CELERY

Strategic Agrichemical Review Process 2011-2014

HAL Projects - MT10029 & VG12081

AgAware Consulting Pty Ltd
Checkbox 3D Pty Ltd

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

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

Purpose of the report:
This report was funded by Horticulture Australia and the Australian vegetable industry to investigate the pest problem, agrichemical usage and pest management alternatives for the celery industry across Australia. The information in this report will assist the celery 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.

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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:

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

SARP workshops for celery 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 celery 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)
Early blight or Cercospora leaf spot	*Cercospora apii*
Sclerotinia rot	*Sclerotinia sclerotiorum*
Septoria leaf spot or Late blight	*Septoria apiicola*

Registrations for control of diseases in celery are primarily for old chemistry. Growers want additional, "safer" options and more choice to reduce risk of resistance. Seed treatment has been suggested as a future option for disease management, this being a chemical delivery method not currently used in celery. Non-chemical options are a consideration, with basic crop rotation a common practice to reduce disease carryover. Innovative techniques such as disease forecast modelling would be welcomed, although it can be difficult to find appropriate and sufficiently sensitive measurement devices to facilitate implementation. Introduction of celery varieties resistant to disease would help as there is limited access to chemicals. However growers are not aware of a breeding program at present.

INSECTS

Insects identified as high priorities:

Insect (common name)	Insect (scientific name)
Aphids including Green peach aphid and Cotton aphid	*Myzus persicae*, *Aphis gossypii*
Heliothis	*Helicoverpa* spp
Thrips - including Onion thrips and Plague thrips	*Thrips tabaci, Thrips imaginis*
Western flower thrips	*Frankliniella occidentalis*

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. It can, however be noted that the use of softer chemistry can lead to damaging numbers of pests that would normally be controlled when the key target pests are treated with broader spectrum products. Red legged earth mites are an example cited by growers. Overall, the industry wants to consider all new chemistry introduced to the market for a fit in celery, and more specifically in IPM programs.

NEMATODES

Nematode identified as priorities:

Nematode (common name)	Nematode (scientific name)
Root-Knot Nematodes	*Meloidogune* spp.

Nematodes are seen as only a moderate priority and a need for alternate chemical options wasn't highlighted by growers during the SARP processes, despite the limitations of the current options. Crop rotation is seen as the preferred option.

WEEDS

Weeds identified as high priorities:

Weed (common name)	Weed (scientific name)
Marshmallow	*Malva parviflora*
Winter grass	*Poa annua*
Potato weed	*Galinsoga parviflora.*
Groundsel	*Serecio vulgaris*

Overall there is a need for newer chemistry and increased options for control of weeds in celery.

2. The Australian celery industry

The celery industry is one of Australia's smaller vegetable industries. However, in certain years it has reached production levels great enough to be in the top 12-15 largest vegetable industries in terms of production and value (Ausveg 2011).

Celery is grown across Australia with the main growing regions being:

- Melbourne Metro area (Vic)
- Lockyer and Fassifern Valley, Darling Downs, and Granite Belt (QLD)
- Perth Metro outer areas (WA)
- Adelaide Plains (SA)
- Hunter Valley (NSW)
- Sydney Basin (NSW)

The species discussed in this report is 'celery' (*Apium graveolens* var*. dulce*).

The area planted to celery in 2008/09 was 1,210 ha, involving around 100 producers. This increased from an area of 1,046 ha in 2007/08 with 73 growers, and was a reflection of the ability of Australian vegetable growers to quickly change crops and production volume as a result of market signals. The average yield per hectare in 2008/09 was 47.8 tonnes/ha which was significantly lower than the 2007/08 average of 53.1 tonnes/ha. (Source ABS.)

In 2008/09, the total celery production had a gross value of $44.7 mill and a farm gate value of $33.6 mill. Annual celery production has fluctuated between 48 and 55 kt since 2005 (Source ABS.) In 2011, the per capita celery consumption in Australia was 444 g (Ausveg 2011).

Some Australian celery is also exported with major export countries including Malaysia, Singapore, United Arab Emirates and other Asian countries. Overall, exports saw a gradual decrease in the 2003-2007 period, with exports reaching a high of $3.1 million in 2003 and then dropping to a low of $1 million in 2007 (Ausveg 2007). The main competitor in the export market is China.

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.

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 celery 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 of produce from local markets
- Temporary exclusion from market access
- Rejection of produce from export markets
- Jeopardising of export trading arrangements
- Fines and penalties.

Pesticides have always been an important tool in the production of celery. They control the various diseases, insects and weeds that affect the crop throughout the cropping cycle. Pest, disease and weed control tools 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 celery as a minor crop. The crop fits within the APVMA crop group 017: Stalk and stem vegetables.

As a consequence of the issues facing the celery industry regarding pesticide access, Horticulture Australia Ltd and the vegetable industry undertook a review of the pesticide requirements in celery via a Strategic Agrichemical Review Process (SARP). See Appendix 1 – the Strategic Agrichemical Review Process.

The aim of the SARP process was to determine the current and future pesticide requirements needed to protect celery crops from diseases, insects and weeds. The project took the assessment of pesticide suitability, resistance management, IPM suitability, residue issues and export protocols into consideration during evaluations.

The SARP was conducted in Queensland, South Australia and Victoria as part of combined vegetable meetings in 2008, 2010 and 2011. This assessment provided a list of key endemic diseases, insect pests and weeds that are of major concern to the celery industry. Against these threats the pesticides, pesticide group, withholding period, registered/permitted uses and overall suitability (IPM, residues, efficacy, trade and environment) for these pests were identified. Any potential new risks to the industry were also identified.

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

3.2. Minor use permits and registration

Celery 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

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

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

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 celery 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.

3.4. Results and discussions

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

4. Pests and diseases of celery

4.1. Diseases of celery

Common name	**Scientific name**
HIGH PRIORITY	
Early blight or Cercospora leaf spot…….	*Cercospora apii*
Sclerotinia rot……	*Sclerotinia sclerotiorum*
Septoria spot or Septoria leaf spot or Late blight…	*Septoria apiicola*
MODERATE PRIORITY	
Celery Mosaic Virus.	
LOW PRIORITY	
Bacterial soft rot …….	*Erwinia* spp.
Botrytis rot ……	*Botrytis cinerea*
Bacterial blight……	*Pseudomonas syringae pv. apii*
Leaf curl (Celery anthracnose)…….	*Colletotrichum acutatum and C. orbiculare*
Cemv (Celery Mosaic Virus (KR)	

Biosecurity risk

None listed

4.1.1. High priority diseases

Early blight or Cercospora leaf spot (*Cercospora apii*)

Early blight initially causes small, yellow spots on leaves. As spots enlarge they become irregularly rounded, orange-grey lesions.
The texture of affected areas becomes dry and papery and in wet weather, a very fine, ash-grey fungal mould develops on the spot.
Symptoms appear on the outer leaves first, but elongated spots may also develop on the leafstalk when conditions favour the disease (Qld DPI 1994).

- Early blight is considered a major problem in all areas
  - Disease is seed borne and can survive in crop trash. Disease free seed is essential for preventing the spread of this disease.
  - Seedlings need to be screened prior to transplanting.
  - Growers alternate the use of different fungicides.
  - Growers would like other protective/curative fungicides for alternation.

- Fungicides **registered** for the control of Early blight in celery are:
  - Chlorothalonil (various brand name products) – Group M5 protectant fungicide:
    - Commonly used.
    - Effective as a preventative.
    - Also controls Septoria Leaf Spot.
  - Copper (various) - Group M1 protectant fungicide
    - Commonly used.
    - Effective as a preventative, but some copper products can leave visible residues on the crop.
    - Best not used in cold winter weather as can damage crop.
  - Hydrogen peroxide + peroxy acetic acid (PERATEC PLUS) – Group M contact fungicide
    - Not IPM compatible however breaks down quickly in the environment to harmless molecules.
  - Metiram (POLYRAM) - Group M3 protectant fungicide
    - Only occasionally used but considered effective as a preventative.
    - Can damage predatory mite (PH)
  - Zineb (ZINEB) - Group M3 protectant fungicide
    - Occasionally used.
    - Can damage predatory mites.

- Fungicides listed for control of Early blight control in celery via **permits** are:
  - Difenconazole (SCORE - PER13627) – Group 3 fungicide.
    - Protective and curative fungicide.
    - Commonly used by growers, only used as needed.
    - Considered very effective as a curative.
    - Also provides excellent control of Septoria spot (*Septoria apiicola*).
    - Grower concern with the development of resistance resulting from frequent usage.
    - Permit expires 31-Dec 2015.
    - No manufacturers interested in registering use.
  - Trifloxystrobin (FLINT - PER13658) – Group 11 fungicide.
    - Protective and curative fungicide - mainly protective.
    - Occasionally used.
    - Considered very effective when used at the first signs of disease.
    - Also provides excellent control of Septoria spot (*Septoria apiicola*).
    - Permit expires 30-Sep-14.

Sclerotinia rot (*Sclerotinia sclerotiorum*)

The disease is mainly on aboveground parts, producing a cottony white mould. As leaves decay, small white bodies appear in the mould and gradually change from white to black as hardened sclerotia develop.
The disease frequently occurs in storage.
This organism can cause damping-off of seedlings.
In mature plants, the disease appears as a basal rot of crown and petiole. Decay is watery and fairly rapid. It turns pink and later is covered with white mycelium. In later stages, the white mycelium is covered with hard, black sclerotia.
There are many host plants for Sclerotinia.

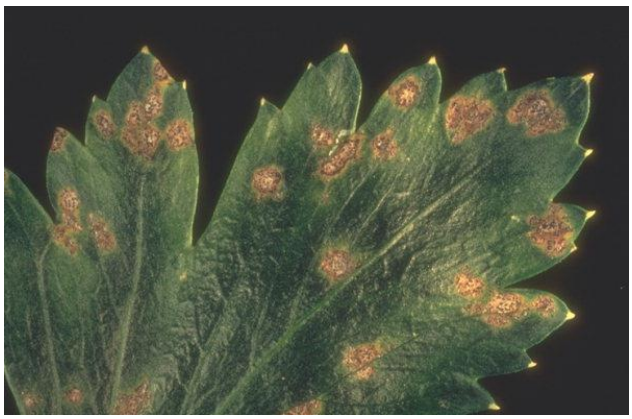
- Sclerotinia rot is considered a major problem in all areas, especially Qld.
    - Sclerotinia tends to be a problem at canopy closure, particularly if plants have sustained mechanical injuries.
    - Crop rotation critical to minimise disease. Many celery businesses also grow lettuce, which is even more susceptible to Sclerotinia and poses problems for crop rotation.
    - Iprodione is registered for control of Sclerotinia, but gives poor control.
    - The industry needs alternatives.

- Fungicides **registered** for the control of Sclerotinia rot in celery are:
    - Iprodione (various) – Group B protectant/curative fungicide:
        - Occasionally used.
        - Growers are having problems adequately controlling Sclerotinia.
        - Some growers report iprodione is ineffective.

- No fungicides are listed for Sclerotinia rot control in celery via **permits**.

- **Potential** fungicide for control of Sclerotinia rot:
    - Penthiopyrad (FONTELIS). Dupont could be approached with regard to development of this use. There are overseas registrations and an Australian label extension could be simple.

Septoria leaf spot or Late blight (*Septoria apiicola*)



Celery is almost always planted in the field as transplants, which are produced in commercial vegetable transplant greenhouses. Transplants compensate for the uneven germination of celery seed and the slow growth of seedlings, yielding a more uniform celery crop in the field. However, certain conditions in transplant greenhouses favour the outbreak of plant diseases on celery transplants. Septoria spot, caused by the seed borne fungus *Septoria apiicola*, can reach high levels on greenhouse-grown celery.

Plants infected at this early stage become significant inoculum sources that later may cause economic losses.
The initial symptoms are small lesions less than 1 cm diameter as water-soaked spots visible on the upper and lower leaf surfaces. As these lesions expanded, they were delimited by leaf veins which gives them an angular appearance. The lesions normally turned light tan to dark brown. Lesions usually occur on the lower, old leaves and only rarely on new developing foliage.

- Septoria spot is considered a major to moderate problem in all areas.
    - Growers alternate the use of different fungicides.
    - Growers would like another curative fungicide for alternation.
    - Growers reported that the fungus is generally introduced into an area in diseased seed and can be spread throughout a crop on implements and animals, and by rain and irrigation water.

- Growers consider crop rotation is important.
- It was reported that 'while celery growers tend to rely on calendar spraying for fungal disease control, at least one Qld business has participated in the evaluation of a disease forecasting model for use in the management of Septoria spot (HAL VG04016) and continues to use the system which has reduced their fungicide usage by up to 50%' (Qld PMS 2008).

- Fungicides **registered** for the control of Septoria spot in celery are:
  - Chlorothalonil (various brand name products) – Group M5 protectant fungicide:
    - Commonly used (reported as most used and most effective).
    - Effective as a preventative, but some formulations can leave residues on the crop.
    - Also controls Cercospora early blight.
  - Copper (various) - Group M1 protectant fungicide
    - Commonly used.
    - Effective as a preventative, but some copper products can leave residues on crop.
    - Can cause crop damage in winter
    - Also controls Cercospora and some control of bacterial soft rot.
  - Mancozeb (various) - Group M3 protectant fungicide
    - Commonly used.
    - Effective as a preventative, but some products can leave residues on crop.
    - Also reported to control Cercospora.
    - Harmful to predatory mites
  - Metiram (POLYRAM) - Group M3 protectant fungicide
    - Not used.
  - Propineb (ANTRACOL) - Group M3 protectant fungicide
    - Not used.
  - Thiram (various) - Group M3 protectant fungicide
    - Not used.
  - Zineb (ZINEB) - Group M3 protectant fungicide
    - Not used.
  - Ziram (various) - Group M3 protectant fungicide
    - No use reported

- Fungicides listed for control of Septoria spot control in celery via **permits** are:
  - Difenconazole (SCORE) - PER13627) – Group 3 fungicide.
    - Protective and curative fungicide.
    - Commonly used by growers, though only used as needed.
    - Considered very effective as a curative.
    - Also provides excellent control of Early blight (*Cercospora apii*).
    - Grower concern with the development of resistance resulting from from frequent usage.
    - Permit expires 31-Dec-15.
    - No manufacturers interested in registering use.
  - Trifloxystrobin (FLINT - PER13658) – Group 11 fungicide.
    - Protective and curative fungicide (mainly protective)
    - Occasionally used.
    - Considered very effective when used at the first signs of disease present.
    - Also provides excellent control of Early blight (*Cercospora apii*).
    - Permit expires 30-Sep-14.
    - Overseas registration on celery
    - Grower and registrant interest in registration should be pursued
  - Metalaxyl-M + mancozeb (RIDOMIL GOLD MZ) - PER13673) – Groups 4 + M3 fungicide.
    - Protective and fungicide
    - Permit expires 30-Sep-16

4.1.2 Biosecurity risk diseases

None identified.

4.1.3 Summary

High Priority Diseases and control options.

Registrations for control of diseases in celery are primarily for old chemistry. Growers want additional, "safer" options and more choice to reduce risk of resistance. Seed treatment has been suggested as a future option for disease management, this being a chemical delivery method not currently used in celery. Non-chemical options are a consideration, with basic crop rotation a common practice to reduce disease carryover. Innovative techniques such as disease forecast modelling would be welcomed, although it can be difficult to find appropriate and sufficiently sensitive measurement devices to facilitate implementation. Introduction of celery varieties resistant to disease would help as there is limited access to chemicals. However growers are not aware of a breeding program at present.

Disease	Control option
Early blight or Cercospora leaf spot (*Cercospora apii)*	**Currently registered fungicides** Chlorothalonil (various brand name products) – commonly used Copper (various) – commonly used Hydrogen peroxide + peroxy acetic acid (PERATEC PLUS) – not commonly used, not IPM compatible Metiram (POLYRAM) - effective but only occasionally used, lacks IPM properties Zineb (ZINEB) - lacks IPM properties **Currently permitted fungicides** Difenconazole (SCORE - PER13627) - resistance issues, won't be registered Trifloxystrobin (FLINT - PER13658) - effective but only occasionally used, unlikely to be registered **Fungicide Gaps** Additional options for alternation to reduce risk of resistance **Potential fungicide solutions** None identified **Non-chemical options** Crop rotation
Sclerotinia rot (*Sclerotinia sclerotiorum)*	**Currently registered fungicides** Iprodione (various) occasionally used and not always effective **Currently permitted fungicides** None **Fungicide gaps** Alternatives – currently only one registration and no permits Some growers report the only registered fungicide (iprodione) as ineffective **Potential fungicide solutions** Penthiopyrad (FONTELIS). Dupont product with similar overseas registrations Boscalid (FILAN) has been mentioned for likely efficacy if applied 3-4 weeks after planting, and there is a current permit for brassica leafy vegetables. However there is no MRL established for stalk and stem vegetables. Boscalid/celery has overseas registrations. **Non-chemical options** Crop rotation

Disease	Control option
Septoria leaf spot or Late blight (*Septoria apiicola)*	**Currently registered fungicides** Chlorothalonil (various brand name products) – effective and commonly used Copper (various) – effective but can be crop damage Mancozeb (various) – commonly used and effective but lacks some IPM properties Metiram (POLYRAM) – not used Propineb (ANTRACOL) – not used Thiram (various) – not used Zineb (ZINEB) – not used Ziram (various) – not used **Currently permitted fungicides** Difenconazole (SCORE) - PER13627) – excellent performance but resistance concerns mean it is unlikely to be registered Trifloxystrobin (FLINT - PER13658) - good efficacy when used properly, overseas registrations Metalaxyl-M + mancozeb (RIDOMIL GOLD MZ - PER13673) – long permit, not key tool **Fungicide gaps** Not all the registered products are used. Growers want alternative curative products **Potential fungicide solutions** None identified **Non-chemical options** Crop rotation Disease forecasting models to reduce fungicide usage

Currently available celery fungicides

Active ingredient	Disease Name	WHP, days	Chemical Group
Chlorothalonil	Cercospora early blight (Cercospora leaf spot), Septoria leaf spot (late blight)	1	M5
Copper as oxychloride	Cercospora early blight (Cercospora leaf spot)	1	M1
Copper as ammonium acetate	Soft rot		
Copper as ammonium complex	Septoria leaf spot (late blight)		
Copper as cuprous oxide	Leaf diseases/spots, Soft rot		
Copper as hydroxide	Leaf diseases/spots, Septoria leaf spot (late blight), Soft rot		
Copper as octanoate	Septoria leaf spot (late blight)		
Copper as oxychloride	Septoria leaf spot (late blight)		
Copper as sulfate tribasic	Soft rot		
Copper as tribasic copper sulphate	Septoria leaf spot (late blight)		
Difenoconazole	Cercospora early blight (Cercospora leaf spot), Septoria leaf spot (late blight)	7	3
Hydrogen peroxide + peroxy acetic acid	Cercospora early blight (Cercospora leaf spot)	-	-
Iodine	Sanitiser - Bacteria, Fungi	NA	-
Iprodione	Sclerotinia rot	1	2
Mancozeb	Septoria leaf spot (late blight)	7	M3
Metalaxyl-M + mancozeb	Septoria leaf spot (late blight)	14	s 4+ M3
Metiram	Cercospora early blight (Cercospora leaf spot), Septoria leaf spot (late blight)	2	M3
Propiconazole	Cercospora early blight (Cercospora leaf spot)	14	3
Propineb	Septoria leaf spot (late blight)	7	M3
Thiram	Botrytis rot, Septoria leaf spot (late blight)	7	M3
Trifloxystrobin	Cercospora early blight (Cercospora leaf spot), Septoria leaf spot (late blight)	3	11
Zineb	Cercospora early blight (Cercospora leaf spot), Septoria leaf spot (late blight)	7	M3
Ziram	Septoria leaf spot (late blight)		

4.2. Nematodes of celery

Common name **Scientific name**

MODERATE PRIORITY

Root-Knot Nematodes……. *Meloidogyne* spp.

Biosecurity risk from nematodes

None identified

4.2.1. Priority nematodes

Root-Knot Nematodes (*Meloidogune* spp.)

Main symptoms of nematodes are found on the roots of the plant as a swelling of the roots from within resulting in galls. The size of galls varies depending on species. Root nodules are attached to the root and can be removed easily, root-knot galls cannot.
Above-ground symptoms include; stunting, poor growth, yellowing, chlorosis, wilting, yield reduction and premature death.
Heavily infected plants do not respond to watering or fertilisation due to nematode infection of roots.

- Nematodes are considered moderate problem in WA and Qld and a minor problem in other states.
  - Growers only apply nematicides if growing celery in a known nematode soil.
  - There are several species that can affect celery in Australia.
    - *Meloidogyne javanica, Meloidogyne hapla* and *Meloidogyne fallax*.

- Nematicides **registered** for the control of nematodes in celery are:
  - Fenamiphos (NEMACUR) - Group 1B systemic insecticide / nematicide:
    - Occasionally used. Fenamiphos is under review by the APVMA
  - 1,3-dichloropropene (various registered products) - broad spectrum fumigant
    - Registered in fruit & field crops for pre-plant only.
    - Occasionally used.
  - Metham sodium (METHAM) - broad spectrum fumigant
    - Registered in fruit & field crops for pre-plant only.
    - Occasionally used.
    - Metham is under review by the APVMA.

- No nematicides are listed for the control of nematodes in celery via **permits**.
- Crop rotation is the preferred control

4.2.2. Summary

Nematode priorities and control options.
Nematodes are seen as only a moderate priority and a need for alternate chemical options wasn't highlighted by growers during the SARP processes, despite the limitations of the current options. Crop rotation is seen as the preferred option.

Nematode	Control option
Root-Knot Nematodes (Meloidogune spp.)	**Currently registered nematicides** Fenamiphos (NEMACUR)- under review by APVMA 1,3-dichloropropene (various registered products) – occasionally used Metham sodium (METHAM) – occasionally used, under review by APVMA **Currently permitted nematicides** None **Nematicide gaps Gaps** Two of the three registered products are under review by the APVMA **Potential nematicide solutions** Fluensulfone 480EC (new Farmoz product soon to have first registration) – efficacy and residue data would be required. **Non-chemical options** Crop rotation

4.3. Insects of celery

Common name	Scientific name
HIGH PRIORITY	
Green peach aphid and Cotton aphid	*Myzus persicae, Aphis gossypii*
Helicoverpa	*Helicoverpa* spp.
Thrips - Onion thrips and Plague thrips ...	*Thrips tabaci, Thrips imaginis*
Western flower thrips	*Frankliniella occidentalis*
MODERATE PRIORITY	
Bugs - including Green vegetable bug and Rutherglen bug	*Nezara viridula, Nysius vinitor*
Cutworms	*Agrotis* spp.
Leafhoppers	*Cicadellidae* family
Lightbrown apple moth	*Epiphyas postvittana*
LOW PRIORITY	
African black beetle	*Heteronychus arator*
Armyworm - including Common armyworm and Southern armyworm	*Mythimna convecta, Persectania ewingii*
Cluster caterpillar	*Spodoptera litura*
Crickets including Black field cricket and Mole cricket	*Teleogryllus commodus, Gryllotalpidae*
Looper caterpillars	*Chrysodeixis spp.*
Mites - including Bryobia mite, European red mite, Rust mite, Tomato russet mite, Two-spotted mite	*Bryobia rubrioculus, Panonychus ulmi, Eriophyidae, Tetranychus urticae, Tetranychus urticae*
Redlegged earth mite	*Halotydeus destructor*
Webworm	*Lepidoptera*
Weevil - including Spotted vegetable weevil and Vegetable weevil	*Desiantha diversipes, Listroderes difficilis*
Wireworm and False wireworms	*Elateridae, Gonocephalum spp*
Whitefly	*Trialeurodes sp.*

Biosecurity risk

None identified

4.3.1. High priority insects

Aphids - Green peach aphid & Cotton aphid (*Myzus persicae, Aphis gossypii*)

Aphids are sap-sucking insects that deposit a sugary waste that encourages the growth of a sooty mould.
Aphids can develop large colonies and they're able to migrate away from plants when plant conditions change unfavourably, some can cause damage to plants and they also can act as vectors for viruses (Horne and Page 2008).
Best management practice includes the use of IPM compatible insecticides in combination with reliance on parasitic wasps.

Beneficial species for controlling aphids - Brown lacewings, Hoverflies, Parasitic wasps and Ladybird beetles.

- Aphids are considered a major problem in all areas.
  - Aphid numbers can vary, but can be heavy and result in stunted plant growth.
  - Growers want 'soft' alternatives.
  - To aid control of celery mosaic virus, aphids need to be controlled - need for new chemistry.
  - There are no aphid specific aphicides registered in celery.
- Insecticides **registered** for the control of aphids in celery are:
  - Dimethoate (various registered products) – Group 1B contact/systemic insecticide.
    - Commonly used.
    - Effective.
    - Also controls other insect pests including thrips, jassids and mites.
    - This treatment is disruptive to beneficial insects in an IPM situation.
    - Still able to be used in celery following APVMA review, but now a 21 day withholding period.
  - Potassium salts (various) – contact biological insecticide.
    - Not used
  - Fenamiphos (various) – Group 1B contact/systemic insecticide.
    - Fenamiphos is not used for this pest.
  - Maldison (various) – Group 1B contact/systemic insecticide.
    - Maldison is occasionally used.
    - It is considered to be very effective.
    - This treatment is disruptive to beneficial insects in an IPM situation.
  - Spirotetramat (MOVENTO) – Group 23 contact insecticide.
    - Broad spectrum insecticide registered for control of Western flower thrips, Tomato thrips, Green peach aphid and cotton aphid in celery
    - IPM compatible
- No insecticide listed for use by Persons Generally for control of aphids in celery via **permit**.
- Potential insecticide for control of aphids in celery:
  - 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
  - Pymetrozine (various) – Group 9B insecticide
    - Currently registered in other vegetable crops for control of aphids
    - IPM compatible
  - Sulfoxaflor (TRANSFORM^) – Group 4C insecticide
    - Registered for aphid control in many vegetables
    - May have adverse effects on parasitic wasps in IPM situations.

Helicoverpa (*Helicoverpa* spp.)

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

All species of Helicoverpa have hairs protruding from each black (or white) dots. Helicoverpa feed prolifically on leaves and are capable of causing large amounts of damage.

- Helicoverpa are considered moderate-major problem in all areas.
  - They are a transient pest.
  - "Insecticide resistance especially in *Helicoverpa armigera,* has made this species a particularly difficult pest when insecticides are totally relied upon for control" (Horne and Page 2008)

- Insecticides **registered** for Helicoverpa control in celery are:
  - Bacillus Thuringiensis (Bt) (various) - Group I16 contact insecticide:
    - Commonly used.
    - Very effective, but needs regular reapplication.
    - IPM compatible.
  - Chlorantraniliprole (various, including CORAGEN) - Group 28 contact/systemic insecticide
    - Commonly used in some regions.
    - Very effective.
    - IPM compatible.
  - Diazinon (various) – Group 1B contact/systemic insecticide.
    - Occasionally used in some regions.
    - Considered very effective.
    - Only used to get 'back in control' of grubs.
    - This treatment is highly disruptive to beneficial insects in an IPM situation.
  - Flubendiamide (BELT) – Group 28 contact/systemic insecticide.
    - Residual activity
    - IPM fit
  - Helicoverpa NPV (various) – is a biological insecticide:
    - Occasionally used but highly rated for efficacy and IPM compatibility.
    - Very effective on small grubs.
    - IPM compatible.
  - Permethrin (various) - Group 3A contact/systemic insecticide
    - Occasionally used in some regions.
    - Considered effective.
    - Only used to get 'back in control' of grubs.
    - This treatment is highly disruptive to beneficial insects in an IPM situation.
    - Resistance issues reported, particularly with *Helicoverpa armigera*
  - Spinetoram (SUCCESS NEO) - Group 5A contact/systemic insecticide
    - Commonly used in some regions.
    - Very effective.
    - Some impact in an IPM situation.
    - Grower concern with the development of resistance resulting from from frequent usage.
    - Used for Lepidoptera and WFT (although reports of lack of efficacy on WFT)

- Insecticides available for the control of Helicoverpa in celery via **permits** are:
  - Permethrin (various - PER14049) - Group 3A contact/systemic insecticide
    - For the control of helicoverpa and looper.
    - Occasionally used.
    - Considered effective.
    - Only used to get 'back in control' of grubs.
    - This treatment is highly disruptive to beneficial insects in an IPM situation.
    - Expires Apr-2023.
    - No support for registration.
  - Indoxacarb (various - PER13654) - Group 22A contact/systemic insecticide
    - For the control of Heliothis/Helicoverpa, Lightbrown apple moth, Lucerne leaf roller and Vegetable weevil.
    - Occasionally used.
    - Considered very effective, but expensive.
    - Some impact in an IPM situation.
    - Expires 30-Sep-14.
    - No support for registration for the group but worthwhile option for vegetable weevil (PH).
  - Emamectin (various – PER13122) – Group 6
    - For the control of Heliothis/Helicoverpa, Light brown apple moth and Cluster caterpillar
    - Expires Sept-2016
    - Not IPM compatible
  - Esfenvalerate (various – PER9161) – Group 3A
    - For the control of *Helicoverpa armigera*
    - Expires March-2016
    - Not IPM compatible

Thrips - including Onion (*Thrips tabaci*), Plague (*Thrips imaginis*)

Adults are 2 mm long, cigar-shaped and range in colour from yellow-orange to grey-black. They have narrow wings folded along their back. Nymphs are similar in shape, pale yellow to orange-yellow, wingless and smaller. They are a sucking pest which damages the surface of plant tissue such as leaves and stems.
Crop can tolerate significant numbers without damage, but can causes streaks on leaves and downgrade of produce.
A hot, dry spring that follows a mild, dry winter favours this pest (Qld DPI 1994).

- Thrips are considered a major problem in all areas
  - All insecticides used in alternation due to the concerns with resistance developing.
  - Along with Helicoverpa, thrips are considered the most important pests of celery (Qld PMS 2008).
  - Thrips, mainly thought to be plague thrips, are a serious problem across most districts, requiring the use of disruptive synthetic pyrethroids and organophosphate insecticides. Softer solutions required.
  - Accurate identification of all thrips that affect celery is difficult for growers.
  - Thrips have few insect enemies however populations can decrease due to weather, i.e. heavy rain or hot dry conditions. (McMaugh 1989).

- Insecticides **registered** for the control of thrips in celery are:
  - Dimethoate (various) – Group 1B contact/systemic insecticide.
    - Commonly used for the control of a range of pests.
    - It is reported to still be effective
    - This treatment is disruptive to beneficial insects in an IPM situation.
    - Still able to use dimethoate in celery per-harvest with a 14 day WHP for the control of aphids, thrips, jassids and Redlegged earth mites.
  - Potassium salts (various) – contact biological insecticide.
    - Not used
  - Fenamiphos (various) – Group 1B contact/systemic insecticide.
    - Not used for this pest.
  - Maldison (various) – Group 1B contact/systemic insecticide.
    - Rarely used for the control of aphids, Green vegetable bugs, jassids, leaf hoppers, Rutherglen bugs and thrips.
    - It is considered to be very effective
    - This treatment is highly disruptive to beneficial insects in an IPM situation.
  - Spirotetramat (MOVENTO) – Group 23 contact insecticide.
    - Broad spectrum insecticide registered for control of Western flower thrips, Tomato thrips, Green peach aphid and cotton aphid in celery
    - IPM compatible

- No insecticides listed for control of thrips in celery via **permits**.

- **Potential** insecticides listed for control of thrips.
  - Sulfoxaflor (TRANSFORM^) – Group 4C insecticide
    - Thrips registrations in a range of vegetables
    - May have adverse effects on parasitic wasps in IPM situations.
    -
  - Thiamethoxam + chlorantraniliprole (DURIVO) - Group 4A + 28 contact and systemic insecticide
    - Registered in other vegetables as a seedling drench or soil drench for aphids, lepidoptera, whitefly and thrips.
    - Effective but moderately harmful to some beneficial insects.

Western flower thrips (*Frankliniella occidentalis*)

The adults are tiny insects, generally measuring only 1 to 2 mm in length. They have thin bodies and vary in colour from near black to straw coloured.
While thrips can cause direct damage to foliage and fruit, their role as vectors of tomato spotted wilt is of primary concern, especially in tomato and pepper.
Crop can tolerate significant numbers without damage, but can causes streaks on leaves and downgrade of produce.

- Western flower thrips are considered a major problem in all regions.
  - All insecticides used in alternation due to rapid resistance development to many commonly used insecticides.
  - Growers find it difficult to distinguish difference between thrips species with the naked eye due to their very small size.
  - WFT develop resistance more easily than other thrips species.
  - Growers need multiple options.
  - Vector for T.S.W.V. (Tomato spotted wilt virus)

- Insecticides registered for the control of Western flower thrips in celery:
  - Spirotetramat (MOVENTO) – Group 23 contact insecticide.
    - Broad spectrum insecticide registered for control of Western flower thrips, Tomato thrips, Green peach aphid and cotton aphid in celery
    - IPM compatible
- Insecticides that are registered for the control of thrips in celery:
  - Dimethoate (various) – Group 1B contact/systemic insecticide.
  - Fenamiphos (various) – Group 1B contact/systemic insecticide.
  - Maldison (various) – Group 1B contact/systemic insecticide.

  that are likely to be ineffective against Western flower thrips due to resistance.

- No insecticides are listed for control of Western flower thrips in celery via permits.

4.3.2. Biosecurity risk insects

None listed.

4.3.3. 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. It can, however be noted that the use of softer chemistry can lead to damaging numbers of pests that would normally be controlled when the key target pests are treated with broader spectrum products. Red legged earth mites are an example cited by growers. Overall, the industry wants to consider all new chemistry introduced to the market for a fit in celery, and more specifically in IPM programs.

Insect	Control option
Aphids including Green peach aphid and Cotton aphid (*Myzus persicae*, *Aphis gossypii)*	**Currently registered insecticides** Dimethoate (various registered products) – effective but not IPM compatible Potassium salts (various) - not used Fenamiphos (various) – not used for this pest Maldison (various) - effective but not IPM compatible Spirotetramat (MOVENTO) – broad spectrum, IPM compatible **Currently permitted insecticides** None available to persons generally **Insecticide Gaps** No aphid-specific chemistry for celery "Soft" solutions **Potential insecticide solutions** Flonicamid (new ISK/FMC product)– Group 9C – efficacy and residue data required. Imidacloprid has been mentioned as expected to be efficacious. There is a permit for rhubarb/aphids and a temporary MRL for rhubarb, but no MRL for stem or stalk vegetables. Pymetrozine (various) – IPM compatible, registered in other crops for aphids. Sulfoxaflor (TRANSFORM^) – Group 4C aphid registrations on other crops **Non-chemical options** Best management practice includes the use of IPM compatible insecticides in combination with reliance on parasitic wasps

Insect	Control option
Helicoverpa *Helicoverpa* spp	**Currently registered insecticides** Bacillus Thuringiensis (Bt) (various) - effective, IPM compatible Chlorantraniliprole (various, including CORAGEN) - effective, IPM compatible Diazinon (various) - occasional use, not IPM compatible Flubendiamide (BELT) - IPM fit Helicoverpa NPV (various) - effective on small grubs, IPM compatible Permethrin (various) - effective, occasional use, not an IPM fit Spinetoram (SUCCESS NEO) - effective, common use, resistance issues **Currently permitted insecticides** Permethrin (various - PER14049) Indoxacarb (various - PER13654) - no support for registration Emamectin (various - PER13122) - not IPM compatible Esfenvalerate (various - PER9161) - not IPM compatible **Insecticide Gaps** Insecticide resistance in many chemicals with helicoverpa **Potential insecticide solutions** None identified **Non-chemical options** None identified – this should be investigated in future SARPS
Thrips - including Onion thrips and Plague thrips (*Thrips tabaci, Thrips imaginis*)	**Currently registered insecticides** Dimethoate (various) - effective but not IPM compatible Potassium salts (various) - not used Fenamiphos (various) - not used for this pest Maldison (various) - effective but not IPM compatible Spirotetramat (MOVENTO) - broad spectrum, IPM compatibility **Currently permitted insecticides** None **Insecticide Gaps** Soft alternatives, more alternatives **Potential insecticide solutions** Sulfoxaflor (TRANSFORM^) – Group 4C – thrips registrations in many crops Thiamethoxam + chlorantraniliprole (DURIVO, Group 4A+28, efficacious but moderately harmful to some beneficial insects **Non-chemical options** None identified – this should be investigated in future SARPS
Western flower thrips *(Frankliniella occidentalis)*	Of the above, spirotetramat is broad spectrum, with efficacy on WFT The following are likely to be ineffective due to resistance: dimethoate, fenamiphos, maldison. WFT can be controlled to an extent by not allowing mite numbers to build.

Currently available celery insecticides

Active ingredient	Insect name	WHP, days	Chemical
Alpha-cypermethrin	Leafroller caterpillar, Redlegged earth mite, vegetable weevil (PER13700, not persons generally)	3	3A
Bacillus thuringiensis (bt)	Helicoverpa / Heliothis	-	I16
Buprofezin	Whitefly (PER13936)	3	16
Carbaryl, maldison	Australian plague locust	See Label	1A/1B
Chlorantraniliprole	Helicoverpa / Heliothis	3	28
Chlorpyrifos	Australian plague locust, Black field cricket, Cutworms, Field crickets, Mole crickets, Spotted vegetable weevil, Vegetable weevil, Wingless grasshopper	14	1B
Diazinon	Australian plague locust , Caterpillars, Cutworms	14	1B
Dimethoate	Aphids, Bugs, Green vegetable bug, Jassids, Leafhoppers, Leafminer flies, Mites, Thrips, Wingless grasshopper,	21	1B
Emamectin	Cluster caterpillar, Helicoverpa / Heliothis, Lightbrown apple moth	3	6
Esfenvalerate	Helicoverpa / Heliothis, Looper caterpillars	1	3A
Fenamiphos	Aphids, Insects – Sucking, Thrips	84	1B
Flubendiamide	Diamondback moth, Cabbage white butterfly, Cluster caterpillar, Potato moth, Helicoverpa	1	28
Helicoverpa NPV	Helicoverpa / Heliothis	NA	-
Indoxacarb	Helicoverpa / Heliothis, Lightbrown apple moth, Looper caterpillars, Vegetable weevil	7	22A
Maldison	28-spotted potato ladybird, Aphids, Green vegetable bug, Jassids, Leafhoppers, Redlegged earth mite, Rutherglen bug, Thrips	3	1B
Permethrin	Common armyworm, Helicoverpa / Heliothis, Looper, Lucerne leafroller, Southern armyworm,	1	3A
Petroleum	Aphids, Green mired, Green vegetable bug, Grey cluster bug, Leafhoppers, Mites, Rutherglen bug	3	-
Potassium salts	Thrips	-	-
Spinetoram	Helicoverpa / Heliothis	1	5
Spirotetramat	Aphids, Thrips	3	23
Trichlorfon	Cabbage moth, Cabbage white butterfly, Cutworms, Green vegetable bug	2	1B

4.4. Weeds of celery

4.4.1. High priority weeds

Weeds identified as a high priority for control are:

Weed (common name)	**Weed (scientific name)**
Marshmallow……..	*Malva parviflora*
Winter grass……	*Poa annua*
Potato weed……	*Galinsoga* spp.
Groundsel……	*Serecio vulgaris*

Registered herbicides that are used in celery are:

- Clethodim (Various) – Group A grass selective post-emergent herbicide.
  - Occasionally used.
  - Considered very effective.
  - Controls most grass weeds.
- Fluazifop (various) – Group A grass selective post-emergent herbicide.
  - Occasionally used.
  - Broad spectrum, although does not control winter grass
  - considered very effective.
  - Controls most grass weeds. Does not control Winter grass.
- Prometryn (various) - Group C general knockdown & residual herbicide.
  - Occasionally used.
  - Considered very effective.
  - Controls most weeds.
  - Some reports of resistance to stinging nettles.
- Glyphosate (Various) – Group M pre-plant general knockdown herbicide.
  - Commonly used.
  - Works well as a pre-crop spray.
- Paraquat + diquat (Various) - Group L pre-plant general knockdown herbicide.
  - Occasionally used.
  - Works well as a pre-crop spray

- The herbicides listed for control of weeds in celery via **permits** are:
  - Linuron (various - PER13496) - Group C general knockdown & residual herbicide.
    - Commonly used.
    - Considered very effective.
    - Controls most weeds.
    - Permit expires 30-Apr-17.

4.4.2. Summary

High priority weeds and control options
Overall there is a need for newer chemistry and increased options for control of weeds in celery.

Insect	Control option
Marshmallow (*Malva parviflora)* Winter grass (*Poa annua)* Potato weed (*Galinsoga* spp.*)* Groundsel (*Serecio vulgaris)*	**Currently registered herbicides** Glyphosate (Various) Paraquat + diquat (Various) **Currently permitted herbcides** Linuron (various - PER13496) **Herbicide Gaps** Additional registered and permitted options needed **Potential herbicide solutions** Pendimethalin mentioned as possible option. It is not registered for use in celery in Australia, although is overseas. Other herbicides have permits for similar minor use crops eg oxyfluorfen, which has also been considered under the IR-4 program. Data required. Pyroxasulfone (SAKURA) is a new, IPM compatible grass herbicide that could be considered and is the subject of an IR4 project. Data required. However herbicide gaps and solutions were not highlighted by growers during the SARP process. **Non-chemical options** None identified – this should be investigated in future SARPS.

Currently available celery herbicides

Active ingredient	Weeds	WHP, days	Chemical Group
Clethodim	Annual and perennial grasses. Not recommended for use in seed crops	30	A
Diquat + paraquat	Grasses and broadleaf weeds	-	L
Fluazifop	Annual Phalaris, Annual (Wimmera) Ryegrass, Barley Grass, Barnyard Grass, Brome Grasses, Crowsfoot Grass, Green Summer Grass, Johnson Grass (seedling), Liverseed Grass, Panicum spp., Paspalum, Stinkgrass, Volunteer Cereals, Wild Oats	4	A
Glyphosate	Grasses and broadleaf weeds	-	M
Prometryn	Amaranth (Powell's, Slim and Redroot), Amsinckia, Blackberry Nightshade, Capeweed, Charlock, Chickweed, Common Spurry, Corn Gromwell, Fumitory (Common, White and Dense Flowered), Fat Hen, Hedge Mustard, Hexham Scent, Indian Hedge Mustard, Lesser Nettle, Mountain Sorrel, Rough Poppy, Three-cornered Jack, Wild Radish. **Pre-emergent suppression** of Annual Ryegrass, Barnyard Grass, Prairie Grass and Summer Grass.	-	C
Linuron	Annual broadleaf weeds and grasses	-	C

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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, minor use)
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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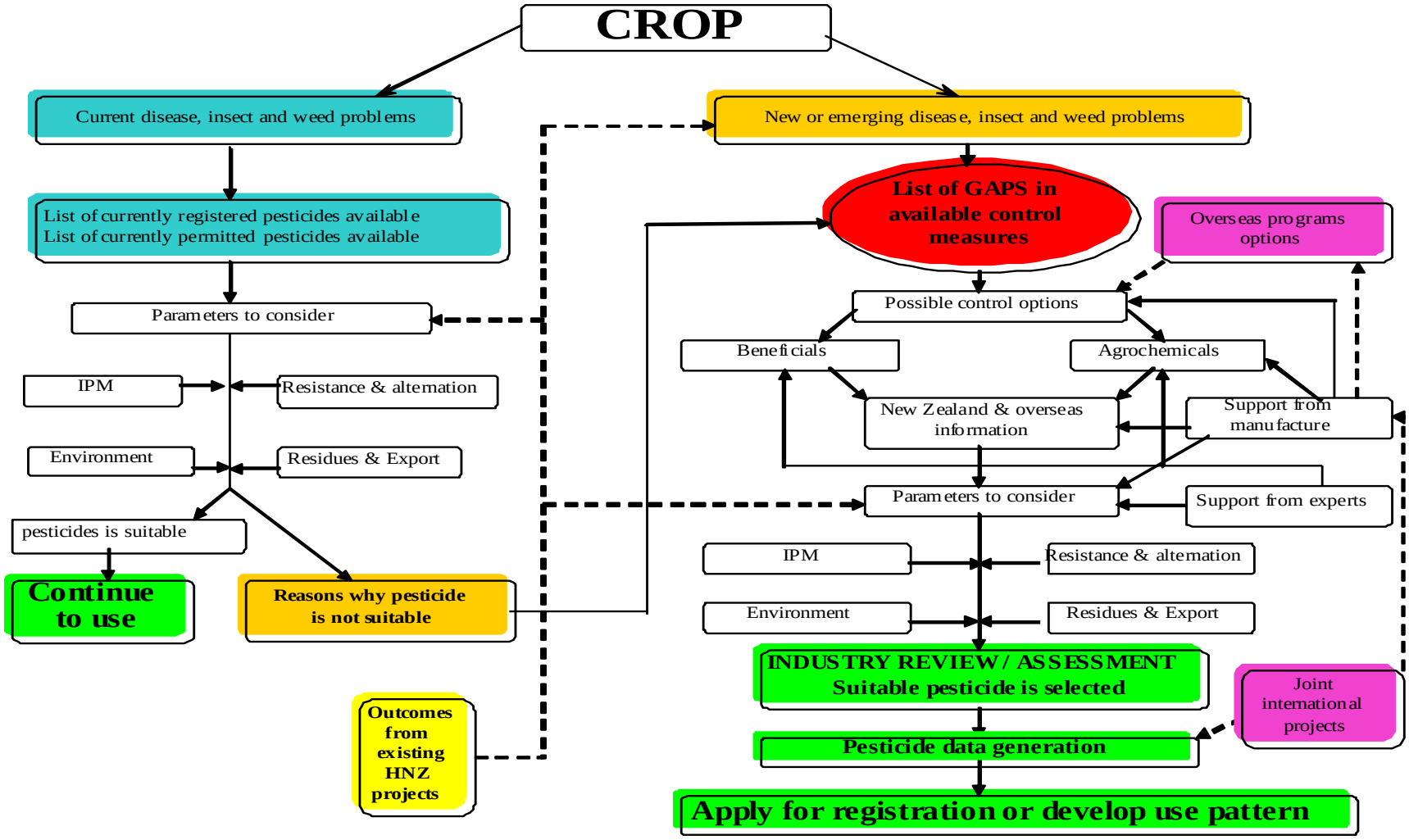
6. Appendices

DIAGRAM 1: The Strategic Agrichemical Review Process



Appendix 2 – currently available fungicides in celery.

Disease Name	Active ingredient	WHP, days	Chemical Group
Bactericide	iodine	NA	Sanitiser
Botrytis rot	thiram	7	M3
Cercospora early blight (Cercospora leaf spot)	chlorothalonil	1	M5
	copper as oxychloride	1	M1
	difenoconazole	7	3
	hydrogen peroxide + peroxy acetic acid		
	metiram	2	M3
	propiconazole	14	3
	trifloxystrobin zineb	3 7	11 M3
Fungi	iodine	NA	Fungicide, Sanitiser
Leaf diseases/spots	copper as hydroxide	1	M1
	copper as cuprous oxide	1	M1
Sclerotinia rot	iprodione	1	2
Septoria leaf spot (late blight)	chlorothalonil	1	M5
	copper as ammonium complex	1	M1
	copper as hydroxide	1	M1
	copper as octanoate	1	M1
	copper as oxychloride	1	M1
	copper as tribasic copper sulphate	1	M1
	difenoconazole	7	3
	mancozeb	7	M3
	metalaxyl-M + mancozeb	14	s 4+ M3
	metiram	2	M3
	propineb	7	M3
	thiram	7	M3
	trifloxystrobin	3	11
	zineb	7	M3
	ziram		
Soft rot	copper as ammonium acetate	1	M1
	copper as hydroxide	1	M1
	copper as copperprous oxide	1	M1
	copper as sulfate tribasic	1	M1

Appendix 3 – currently available insecticides in celery.

Insect name	Active ingredient	WHP, days	Chemical Group
28-spotted potato ladybird	maldison	3	1B
Aphids	dimethoate	21	1B
	fenamiphos	84	1B
	maldison	3	1B
	petroleum	3	-
	spirotetramat	3	23
Australian plague locust	carbaryl, chlorpyrifos, diazinon, maldison	See Label	1A/1B
Black field cricket	chlorpyrifos	14	1B
Bugs	dimethoate	21	1B
Cabbage moth	trichlorfon	2	1B
Cabbage white butterfly	flubendiamide	1	28
	trichlorfon	2	1B
Caterpillars	diazinon	14	1B
Cluster caterpillar	emamectin	3	6
	flubendiamide	1	28
Common armyworm	permethrin	1	3A
Cutworms	chlorpyrifos	NS	1B
	diazinon	14	1B
	trichlorfon	2	1B
Diamondback moth	flubendiamide	1	28
Field crickets	chlorpyrifos	Not specified	1B
Green mirid	petroleum	3	-
Green vegetable bug	dimethoate	21	1B
	maldison	3	1B
	petroleum	3	-
	trichlorfon	2	1B
Grey cluster bug	petroleum	3	-
Helicoverpa / Heliothis	Bacillus Thuringiensis (Bt)	-	I16
	chlorantraniliprole	3	28
	emamectin	3	6
	esfenvalerate	1	3A
	flubendiamide	1	28
	Helicoverpa NPV	NA	-
	indoxacarb	7	22A
	permethrin	1	3A
	spinetoram	1	5
Insects - Sucking	fenamiphos	84	1B
Jassids	dimethoate	21	1B
	maldison	3	1B
Leafhoppers	dimethoate	21	1B
	maldison	3	1B
	petroleum	3	-
Leafminer flies	dimethoate	21	1B
Leafroller caterpillar	alpha-cypermethrin	3	3A
Lightbrown apple moth	emamectin	3	6

Insect name	Active ingredient	WHP, days	Chemical Group
	indoxacarb	7	22A
Looper caterpillars	esfenvalerate	1	3A
	indoxacarb	7	22A
Lucerne leafroller	permethrin	1	3A
Mites	dimethoate	21	1B
	petroleum	3	-
Mole crickets	chlorpyrifos	Not specified	1B
Potato moth	flubendiamide	1	28
Redlegged earth mite	alpha-cypermethrin	3	3A
	maldison	3	1B
Rutherglen bug	maldison	3	1B
	petroleum	3	-
Southern armyworm	permethrin	1	3A
Spotted vegetable weevil	chlorpyrifos	0	1B
Thrips	dimethoate	21	1B
	fenamiphos	84	1B
	maldison	3	1B
	potassium salts	-	-
	spirotetramat	3	23
Vegetable weevil	alpha-cypermethrin	3	-
	chlorpyrifos	NS	1B
	indoxacarb	7	22A
Whitefly	buprofezin	3	16
Wingless grasshopper	chlorpyrifos	0	1B
	dimethoate	21	1B

Appendix 4 – currently available herbicides in celery.

Weed groups	Active ingredient	Weeds	WHP, days	Chemical Group
Grasses	Clethodim	Annual and perennial grasses. Not recommended for use in seed crops	30	A
	Fluazifop	Annual Phalaris, Annual (Wimmera) Ryegrass, Barley Grass, Barnyard Grass, Brome Grasses, Crowsfoot Grass, Green Summer Grass, Johnson Grass (seedling), Liverseed Grass, Panicum spp., Paspalum, Stinkgrass, Volunteer Cereals, Wild Oats	4	A
Grass and broadleaf weeds	Diquat + paraquat	Grasses and broadleaf weeds	-	L
	Glyphosate	Grasses and broadleaf weeds	-	M
	Linuron	Annual broadleaf weeds and grasses	-	C
	Prometryn	Amaranth (Powell's, Slim and Redroot), Amsinckia, Blackberry Nightshade, Capeweed, Charlock, Chickweed, Common Spurry, Corn Gromwell, Fumitory (Common, White and Dense Flowered), Fat Hen, Hedge Mustard, Hexham Scent, Indian Hedge Mustard, Lesser Nettle, Mountain Sorrel, Rough Poppy, Three-cornered Jack, Wild Radish. Pre-emergent suppression of Annual Ryegrass, Barnyard Grass, Prairie Grass and Summer Grass.	-	C