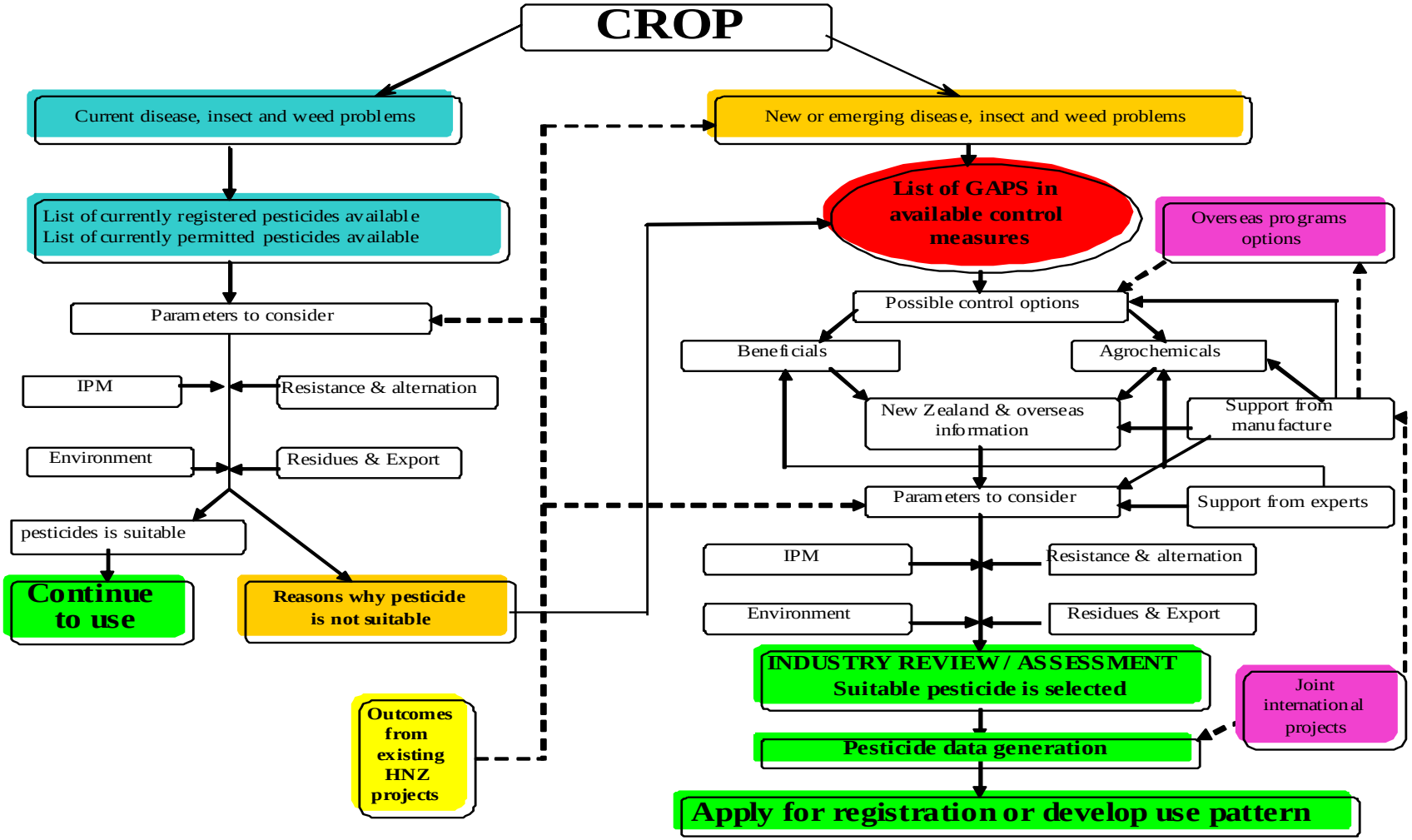
APVMA: All staff especially Alan Norden
Government agencies: Each state DPI as excellent sources of information
Industry development officers and associates

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 brassica vegetable.

As Brassicas are considered a Major crop group and have a considerable number of registrations, full detail is not given of all registered active and disease combinations. This information is available on the APVMA website.

Fungicides registered for use in brassicas:

Active ingredient	**Chemical Group**
Boscalid	7
Chlorothalonil	M5
Copper	M1
Fluazinam	29
Hydrogen peroxide + peroxyacetic acid	M
Iodine	M
Iprodione	2
Mancozeb	M3
Mancozeb + copper	M3 + M1
Mancozeb + sulphur	M3 + M2
Metalaxyl	4
Metalaxyl-M	4
Metalaxyl -M + copper	
Metiram	M3
Penconazole	3
Penthiopyrad	7
Phosphorous acid	33
Quintozene (suspended)	14
Sulphur	M2
Thiram	M3
Triadimenol	3
Zineb	M3

Fungicides permitted for use in brassicas:

Active	**Crop**	**Pest**	**WHP (H) days**	**WHP (G) days**	**Chemical Group**
Azoxystrobin (PER13123, expires Mar 2013)	Broccoli, Brussels sprouts, cauliflower	White blister	1	don't	11
Boscalid (PER13897, expires Jun 2014)	Brassicas	Sclerotinia	7	_	3
Iprodione (PER14051, expires Mar 2018)	Broccoli seed	Rhizoctonia	_	_	7
Iprodione (PER10090, expires Aug 2015)	Brussels sprouts	Grey mould	7	*	7
Metalaxyl-M + Mancozeb (PER14045, expires Mar 2018)	Broccoli, cauliflower, brussels sprouts	White blister, DM	7	_	4
Phosphorous acid (PER11951, expires Mar 2015)	Brussel sprouts, broccoli, cauliflower	DM	-	-	33

Appendix 3 – currently available insecticides in brassica vegetable.

As Brassicas are considered a Major crop group and have a considerable number of registrations, full detail is not given of all registered active and pest combinations. This information is available on the APVMA website.

Insecticides registered for use in brassicas:

Active ingredient	Chemical Group
Acephate	1B
Alpha-cypermethrin	3A
Amorphous silica	-
Bacillus thuringiensis var. Aizawai	11
Beta-cyfluthrin	3A
Beta-cypermethrin	3A
Carbaryl	1A
Chlorantraniliprole	28
Chlorantraniliprole + thiamethoxam	28+4A
Chlorfenapyr	13
Chlorpyrifos	1B
Cyfluthrin	3A
Cypermethrin	3A
Deltamethrin	3A
Diazinon	1B
Emamectin benzoate	6
Esfenvalerate	3A
Fenitrothion	1B
Fipronil	2B
Flubendiamide	28
Gamma-cyhalothrin	3A
Imidacloprid	4A
Indoxacarb	22A
Lambda-cyhalothrin	3A
Lambda-cyhalothrin + thiamethoxam	3A+4A
Maldison	1B
Methomyl	1A
Mevinphos	1B
Nuclear Polyhedrosis Virus of Helicoverpa	-
Permethrin	3A
Petroleum oil	-
Phorate	1B
Pirimicarb	1A
Prothiofos	1B
Pymetrozine	9B
Spinetoram	5A
Spinosad	5A
Spirotetramat	23
Sulfoxaflor	4C
Tau-fluvalinate	3A
Thiodicarb	1A
Zeta-cypermethrin	3A

Insecticides permitted for use in brassicas:

Active	crop	pest	WHP (H) days	WHP (G) days	Chemical Group
Alpha cypermethrin (PER14037, expires Mar 2023, WA only)	Cauliflower crops	Staphylinid beetle	1	_	3A
Bifenthrin (PER12947, expires Apr 2015)	Brussel sprouts, broccoli, cauliflower, cabbages	Silverleaf whitefly	7	_	3A
Chlorpyrifos (PER14596, expires Sep 2019, WA only)	Brassica vegetables	Vegetable beetle-Gonocephalum	_	_	1B
Diazinon (PER10272, expires Sep 2016)	Cauliflower	Onion fly	14	-	1B
Methyl bromide (PER11092 (Qld), PER10145 (Tas), expires Oct 2009	Food producing plants (not persons generally)	Thrips	3	3	3
Petroleum (PER12221, expires Nov 2017)	Brassica vegetables	Aphids, Green mired, Green vegetable bug, Grey cluster bug, Leafhoppers, Mites, Rutherglen bug, Thrips	1	-	-
Pymetrozine (PER13111, Expires May 2014)	Broccoli	Silverleaf whitefly	5	_	9A

*Do not graze or cut for stock food

Appendix 5 – currently available herbicides in brassica vegetable.

As Brassicas are considered a Major crop group and have a considerable number of registrations, full detail is not given of all registered active and weed combinations combinations. This information is available on the APVMA website.

Herbicides registered for use in brassicas include:

Active ingredient	**Chemical group**
Chlorthal dimethyl	D
Clethodim	A
Diquat + paraquat	L
Fluazifop-p butyl	A
Glufosinate-ammonium	N
Glyphosate	M
Metolachlor	K
S-Metolachlor	K
Oxyfluorfen	G
Pendimethalin	D
Propachlor	K
Quizalofop-p-ethyl	A
Sethoxydim	A
Trifluralin	D

Herbicides permitted for use in brassicas:

Active	**Crop**	**Weed**	**WHP (H) days**	**WHP (G) days**	**WHP (G) days**
Clethodim (PER14164, expires Jun 2017)	Brassica vegetables	Ryegrass (*Lolium* spp.), Winter grass (*Poa annua*)	28	_	A
Clopyralid (PER13147, expires Sep 2016, WA only)	Cauliflower crops	Capeweed, clover	56	_	I