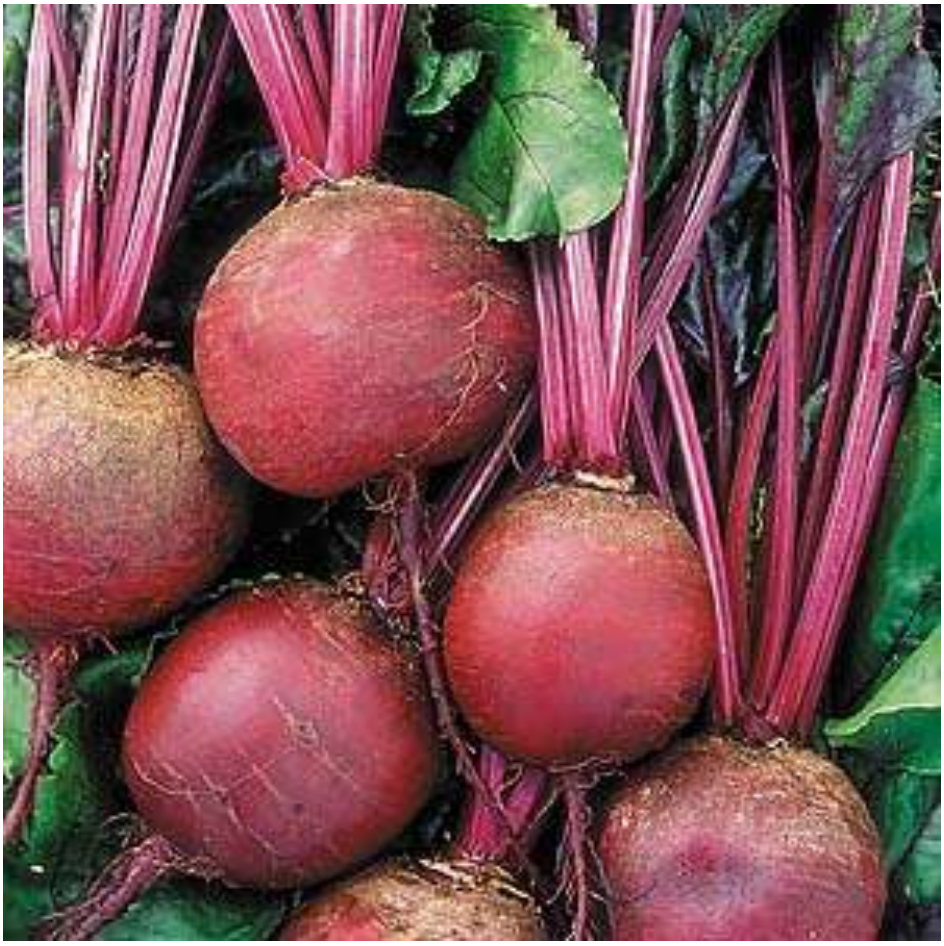

Beetroot

Strategic Agrichemical Review Process 2011-2014

HAL Projects - MT10029 & VG12081

AgAware Consulting Pty Ltd

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 beetroot industry across Australia. The information in this report will assist the beetroot 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:
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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 beetroot were conducted in Queensland, South Australia and Victoria as part of combined vegetable meetings in 2008, 2010 and 2011. The results of the process provide the beetroot 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).

DISEASES

Diseases identified as high priorities:

Disease (common name)	**Disease (scientific name)**
Rhizoctonia	*Rhizoctonia solani*
Damping off	*Pythium aphanidermatum*
Seedling blight	*Aphanomyces cochkiodes*
Downy mildew	*Peronospora farinosa*

Registrations for control of diseases in beetroot are primarily for old chemistry. Growers want additional, "safer" options and more choice to reduce risk of resistance.

Intensive, year round cultivation exacerbates disease; due to build-up of pathogens in the soil and sowing in conditions favourable to disease proliferation. Therefore decisions on timing and crop alternation can impact the outcome of fungicide treatments, along with use of disease-resistant varieties where available, and attention to cultivation practices.

Seed treatment is important in reduction of disease, particularly soil-borne disease.

INSECTS

Insects identified as high priorities:

Insect (common name)	**Insect (scientific name)**
Cluster caterpillar	*Spodoptera litura*
Earwig	*Nala lividipes*
Cutworms	*Agrotis* spp.
Webworm	*Spoladea recurvalis*

As a generalisation there is a desire for different chemistry to be used for alternation, in particular to reduce resistance risks. Soft chemistry is sought by many growers, in conjunction with IPM programs. Overall, the industry wants to consider all new chemistry introduced to the market for a fit in beetroot, and more specifically in IPM programs. The industry is pleased that some new chemistry, including the new Bayer CropScience product, BELT^480 SC (flubendiamide) and the Dow AgroSciences product Transform^ (Sulfoxaflor) were registered in beetroot from the outset.

WEEDS

Weeds identified as high priorities:

Weed (common name)	Weed (scientific name)
Common sowthistle	*Sonchus oleraceus*
Fat hen	*Chenopodium album*
Small flowered mallow (marshmallow).	*Malva parviflora*
Red-root amaranth, pigweed	*Amaranthus* spp.
Wireweed	*Polygonaceae* spp.

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

2. The Australian beetroot industry

The Australian beetroot industry is a small vegetable industry with a regular consumer demand for its fresh product.

Beetroot is grown in all states, with Qld the major producer. The area planted to beetroot in 2008/09 was 1,611 ha (some still for processing). This grew from 1,577 ha in 2007/08. The average yield per hectare in 2008/09 were 26.9 tonnes/ha which was lower than the 2007/08 average of 27.5 tonnes/ha.

In 2008/09, the total beetroot production in Australia was 43,268 tonnes with a gross value of $13.6 mill and a farm gate value of $12.3 mill. Production levels are expected to rise with a general increase in consumer demand for vegetables in Australia.

Canned beetroot consumed in Australia was until recently produced in Australia by several processors. This sector has now closed down as cheap imports made it unsustainable: the major producer, Heinz, moved production to New Zealand in 2011 and the final cannery, Windsor Farm was closed in 2013.

Vacuum packed beets entered the market in 2013 as an alternate form of the fresh commodity, to be supplied in the major supermarket chains. (Trute P, 2014) It is too soon to know if this form of the commodity will increase consumer demand and beetroot production.

No information is available on the export of Australian beetroot.

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 beetroot 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 beetroot. 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 beetroot as a minor crop. The crop fits within the APVMA crop group 016: Root and tuber 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 beetroot 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 beetroot 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 beetroot production in Australia but attempts to prioritise the major problems.

3.2. Minor use permits and registration

Beetroot is classified as a minor crop 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 beetroot industry is for manufacturers to register new pesticides for uses in beetroot.

3.3. Methods

The SARP was conducted in 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 beetroot 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 beetroot 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 beetroot

4.1 Diseases of beetroot

Common name	Scientific name
HIGH PRIORITY	
Rhizoctonia	*Rhizoctonia solani*
Damping off	*Pythium aphanidermatum*
Seedling blight	*Aphanomyces cochkiodes*
Downy mildew	*Peronospora farinosa*
MODERATE PRIORITY	
Alternaria leaf spots	*Alternaria* spp.
Leaf spot	*Cercospora beticola*
Powdery mildew	*Erysiphe polygoni*
Sclerotinia rot	*Sclerotinia* spp.
LOW PRIORITY	
Neck and bulb rot	*Aphomyces* spp.
Phoma leaf spot	*Phoma betae*
Ringspot	*Mycosporella* spp.
Rust	*Uromyces betae*
Biosecurity risk	
None listed	

4.1.1 High priority diseases

Downy mildew (*Peronospora farinosa*)

Downy mildew can affect all aboveground plant parts may be affected. Large, light green leaf spots develop on the upper leaf surfaces. Under moist conditions, a white to grey mould appears on the lower or upper leaf surfaces. Affected leaves may wilt, and then die.
Crown infection causes excessive leaf proliferation, which in turn causes misshapen bulbs.

- Downy mildew is considered a major problem in some parts of Qld and a moderate problem in other parts of Qld and in SA and Vic.
  - Growers alternate the use of different fungicides.
  - Growers would like other protective/curative fungicides for alternation.
  - Growers have a need for products with short WHP.

- Fungicides **registered** for the control of Downy mildew in beetroot are:
  - Copper (various brand name products) - Group M1 – protectant fungicide:
    - Commonly used as a protectant.
    - It is not effective in high pressure situations.
    - Moderately harmful to some beneficial insects.
    - Has a 1 day WHP - favourable.
  - Mancozeb (various) - Group M3 - protectant fungicide:
    - Occasionally used as a protectant.
    - It is not effective in high pressure situations.
    - Low impact on beneficial insects.
    - Has a 14 day WHP - unfavourable.

- Fungicides listed for the control of Downy mildew in beetroot via **permits:**
  - Phosphorous (various, PER14184) - Group 33 – systemic fungicide:
    - Permit obtained late 2013, reports of efficacy not available
    - Expires June 2017
    - IPM fit

- **Potential** fungicide for the control of downy mildew in beetroot:
  - 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.

  - 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

  - Ametoctradin + dimethomorph (ZAMPRO^) – 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

Rhizoctonia (*Rhizoctonia solani*)

Damping off (*Pythium aphanidermatum*)

Seedling blight (*Aphanomyces cochlioides*)

- These diseases are considered a high priority by some Queensland growers and a moderate priority by other growers.
  - Soilborne diseases.
  - *Pythium* spp., *Aphanomyces cochlioides* and *Rhizoctonia solani* are the predominant soilborne pathogens responsible for root rot complex in beetroot. (Martin, 2003)
  - Exacerbated if there is not crop alternation
  - If not controlled can kill > 90% of glasshouse and field grown seedlings
  - Current control measures involve a combination of chemical and cultural practices
  - Biological control is a potential alternative. Successful use of the method for suppression of *Pythium* induced damping off has been reported in New Zealand. *Penicillium* and *Pseudomonas* test organisms were applied as seed treatments and considered to be promising for further evaluation. (Dodd and Stewart, 1992)

- Fungicides **registered** for the control of soil borne diseases in beetroot are:
  - Metalaxyl, Metalaxyl-M (various) – Group 4 protective and curative fungicide
    - Registered for damping off.
    - Key tool to minimise disease in beetroot
    - Potential resistance issues

  - 1,3-dichloropropene + chloropicrin (various) fumigant
    - Restricted chemical
    - Broad vegetable claim for control of soil borne diseases as pre-plant treatment
    - Schedule 7 dangerous poison

  - Tolclofos-methyl (various) - Group 14 - Non systemic, contact fungicide with protective and curative action:
    - Registered for control of *Rhizoctonia* spp. only. Will not control Pythium
    - Qld and NSW registration only
    - In-furrow application at planting.
    - Essential tool in disease management

- Fungicides listed for the control of soil borne diseases in beetroot via **permits:**
  - Phosphorous (various, PER14184) - Group 33 – systemic fungicide:
    - Permitted for control of damping off
    - Permit obtained late 2013, reports of efficacy not available
    - Expires June 2017
    - IPM fit

- **Potential** fungicides for the control of soil borne diseases in beetroot are:
  - Cyazofamid (likely to be called RANMAN^?, new ISK/FMC Fungicide) – FRAC code 21 – contact and residual fungicide
    - Application for registration is with the APVMA, for potatoes, brassicas and possibly brassica leafy vegetables.
    - 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.

  - Fluopicolide is a new Bayer active in the FRAC group 43, a group with no actives registered in Australia. Bayer CropScience has applied for approval of the active in Australia but registration of a registered product will take some time. An IR-4 use request indicates efficacy on *Aphanomycete* spp. and *Pythium* spp. It would be sensible to approach Bayer to discuss development opportunities.

- Hymexazol has been reported as having efficacy against *Pythium* spp. and *Aphanomyces* spp. (Martin, 2003) However, as the active is not registered in Australia this is not a near term solution, especially for a minor crop.

- Pencycuron (MONCERON^) – a Group 20 non-systemic Fungicide
  - Rhizoctonia spp. control. (Martin, 2003)
  - Registered in potatoes for application at planting
  - The widespread availability of this product is uncertain – this could limit the suitability of a permit.
  - No MRL

4.1.2 Biosecurity risk diseases

None identified

4.1.3 Summary

High Priority Diseases and control options

Registrations for control of diseases in beetroot are primarily for old chemistry. Growers want additional, "safer" options and more choice to reduce risk of resistance.

Intensive, year round cultivation exacerbates disease; due to build-up of pathogens in the soil and sowing in conditions favourable to disease proliferation. Therefore decisions on timing and crop alternation can impact the outcome of fungicide treatments, along with use of disease-resistant varieties where available, and attention to cultivation practices.

Seed treatment is important in reduction of disease, particularly soil-borne disease.

Disease	Control option
Downy mildew *(Peronospora farinosa)*	**Currently registered fungicides** Copper (various brand name products) – commonly used, moderately harmful to beneficials, reduced efficacy under high pressure. Mancozeb (various) – occasional use, low impact on beneficials. **Currently permitted fungicides** Phosphorous (various, PER14184) - IPM fit, extent of use not known **Fungicide Gaps** New chemistry with IPM fit – if the chemistry listed below is registered or permitted there should be adequate tools for control **Potential fungicide solutions** Ametoctradin + dimethomorph (ZAMPRO^) – new BASF chemistry registered for downy mildew in other crops. 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. **Non-chemical options** Crop rotation Plant spacing to improve air flow and spray penetration Resistant varieties
Soil borne diseases: Rhizoctonia (*Rhizoctonia solani*) Damping off (*Pythium aphanidermatum*) Seedling blight (*Aphanomyces cochlioides*) Sclerotinia rot (*Sclerotinia sclerotiorum)*	**Currently registered fungicides** Metalaxyl, Metalaxyl-M (various) – Damping off registration Tolclofos-methyl (various) – efficacy on *Rhizoctonia* spp. **Currently permitted fungicides** Phosphorous (various, PER14184) - IPM fit, extent of use not known **Fungicide gaps** New chemistry with IPM fit – if the chemistry listed below is registered or permitted there should be adequate tools for control **Potential fungicide solutions** 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. Efficacy on *Aphanomycete* spp. and *Pythium* spp. Pencycuron (MONCERON^) – reported as efficacious in trials but the product may not be widely available **Non-chemical options** Crop rotation gramineous or biofumigant crops Disease-resistant varieties – varieties resistant to Rhizoctonia reported in the USA Alternation of sowing dates to favour cooler, drier months Seed priming in combination with fungicides Avoidance of throwing soil up over the plants during inter-row cultivation Consider disease species in the site when making planting decisions

Currently available fungicides

Active ingredient	Disease name	WHP, days	Chemical group
1,3-dichloropropene, chloropicrin (fumigant, restricted use)	Soil borne diseases	-	8B (chloropicrin)
Boscalid	Sclerotinia rot	7	3
Copper	Downy mildew, Rust	1	M1
Difenoconazole	Alternaria leaf spots (early blight, target spot), Cercospora leaf spot (PER14245)	7	3
Mancozeb	Cercospora leaf spot, Downy mildew	14	M3
Metalaxyl, metalaxyl-M	Damping off	-	4
Penthiopyrad	Alternaria leaf spots (early blight, target spot)		7
Phosphorous	Damping off, Downy mildew (PER14184)	1	33
Sulphur (broad vegetable claim)	Powdery mildew	-	M2
Tebuconazole	Sclerotinia rot (PER10908)	35	3
Tolclofos-methyl	Rhizoctonia	-	14
Trifloxystrobin	Alternaria leaf spots (early blight, target spot), Cercospora leaf spot (PER11919)	SL	11

4.2 Insects of beetroot

Common name	Scientific name
HIGH PRIORITY	
Cluster caterpillar	*Spodoptera litura*
Earwig	*Nala lividipes*
Cutworms	*Agrotis* spp.
Webworm	*Spoladea recurvalis*
MODERATE PRIORITY	
Helicoverpa	*Helicoverpa* spp.
Green vegetable bug	*Nezara viridula*
Mites	*Acarina* spp.
Rutherglen bug	*Nysius vinitor*
Aphids	*Aphidae* spp.
Jassids & Leafhoppers	*Cicadellidae*
LOW PRIORITY	
Beet leafminer	*Liriomyza chenopodii*
Crickets	*Gryllotalpidae* spp.
Leafminer flies	*Agromyzidae* spp.
Loopers	*Geometridae* spp.
Weevil	*Curculionidae* spp.
Wireworms	*Tenebrionidae* spp.
Biosecurity risk	
None listed	

4.2.1 High - moderate priority insects

Cluster caterpillar (*Spodoptera litura*)

Young larvae of Cluster caterpillar 'cluster' together and are translucent green with a darker thorax. These change colour as they mature with a pattern of red, yellow and green lines, to brown. They have a row of black dots along each side, and a row of conspicuous dark half-moons along the back. Final instar larvae are dark and can exceed 50 mm in length.
The cluster caterpillar feeds on many types of plants.
Small larvae window leaves, but older larvae chew holes in leaves and are the most damaging.

- Cluster caterpillar are considered a major problem in Qld and a medium problem in other states.
  - Growers require an effective range of insecticides for alternation.
  - Growers have a need for products with short WHP.

- Insecticides **registered** for the control of Cluster caterpillar in beetroot:
  - Flubendiamide (BELT) – Group 28 contact/systemic insecticide.
    - Residual activity
    - IPM fit

- No insecticides are listed for control of Cluster caterpillar in beetroot via **permits**.

- **Potential** insecticides for the control of Cluster caterpillar in beetroot. The following are permitted for use in other minor situations control cluster caterpillar and may have potential for beetroot:
  - Emamectin, Methomyl, Methoxyfenozide, Chlorantraniliprole (CORAGEN), Amorphous silica, indoxacarb

Earwig (*Nala lividipes*)

http://aciar.gov.au/files/teccipm-14-web-03-2dec13.pdf, accessed 15/02/14

Earwigs are dark brown, slender and elongate, with a pair of "pincers" at the rear. They have a foul odour when disturbed. Earwigs are generally considered as beneficials, feeding on caterpillars, pupae, eggs and other insects but many are also plant feeding

- Earwigs are considered a major- moderate pest in some areas.

- Insecticides **registered** for the control of earwigs in beetroot:
  - Chlorpyrifos (various) – Group 1B contact and systemic insecticide
    - Harsh chemistry.
    - Insecticide under review by APVMA.
  - Carbaryl (various) - Group 1A contact and systemic insecticide
    - Old chemistry.
    - Moderately harmful to harmful to many beneficial insects

- No insecticides are listed for control of earwigs in beetroot via **permits**.

Cutworms (*Agrotis* spp.)

http://agspsrv34.agric.wa.gov.au/ento/pestweb/Query1_1.idc?ID=-854760085,accessed 15/02/14

There are several species which may cause damage. The larvae of all are smooth and plump. Larvae grow 50 mm long. The adults are broad-bodied, with a wing span of up to 40 mm. The forewings are patterned brown or dark grey. Several generations are possible in one season. Cutworm don't occur regularly but can cause significant damage quickly, as they cut down the plant and ground level.

- Cutworm are a high priority in some areas but usually a moderate priority.

- Insecticides **registered** for the control of cutworm in beetroot:
  - Chlorpyrifos (various) – Group 1B contact and systemic insecticide
    - Harsh chemistry.
    - Insecticide under review by APVMA.
  - Carbaryl (various) - Group 1A contact and systemic insecticide
    - Old chemistry.
    - Moderately harmful to harmful to many beneficial insects

- No insecticides are listed for control of cutworm in beetroot via **permits**.

Webworm (*Spoladea recurvalis*)

http://www.daff.qld.gov.au/plants/field-crops-and-pastures/, accessed 15/02/14

Larvae are creamy-white at first, later developing greyish-green and black marks. When the larvae reach about 20-25 mm long they have a distinct black line down the middle of the back. Moths are around 10 mm long and have brown forewings with two white bands and brown hindwings with one white band.

- Beet webworm occasionally causes severe leaf damage when high numbers feeding on wild hosts in summer move onto beetroot when the weeds die in autumn.

- Insecticides **registered** for the control of webworm in beetroot:
  - Diazinon (various) – Group 1B contact/systemic insecticide.
    - Occasionally used in some regions.
    - This treatment is highly disruptive to beneficial insects in an IPM situation.

- No insecticides are listed for control of webworm in beetroot via **permits**.

- **Potential** insecticides for the control of webworm in beetroot.:
  - Pesticides effective against *Helicoverpa* (except *Helicoverpa virus*) will most likely control beet webworm DAFF, 2010)

4.2.2 Biosecurity risk insects

None identified

4.2.3 Summary

High Priority Insects and control options
As a generalisation there is a desire for different chemistry to be used for alternation, in particular to reduce resistance risks. Soft chemistry is sought by many growers, in conjunction with IPM programs. Overall, the industry wants to consider all new chemistry introduced to the market in other crops for a fit in beetroot, and more specifically in IPM programs. The industry is pleased that the new Bayer CropScience product, BELT^480 SC (flubendiamide) and the Dow AgroSciences product Transform^ (Sulfoxaflor) were registered in beetroot from the outset.

Disease	Control option
Cluster caterpillar (*Spodoptera litura)*	**Currently registered insecticides** Flubendiamide (BELT) – IPM fit, residual activity. **Currently permitted insecticides:** None **Insecticides Gaps** Alternate chemistry **Potential insecticides solutions** Permits in other minor crops - Emamectin, Methomyl, Methoxyfenozide, Chlorantraniliprole (CORAGEN), Amorphous silica, indoxacarb **Non-chemical options** None identified – this should be investigated in future SARPS
Earwig (*Nala lividipes)*	**Currently registered insecticides** Chlorpyrifos (various) – under APVMA review, poor IPM fit. Carbaryl (various) – moderately harmful to beneficials. **Currently permitted insecticides:** None **Insecticides Gaps** New chemistry with IPM fit **Potential insecticides solutions** Fipronil – growers have requested a permit for this use **Non-chemical options** None identified – this should be investigated in future SARPS
Cutworms (*Agrotis* spp.)	**Currently registered insecticides** Chlorpyrifos (various) – under APVMA review, poor IPM fit. Carbaryl (various) – moderately harmful to beneficials. **Currently permitted insecticides:** None **Insecticides Gaps** New chemistry with IPM fit **Potential insecticides solutions** None identified – this should be investigated in future SARPS **Non-chemical options** Biological control, such as by fungal diseases, wasp and fly parasites –these may reduce the incidence and severity of attacks
Webworm (*Spoladea recurvalis)*	**Currently registered insecticides** Diazinon (various) – disruptive to beneficials **Currently permitted insecticides:** None **Insecticides Gaps** New chemistry with IPM fit **Potential insecticides solutions** Insecticides that control *Helicoverpa* **Non-chemical options** None identified – this should be investigated in future SARPS

Currently available beetroot insecticides

Active ingredient	Insect name	WHP, days, harvest	Chemical Group
1,3-dichloropropene, chloropicrin (fumigant, restricted use)	Nematodes	_	8B (chloropicrin)
abamectin	Western flower thrips	3	6
alpha cypermethrin PER13090	Loopers (PER13090), Plague thrips, Vegetable weevil	1	3A
carbaryl	Armyworms, Australian plague locust (PER11658), Cabbage white butterfly, Cutworms, Earwigs, Green vegetable bug, *Helicoverpa*, Leafeating, ladybirds, Potato moth (Leafminer), Pumpkin beetles, Rutherglen bug, Wingless grasshopper	3	1A
carbaryl + chlorpyrifos + diazinon + maldison - PER11658	Australian plague locust (PER11658),	SL	1A/1B
chlorpyrifos	Australian plague locust (PER11658), Black field cricket, Cutworms, False wireworms, Field crickets, Mole crickets, Seedharvesting ants, Spotted vegetable weevil, Vegetable weevil, Wingless grasshopper, Earwigs	_	1B
Diazinon	Australian plague locust (PER11658), Webworms	14	1B
dimethoate	Aphids, Bugs, Jassids, Leafhoppers, Leafminer flies, Mites, Redlegged earth mite, Thrips, Wingless grasshopper	14	1B
fenamiphos	Aphids, Insects – Sucking, Nematodes, Thrips	84	1B
flubendiamide	Cabbage white butterfly, Cluster caterpillar, Diamondback moth, *Helicoverpa*, Potato moth (Leafminer)	1	28
Imidacloprid PER11853	Aphids, Thrips	7	4A
lambda-cyhalothrin - PER11949	Loopers, Onion (Cotton seedling) thrips, Plague thrips, Rutherglen bug, Vegetable weevil	2	3A
Maldison	Australian plague locust (PER11658),		
methyl bromide PER11092, PER10145 (not for persons generally)	Thrips	3	8A
pirimicarb	Green peach aphid	2	1A
spinetoram	Helicoverpa, Lightbrown apple moth, Loopers Potato moth (Leafminer)	3	5
Sulfoxaflor	Aphids	7	4C
sulphur (broad vegetable claim)	Two spotted mite (red spider mite)	-	M2

4.3 Weeds of beetroot

4.3.1. High priority weeds

Common name	Scientific name
HIGH PRIORITY	
Common sowthistle	*Sonchus oleraceus*
Fat hen	*Chenopodium album*
Small flowered mallow (marshmallow).	*Malva parviflora*
Red-root amaranth, pigweed	*Amaranthus* spp.
Wireweed	*Polygonaceae* spp.

Herbicides **registered** and used in beetroot:

- Chloridazon (PYRAMIN^) – Group C general pre-emergent herbicide
  - Used for grasses and broadleaf weeds.
  - Considered very effective and controls most weeds.
- Clethodim (various) – Group A grass selective post-emergent herbicide
  - Used for grasses weeds only
  - Considered very effective.
- Ethofumesate (various, not WA or NT) – Group K general pre and post emergent herbicide
  - Used for selective grasses and broadleaf weeds.
  - Considered effective but narrow weed spectrum.
  - Permit expires 30-Jun-15.
- Phenmedipham (BETANAL^) - Group C post-emergent herbicide.
  - Used for grasses and broadleaf weeds.
  - Considered very effective.
- Propachlor (RAMROD^) - Group H selective post-emergent herbicide
  - Used for potato weed only.
  - Growers comment that does not control enough weeds.
- Quizalofop-P-ethyl (various) - Group A grass selective post-emergent herbicide
  - Not used.
- Sethoxydim (various) - Group A grass selective post-emergent herbicide
  - Not used.
- Glyphosate (various) – Group M pre-plant general knockdown herbicide
  - Works well as a pre-crop spray.
- Paraquat + diquat (various) - Group L pre-plant general knockdown herbicide
  - Works well as a pre-crop spray

- The herbicides listed for control of weeds in beetroot via **permits** are:
  - Ethofumesate (various, PER11450) – Group K general pre and post emergent herbicide
    - Used for selective grasses and broadleaf weeds.
    - Considered effective but narrow weed spectrum.
    - Permit expires 30-Jun-15.
  - A permit issued to Pacific Seeds only allows weed control in seed crops with Fluazifop-P, Clopyralid, Haloxyfop and Pendimethalin. There is potential to apply for similar permits for use by "Persons Generally". There are no MRLs for clopyralid or haloxyfop so the residue situation in use outside of seed crops would need to be considered

4.3.2. Summary

High priority weeds and control options

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

Insect	Control option - Currently registered herbicides
Common sowthistle (*Sonchus oleraceus*)	Chloridazon, phenmedipham, glyphosate, paraquat+diquat
Fat hen (*Chenopodium album)*	Chloridazon, ethofumosate phenmedipham, glyphosate, paraquat+diquat
Marshmallow (*Malva parviflora)*	Chloridazon, glyphosate, paraquat+diquat
Pigweed, amaranth (*Amaranthus* spp.)	ethofumosate, phenmedipham, glyphosate, paraquat+diquat
Wireweed (*Polygonaceae* spp.)	Ethofumosate, phenmedipham, glyphosate, paraquat+diquat

Currently available beetroot herbicides

Active ingredient	Weed	Chemical group
Ethofumesate	Various grass and broadleaf weeds	K
Fluazifop PER13778 (NSW, Vic, Tas, SA only, not for persons generally)	Various grass and broadleaf weeds	A
Clopyralid PER13778 (NSW, Vic, Tas, SA only, not for persons generally)	Thistles, Legumes	I
Haloxyfop PER13778 (NSW, Vic, Tas, SA only, not for persons generally)	Various grass weeds	A
Pendimethalin PER13778 (NSW, Vic, Tas, SA only, not for persons generally)	Various grass and broadleaf weeds	D
Isoxaben PER13691 (Tas only)	Wild radish	O
Chloridazon	Various grass and broadleaf weeds	C
Clethodim	Various grass weeds	A
Phenmedipham	Various grass and broadleaf weeds	C
Propachlor	Potato weed	K
Quizalofop-P-ethyl	Various grass weeds	A
Glyphosate	Various grass and broadleaf weeds	M
Paraquat + diquat	Various grass and broadleaf weeds	L

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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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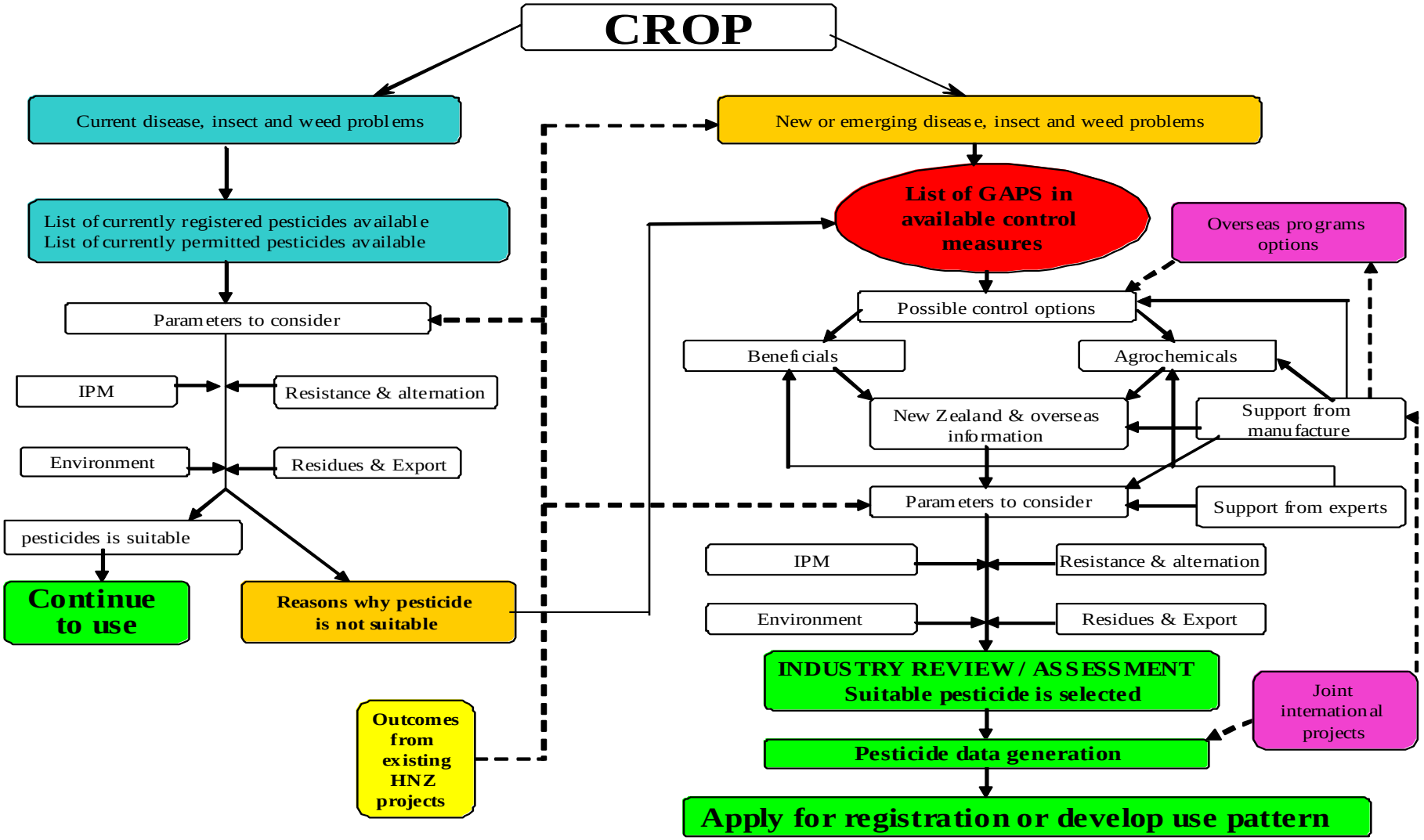
^Trademark

6. Appendices

DIAGRAM 1: The Strategic Agrichemical Review Process



Appendix 2 – currently available fungicides in beetroot.

Disease name	Active ingredient	WHP, days	Chemical group
Alternaria leaf spots (early blight, target spot)	difenoconazole – PER14245	7	3
	Mancozeb+ metalaxyl-M (PER14045, exp 03/18)	14	M3+4
	penthiopyrad		7
	trifloxystrobin - PER11919	SL	11
Cercospora leaf spot	difenoconazole – PER14245	7	3
	mancozeb	14	M3
	trifloxystrobin - PER11919	SL	11
Damping off	metalaxyl, metalaxyl-M	-	4
	phosphorous PER14184	1	33
Downy mildew	copper	1	M1
	Mancozeb+ metalaxyl-M (PER14045, exp 03/18)	14	M3+4
	mancozeb	14	M3
	phosphorous PER14184	1	33
Rhizoctonia	tolclofos-methyl	-	14
Rust	copper	1	M1
Sclerotinia rot	tebuconazole - PER10908	35	3
	boscalid	7	3
Powdery mildew	sulphur (broad vegetable claim)	-	M2
Soil borne diseases	1,3-dichloropropene, chloropicrin (fumigant, restricted use)	-	8B (chloropicrin)

Appendix 3 – currently available insecticides in beetroot.

Insect name	Active ingredient	WHP	Chemical group
Aphids	dimethoate	14	1B
	fenamiphos	84	1B
	imidacloprid PER11853	7	4A
	sulfoxaflor	7	4C
Armyworms	carbaryl	3	1A
Australian plague locust	carbaryl + chlorpyrifos + diazinon + maldison - PER11658	_	1A/1B
Black field cricket	chlorpyrifos	_	1B
Helicoverpa	carbaryl	3	1A
	flubendiamide	1	28
	spinetoram	3	5
Bugs	dimethoate	14	1B
Cabbage white butterfly	carbaryl	3	1A
	flubendiamide	1	28
Cluster caterpillar	flubendiamide	1	28
Cutworms	carbaryl	3	1A
	chlorpyrifos	_	1B
Diamondback moth	flubendiamide	1	28
Earwigs	chlorpyrifos (Qld only)	_	1B
	carbaryl	3	1A
False wireworms	chlorpyrifos	_	1B
Field crickets	chlorpyrifos	_	1B
Green peach aphid	pirimicarb	2	1A
Green vegetable bug	carbaryl	3	1A
	dimethoate	14	1B
Insects - Sucking	fenamiphos	84	1B
Jassids	dimethoate	14	1B
Leafeating ladybirds	carbaryl	3	1A
Leafhoppers	dimethoate	14	1B
Leafminer flies	dimethoate	14	1B
Lightbrown apple moth	spinetoram	3	5
Loopers	lambda-cyhalothrin - PER11949	2	3A
	alpha cypermethrin PER13090	1	3A
	spinetoram	3	5
Mites	dimethoate	14	1B
Mole crickets	chlorpyrifos	NFC	1B
Nematodes	fenamiphos	84	1B
	1,3-dichloropropene, chloropicrin (fumigant, restricted use)		8B (chloropicrin)
Onion (Cotton seedling) thrips	lambda-cyhalothrin - PER11949	2	3A
Plague thrips	alpha cypermthrin PER13090	1	3A
	lambda-cyhalothrin - PER11949	2	3A
Potato moth (Leafminer)	carbaryl	3	1A
	flubendiamide	1	28
	spinetoram	3	5
Pumpkin beetles	carbaryl	3	1A
Redlegged earth mite	dimethoate	14	1B

Insect name	Active ingredient	WHP	Chemical group
Rutherglen bug	carbaryl	3	1A
	lambda-cyhalothrin - PER11949	2	3A
Seedharvesting ants	chlorpyrifos	NFC	1B
Spotted vegetable weevil	chlorpyrifos	0	1B
Thrips	dimethoate	14	1B
	fenamiphos	84	1B
	imidacloprid PER11853	7	4A
	methyl bromide PER11092, PER10145 (not for persons generally)	3	8A
Vegetable weevil			
	alpha cypermtthrin PER13090		
	chlorpyrifos	NS	1B
	lambda-cyhalothrin - PER11949	2	3A
Webworms	diazinon	14	1B
Western flower thrips	abamectin	3	6
Wingless grasshopper	carbaryl	3	1A
	chlorpyrifos	NS	1B
	dimethoate	14	1B
Two spotted mite (red spider mite)	sulphur (broad vegetable claim)	-	M2

Appendix 4 – currently available herbicides in beetroot.

Weed	Active ingredient	Chemical group
Grass and broadleaf (including fat hen, amaranthus, wireweed)	ethofumesate	K
Grass and broadleaf (including pigweed, fat hen, wireweed, sowthistle and marshmallow)	fluazifop PER13778 (NSW, Vic, Tas, SA only, not for persons generally)	A
Thistles, Legumes	clopyralid PER13778 (NSW, Vic, Tas, SA only, not for persons generally)	I
Various grass weeds (including pigweed, fat hen, wireweed, sowthistle and marshmallow)	haloxyfop PER13778 (NSW, Vic, Tas, SA only, not for persons generally)	A
Grass and broadleaf, pre-emergent (including pigweed, fat hen, wireweed, sowthistle and marshmallow)	pendimethalin PER13778 (NSW, Vic, Tas, SA only, not for persons generally)	D
Wild radish	isoxaben PER13691 (Tas only)	O
Grass and broadleaf (including pigweed, fat hen, sowthistle and marshmallow)	cloridazon	C
Various grass weeds	clethodim	A
Grass and broadleaf (including fat hen, pigweed, sowthistle, amaranthus, wireweed)	phenmedipham	C
Potato weed	propachlor	K
Various grass weeds	quizalofop-P-ethyl	A
Various grass weeds	sethoxydim	A
Grass and broadleaf (including pigweed, fat hen, wireweed, sowthistle and marshmallow)	glyphosate	M
Grass and broadleaf (including pigweed, fat hen, wireweed, sowthistle and marshmallow)	paraquat + diquat	L