



Fennel (bulb)

Strategic Agrichemical Review Process
(SARP)

June 2021

Hort Innovation
Project - VG18004

Hort Innovation Project Number:

VG18004 – Vegetable Strategic Agrichemical Review Process (SARP) Report Updates

SARP Service Provider:

Vasanthe Vithanage T/A Hortigrow Consulting

Purpose of the report:

This report was funded by Hort Innovation to investigate the pest problem, agrichemical usage and pest management alternatives for the Fennel (bulb) industry across Australia. The information in this report will assist the industry with its agrichemical selection and usage into the future.

Date of report:

June 2021

Disclaimer:

Hort Innovation makes no representations and expressly disclaims all warranties (to the extent permitted by law) about the accuracy, completeness, or currency of information in the Fennel (bulb) industry SARP Report. Users of this material should take independent action before relying on its accuracy in any way.

Reliance on any information provided by Hort Innovation is entirely at your own risk. Hort Innovation is not responsible for, and will not be liable for, any loss, damage, claim, expense, cost (including legal costs) or other liability arising in any way (including from Hort Innovation or any other person's negligence or otherwise) from your use or non-use of the Fennel (bulb) industry SARP Report, or from reliance on information contained in the material or that Hort Innovation provides to you by any other means.

Legal Notice:

Copyright © Horticulture Innovation Australia Limited 2019

Copyright subsists in the Fennel (bulb) SARP. Horticulture Innovation Australia Limited (Hort Innovation) owns the copyright, other than as permitted under the Copyright ACT 1968 (Cth). The Fennel (bulb) SARP (in part or as a whole) cannot be reproduced, published, communicated or adapted without the prior written consent of Hort Innovation. Any request or enquiry to use the Fennel (bulb) SARP should be addressed to:

Communications Manager
Hort Innovation
Level 7, 141 Walker Street
North Sydney NSW 2060
Australia
Email: communications@horticulture.com.au
Phone: 02 8295 2300

 	<p>This project has been funded by Hort Innovation using the vegetable research and development levy and funds from the Australian Government. For more information on the fund and strategic levy investment visit horticulture.com.au</p>
---	--

Table of Contents

1. Summary	4
1.1 Diseases	5
1.2 Insects and other pests	5
1.3 Weeds	5
2. The Australian Fennel Bulb Industry	6
3. Introduction	7
3.1 Background.....	7
3.2 Minor use permits and registration	8
3.3 Methods	9
3.4 Results and discussions	10
3.4.1 Detail.....	10
3.4.2 Appendices	10
4. Pests, Diseases and Weeds of Fennel bulb	11
4.1 Diseases of fennel bulb.....	12
4.1.1 Disease priorities	12
4.1.2 Available and potential products for priority diseases	13
4.2 Insect and other pests of fennel bulb	23
4.2.1 Insect and other pest priorities.....	23
4.2.2 Available and potential products for priority insects and other pests	25
4.3 Weeds in fennel bulb	44
4.3.1 Weed priorities	44
4.3.2 Available and potential products for weed control.....	45
5. References.....	47
5.1 Information:	47
5.2 Abbreviations and Definitions:	47
5.3 Acknowledgements:	47
6. Appendices:	48
Appendix 1. Products available for disease control in fennel bulb	49
Appendix 2. Products available for control of insect and other pests in fennel bulb.....	50
Appendix 3. Products available for weed control in fennel bulb	53
Appendix 4. Current permits for use in fennel bulb.....	54
Appendix 5. Fennel bulb Maximum Residue Limits (MRLs)	55
Appendix 6: Fennel bulb Agrichemical Regulatory Risk Assessment	57

1. Summary

The strategic levy investment project Vegetable Industry SARP Report Updates (VG18004) is part of the Hort Innovation Vegetable Fund. A Strategic Agrichemical Review Process (SARP), through the process of a desktop audit and industry liaison;

- (i) Assesses the importance of the diseases, insects and weeds (plant pests) that can affect a horticultural industry;
- (ii) Evaluates the availability and effectiveness of fungicides, insecticides and herbicides (pesticides) to control the plant pests;
- (iii) Determines any gaps in the pest control strategy and
- (iv) 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

The results of this process will provide the Fennel (bulb) industry with sound pesticide usage for the future that the industry can pursue for registration with the manufacturer, or minor-use permits with the Australian Pesticide and Veterinary Medicines Authority (APVMA).

1.1 Diseases

The high priority diseases are:

Common name	Scientific name
Sclerotinia Rot	<i>Sclerotinia</i> spp.
Leaf Blight	<i>Cercosporidium</i> spp.
Septoria Leaf Spot	<i>Septoria</i> spp.

1.2 Insects and other pests

The high priority insects are:

Common name	Scientific name
High	
Melon Thrips	<i>Thrips palmi</i>
Plague Thrips	<i>Thrips imagines,</i>
Western Flower Thrips	<i>Frankliniella occidentalis</i>
Green Peach Aphids	<i>Myzus persicae</i>
Rutherglen Bug	<i>Nysius vinitor</i>

1.3 Weeds

No weeds have been identified for Fennel (bulb) in the recently conducted industry survey.

2. The Australian Fennel Bulb Industry

The Australian Fennel (bulb) industry is a small horticultural industry the majority of production being used in the fresh market.

Fennel (bulb) is grown in most states of Australia, with most of the production occurring in the Werribee region in Victoria.

Fresh Fennel (bulb) Seasonality by State

State	19/20 t	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
New South Wales (5%)	67												
Victoria (80%)	1,076												
Queensland (11%)	148												
Western Australia (3%)	40												
South Australia (1%)	13												
Availability legend			High		Medium		Low						None

Almost all the Fennel (bulb) grown in Australia are destined for the fresh market.

Production for the year ending June 2020¹:

- 1,345 t were produced with 3% sent to processing.
- The value of production was \$2.7 m while the wholesale value of the fresh supply was \$3.1 m.

¹ Hort Innovation (2020). Australian Horticulture Statistics Handbook 2019/20. [online] Available at: <https://www.horticulture.com.au/globalassets/hort-innovation/resource-assets/ha18002-australian-horticulture-statistics-handbook-2019-20-vegetables.pdf>

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 may not be of sufficient size for Agrichemical companies 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 Agrichemical companies unwilling to bear the initial high cost of registering suitable pesticides.

Growers may face severe losses from diseases, pests and weeds due to a lack of registered or approved (via a permit) chemical control tools.

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.

In combination with cultural practices, pesticides are important tools in Fennel (bulb) production and respective IPM programs. 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 utilised during establishment and development, and to maximise quality and customer appeal.

As a consequence of the issues facing the Fennel (bulb) industry regarding pesticide access, Hort Innovation has undertaken a review of the pesticide requirements via a Strategic Agrichemical Review Process (SARP) and its current position is outlined here.

The SARP process identifies diseases, insect pests and weeds of major concern to the Fennel (bulb) industry. Against these threats, available registered or permitted pesticides are evaluated for overall suitability in terms of IPM, resistance, efficacy, trade, human safety and environmental issues. Where tools are unavailable or unsuitable the process aims to identify potential future solutions. Potential new risks to the industry are also identified.

The results will provide the Fennel (bulb) industry with a clear outlook of gaps in existing pest control options. This report is not a comprehensive assessment of ALL pests and control methods used in Fennel (bulb) but attempts to prioritise the major problems.

Exotic plant pests, not present in Australia, are not addressed in this document. A biosecurity plan has been developed for the Vegetable Industry in consultation with industry, government and scientists. The Biosecurity Plan for the Vegetable Industry which covers Fennel (bulb) outlines key threats to the industry, risk mitigation plans, identification and categorisation of exotic pests and contingency plans. High priority exotic pests have been assessed based on their potential to enter, establish, and spread in Australia (e.g. environmental factors, host range, vectors) and the cost to industry of control measures.

<https://ausveg.com.au/app/uploads/2018/06/Industry-Biosecurity-Plan-for-the-Vegetable-Industry.pdf>

3.2 Minor use permits and registration

From a pesticide access perspective, the APVMA classifies Fennel (bulb) as a minor crop. The crop fits within the APVMA crop group Crop Group 017: Stalk and Stem vegetables.

Crop Group	Subgroup	Commodity Name	Codex Code	Scientific Name
Crop Group 017: Stalk and stem vegetables VS 0078	Subgroup 017A, Stems and petioles	Fennel, Bulb	VS 0380	Foeniculum vulgare Mill. subsp. vulgare var. azoricum (Mill.) Thell- (Fennel Florance)
Crop Group 027: Herbs HH 0092	Subgroup 027A, Herbs (Herbaceous plants)	Fennel leaves	HH 0731	Foeniculum vulgare Mill.
Crop Group 028: Spices HH 0093	Subgroup 028A, Spices, seeds	Fennel, seed	HS 0731	Foeniculum vulgare Mill., syn: F. officinale All, F. capilaceum Gilib.

Therefore, access to minor use permits can be relatively straight forward as long as a reasonable justification is provided in accordance with the APVMA's minor use guidance².

Possible justification for future permit applications could be based on:

- New disease, insect or weed identified as a cropping issue
- No pesticide approved for the problem
- Insufficient options for resistance management
- Current pesticides ineffective due to resistance
- Trade risk - current pesticides unsuitable where crop commodities will be exported
- IPM, environment or OH&S issues
- Loss of pesticides due to removal from market or chemical review restrictions
- Opportunity to extrapolate a use pattern when a new, effective pesticide is registered in another crop
- Alternate pesticide has overseas registration or minor use permit
- Market failure – insufficient return on investment for registrant.

With each of these options, sound, scientific argument is required to justify any new permit applications. Another option for the Fennel (bulb) industry is for manufacturers to register new pesticides uses in the crop.

² <https://apvma.gov.au/node/10931>

3.3 Methods

The current position of the Fennel (bulb) Strategic Agrichemical Review Process (SARP) is being conducted by desktop audit using industry information gathered along similar lines in other vegetable reviews – Managing pesticide access in horticulture and finalised under VG12081 - Review of vegetable SARP reports. The process included gathering, collating and confirming information:

Hort Innovation Project Reference	Process of Review - Activity
VG16060 -Vegetable Agrichemical Pest Management Needs and Priorities (AUSVEG) - Commenced: 2 May 2017	<p>Engagement and consultation with growers and other relevant stakeholders. Including; Online crop specific surveys, workshops and one on one consultation Nationally.</p> <p>Collation of information collected by commodity on applicable pests, diseases and weeds in order of priority.</p>
MT17019 – Regulatory Support & Co-ordination (AKC)	<p>Fennel (bulb) Agrichemical Regulatory Risk Assessment Document</p> <p>To assist strategic planning, with respect to future pest management options, this document was developed as part of the Hort Innovation funded project MT17019 to highlight the regulatory threats to agrichemicals currently approved for the management of the pests and diseases in Fennel (bulb) as well as current initiatives aimed at addressing identified pest management deficiencies.</p>
VG18004 – Vegetable Strategic Agrichemical Review Process (SARP) Report Updates	<p>SARP updated via a desktop audit:</p> <p>Review list of priorities ranked as high, moderate and low for each plant pest groups (disease, insects and weeds) – provided by VG16060</p> <p>Identify industries pest priority gaps in order of importance</p> <p>Update current pesticides available via label registrations or minor use permits</p> <p>Update available pesticide use patterns, IPM ranking/compatibility, mode of action and chemical group.</p> <p>Identify pesticides at risk (under review and/or limited uses) via MT17019 Regulatory Support & Co-ordination – AKC consulting.</p> <p>Identify any appropriate solutions through the outcomes of the AgChem Forum’s or similar market intelligence and their overall suitability (IPM compatibility, Chemical group to manage resistance, risk profile, existing domestic MRL’s or global MRL’s including any potential trade barriers, efficacy, OH&S, environmental safety and sustainability).</p> <p>Include known pesticide solutions that are currently under development with registrants for new uses in the nominated crops or in current Hort Innovation projects.</p> <p>Update MRL tables to include Australian MRL’s, Codex and any applicable export market MRL’s</p>

3.4 Results and discussions

3.4.1 Detail

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

3.4.2 Appendices

Refer to additional information in the appendices:

Appendix 1. Products available for disease control in fennel bulb

Appendix 2. Products available for control of insect and other pests in fennel bulb

Appendix 3. Products available for weed control in fennel bulb

Appendix 4. Current permits for use in fennel bulb

Appendix 5. Fennel bulb Maximum Residue Limits (MRLs)

Appendix 6. Fennel bulb Agrichemical Regulatory Risk Assessment

4. Pests, Diseases and Weeds of Fennel bulb

Resistance management: To manage the risk of resistance development, integrated disease/pest/weed management (IDM/IPM/IWM) strategies should be adopted. The general principle is to integrate diverse chemical and non-chemical strategies; maximise efficacy; not rely on singular tools and rotate between different modes of action. It is always essential to follow all the label instructions. Specific resistance management strategies may apply. These can be found, along with other useful information, on the CropLife Australia website³.

In chapter 4, information on regulatory risk derived from project MT17019 - Regulatory support and coordination (Appendix 6) has been incorporated.

Some of the suggested options have no overseas MRLs (see Appendix 5). If treated fruit is to be exported nil residues at harvest would be needed for these options.

While care has been taken to ensure the accuracy of the information provided in this document the APVMA registered label and where relevant the APVMA approved permit must always be followed.

³ <https://www.croplife.org.au/resources/programs/resistance-management/>

4.1 Diseases of fennel bulb

4.1.1 Disease priorities

Common name	Scientific name
High	
Sclerotinia Rot	<i>Sclerotinia</i> spp.
Leaf Blight	<i>Cercosporidium</i> spp.
Septoria Leaf Spot	<i>Septoria</i> spp.
Moderate	
Fusarium Root Rot	<i>Fusarium solani</i>
Low	
Damping Off	<i>Pythium</i> spp., <i>Phytophthora</i> spp., <i>Fusarium</i> spp., <i>Rhizoctonia</i> spp.
Downy Mildew	<i>Plasmopara petroselini</i>
Grey Mould	<i>Botrytis cinerea</i>
Bacterial Soft Rot	<i>Erwinia</i> spp.
Powdery Mildew	<i>Erysiphe</i> spp.
Rust	<i>Puccinia menthae</i>

The most important disease issues based on the feedback received were Sclerotinia Rot, Leaf Blight and Septoria Leaf Spot. Available and potential products for control of these diseases are listed in Section 4.1.2.

Some of the fungal and bacterial diseases that have received moderate to low priority have few options to suppress or control but should be supplemented by management practices that increase airflow and minimise moisture in the plant canopy. Other disease management practices include use of clean planting material, early detection and disposal of infected seedlings, eliminating alternative hosts, crop rotation, cover crops and general farm hygiene.

Resistance Management

Downy Mildew and Powdery Mildew are both considered to have a high risk of resistance development. In Australia there are confirmed cases of Powdery Mildew resistance to Group 8 Bupirimate, Group 11 Strobilurins and Group 3 Triadimenol.

There are several disease strategies that apply to various vegetables on the Croplife website⁴, including Downy Mildew and Powdery Mildew.

⁴ www.croplife.org.au/resources/programs/resistance-management/

4.1.2 Available and potential products for priority diseases

TABLE KEY: Note that blank fields in the table indicate no information has been provided.

Availability		Regulatory risk (refer to Appendix 6)	
A	Available via either registration or permit approval	R1	Short-term: Critical concern over retaining access
P	Potential - a possible candidate to pursue for registration or permit	R2	Medium-term: Maintaining access of significant concern
P-A	Potential, already approved in the crop for another use	R3	Long-term: Potential issues associated with use - Monitoring required
Withholding Period (WHP) – Number of days from last treatment to harvest (H) or Grazing (G)			
Harvest	H	Not Required when used as directed	NR
Grazing	G	No Grazing Permitted	NG

Disease / Active Ingredient (Trade Name)	Chemical group	Activity	WHP, days	Availability	States	Comments	Regulatory risk
Sclerotinia Rot (<i>Septoria</i> spp.)							
Priority: High							
Sclerotinia Rot was ranked as a high priority in VIC, QLD, SA & TAS. The fungus can survive in the soil for many years. Management options include general farm hygiene, crop rotation, planting space (to allow air movement) and the use of protectant and curative fungicide spray applications when conditions favour disease.							
1,3-Dichloropropene + Chloropicrin (Telone C-35)	8B	Fumigant	NR	A	ALL	Registered in vegetables for pre-planting control of soil borne diseases including <i>Fusarium</i> , <i>Verticillium</i> Wilts, <i>Rhizoctonia</i> and <i>Pythium</i> . For use by professional and registered fumigators only.	-
Metham Sodium	-	Fumigant	NR	A	ALL	Registered in food crops as a pre-plant fumigant for control of fungus diseases including <i>Rhizoctonia</i> , <i>Pythium</i> , <i>Fusarium</i> , <i>Phytophthora</i> , <i>Verticillium</i> , Sclerotinia and Club Root of crucifers. Applied as a soil injection, soil surface spray in front of a rotary tiller or through approved trickle irrigation systems.	-
Penthiopyrad (Fontelis) Corteva	7	Protectant	3	A	ALL	Registered in leafy vegetables including fennel (bulb) for control of Sclerotinia Rot , Grey Mould and Powdery Mildew. [Max. 3 applications per crop with no more than 2 consecutive; retreatment interval 7-10 d]	-

Disease / Active Ingredient (Trade Name)	Chemical group	Activity	WHP, days	Availability	States	Comments	Regulatory risk
<i>Bacillus amyloliquefaciens</i> (Serenade Opti) Bayer	BM 02	Biological		P		Registered for control of Botrytis in strawberries & grapes, suppression of Bacterial Spot in tomato, chilli & capsicum & control of Anthracnose & suppression of Stem End Rot in tropical fruits. US registration for control of Pink Rot (<i>Sclerotinia sclerotiorum</i>) & Sclerotinia Head & Leaf Drop (<i>Sclerotinia spp.</i>) in celery.	-
<i>Bacillus amyloliquefaciens</i> strain MBI 600 (Serifel) BASF	BM 02	Biological		P		Registered for control of <i>Botrytis</i> in grapes and strawberries. US registration for control of Bacterial Leaf Spot, <i>Botrytis</i> , Cercospora, Downy Mildew, Head and Leaf Drop, Pink Rot (<i>Sclerotinia sclerotiorum</i>), Powdery Mildew, White Mould (<i>Sclerotinia sclerotiorum</i>), White Rust, Bottom Rot and Verticillium Wilt in celery.	-
Cyprodinil + Fludioxonil (Switch) Syngenta	9+12	Protective & Curative		P		Registered for control of Sclerotinia , Botrytis and other diseases in several vegetable crops including leafy vegetables, peas, beans, leafy vegetables & lettuce. US registration for control of Alternaria, Septoria, Botrytis, Sclerotinia , Basal Rot and suppression of Powdery Mildew in celery.	R3
Iprodione	2	Protective		P		Registered in celery for control of Sclerotinia Rot .	R3
NUL3446 Nufarm	TBC			P		New active in development from Nufarm with activity on Sclerotinia .	-
Pydiflumetofen + Fludioxonil (Miravis Prime) Syngenta	7+12	Protectant & Curative		P		Registered for control of <i>Botrytis</i> in berries, grapes and strawberries and control of <i>Botrytis</i> and Sclerotinia in leafy vegetables, lettuce and potatoes.	R3
Leaf Blight (<i>Cercosporidium</i> spp.)							
Priority: High							
Leaf Blight was ranked as a high priority in VIC & QLD, and as a moderate priority in SA & TAS. This disease is seed borne and can survive in crop trash. Disease free seeds and seedlings are essential for preventing the spread of this disease.							
Mancozeb	M3	Protective	14	A	TAS	Registered in Fennel (bulb) for control of Leaf Blight . [Max. 2 applications per crop; re-treatment interval 10-14 d]	R2
Chlorothalonil (Bravo) PER82895	M5	Protective	7	P-A	ALL	Permitted for use in fennel (bulb) for control of Downy Mildew & Purple Blotch. Registered for control of Late Leaf Blight (<i>Cercosporidium personatum</i>) in peanuts and for control of Downy Mildew, Alternaria Leaf Spot & Grey Mould in Brassica leafy vegetables.	R3

Disease / Active Ingredient (Trade Name)	Chemical group	Activity	WHP, days	Availability	States	Comments	Regulatory risk
Septoria Leaf Spot (<i>Septoria</i> spp.)							
Priority: High							
Septoria Leaf Spot was ranked as a high priority in VIC, and as a moderate priority in QLD, SA & TAS. Septoria Spot is favoured by cool and wet conditions. It is considered more of an autumn and winter issue. The fungus survives in several ways: it can survive on the old leaves removed at harvest, on weeds, and as spores on seed. The use of drip irrigation is recommended rather than sprinklers.							
Mancozeb	M3	Protective	14	P-A	TAS	Registered in Fennel (bulb) for control of Leaf Blight. Registered for control of Septoria Leaf Spot in celery, cut flowers, lettuce, passionfruit and pumpkin.	R2
Copper	M1	Protective		P		Registered in celery for control of Septoria Leaf Spot and Early Blight.	-
Cyprodinil + Fludioxinil (Switch) Syngenta	9+12	Protective & Curative		P		Registered for control of <i>Sclerotinia</i> , <i>Botrytis</i> and other diseases in several vegetable crops including leafy vegetables, peas, beans, leafy vegetables & lettuce. US registration for control of <i>Alternaria</i> , Septoria , <i>Botrytis</i> , <i>Sclerotinia</i> , Basal Rot and suppression of Powdery Mildew in celery.	R3
Difenoconazole (Digger) Nufarm	3	Protective & Curative		P		Registered for control of Septoria Spot in celery.	R3
Florypicoxamid (Adavelt) Corteva	21	Protective & Curative		P		New Mode of Action fungicide being developed for AU with activity on Powdery Mildew, <i>Botrytis</i> spp., Septoria spp. , Anthracnose, <i>Alternaria</i> spp., Scab, <i>Monilinia</i> spp. and <i>Mycosphaerella</i> spp. Due for registration in 2023.	-
Fluopyram + Tebuconazole (Luna Experience) Bayer	7+3	Protective		P		Registered for control of Yellow Sigatoka, Leaf Speckle & Cordana Leaf Spot in bananas. US registration for control of Septoria in leafy petioles (including celery, fennel (bulb) & rhubarb) citrus, pistachio, fruiting vegetables & root vegetables except sugar beet.	R3

Disease / Active Ingredient (Trade Name)	Chemical group	Activity	WHP, days	Availability	States	Comments	Regulatory risk
Fusarium Root Rot (<i>Fusarium solani</i>)							
Priority: Moderate							
Fusarium Root Rot was ranked as a moderate priority in VIC, QLD, SA & TAS. A soil-borne disease that is widespread in most regions. Infected leaves show yellowing, curling and eventually wither and decay because of the compromised root system. Cultural controls recommended including soil fumigation, crop rotation and the use of resistant varieties.							
1,3-Dichloropropene + Chloropicrin (Telone C-35)	8B	Fumigant	NR	A	ALL	Registered in vegetables for pre-planting control of soil borne diseases including <i>Fusarium</i> , <i>Verticillium</i> Wilts, <i>Rhizoctonia</i> and <i>Pythium</i> . For use by professional and registered fumigators only.	-
Metham Sodium	-	Fumigant	NR	A	ALL	Registered in food crops as a pre-plant fumigant for control of fungus diseases including <i>Rhizoctonia</i> , <i>Pythium</i> , <i>Fusarium</i> , <i>Phytophthora</i> , <i>Verticillium</i> , <i>Sclerotinia</i> and Club Root of crucifers. Applied as a soil injection, soil surface spray in front of a rotary tiller or through approved trickle irrigation systems.	-
<i>Bacillus amyloliquefaciens</i> Strain QST 713 (Serenade Prime) Bayer	BM 02	Biological	NR	P-A	ALL	Registered in vegetable crops for application to soil to improve bioavailability of soil resources to horticultural crops. Provides suppression of soil-borne diseases such as Black Scurf in potatoes and Pineapple Disease in sugarcane.	-
<i>Bacillus amyloliquefaciens</i> strain MBI 600 (Serifel) BASF	BM 02	Biological		P		Registered for control of <i>Botrytis</i> in grapes and strawberries. US registration for control of Bacterial Leaf Spot, <i>Botrytis</i> , <i>Cercospora</i> , Downy Mildew, Head and Leaf Drop, Pink Rot, Powdery Mildew, White Mould, White Rust, Bottom Rot and <i>Verticillium</i> Wilt in celery and control of Fusarium Wilt in artichoke, asparagus, brassica leafy vegetables, bulb vegetables, cucurbits, corn, fruiting vegetables, legume vegetables, oilseeds, soybeans, strawberry & root/tuber vegetables.	-
NUL3163 Nufarm	TBC			P		New active in development from Nufarm with activity on <i>Fusarium</i> , <i>Pythium</i> & <i>Rhizoctonia</i> .	-

Disease / Active Ingredient (Trade Name)	Chemical group	Activity	WHP, days	Availability	States	Comments	Regulatory risk
<i>Streptomyces lydicus</i> WYEC108 (Actinovate) Novozymes Bioag	BM 02	Biological		P		Registered for control of <i>Phytophthora</i> in strawberries and tomato and as a seed treatment for control of <i>Pythium</i> , Fusarium and <i>Rhizoctonia</i> in vegetables.	-
Damping Off (<i>Pythium</i> spp., <i>Phytophthora</i> spp., <i>Fusarium</i> spp., <i>Rhizoctonia</i> spp.)							
Priority: Low							
Damping Off was ranked as a moderate priority in TAS and as a low priority in VIC, QLD & SA. The disease attacks seedlings at the 1-2 leaf stage, causing water-soaked lesions on the stem and roots. Severe infections can cause stunting and yellowing in older crops.							
1,3-Dichloropropene + Chloropicrin (Telone C-35)	8B	Fumigant	NR	A	ALL	Registered in vegetables for pre-planting control of soil borne diseases including <i>Fusarium</i> , <i>Verticillium</i> Wilts, <i>Rhizoctonia</i> and <i>Pythium</i> . For use by professional and registered fumigators only.	-
Metham Sodium	-	Fumigant	NR	A	ALL	Registered in food crops as a pre-plant fumigant for control of fungus diseases including <i>Rhizoctonia</i> , <i>Pythium</i> , <i>Fusarium</i> , <i>Phytophthora</i> , <i>Verticillium</i> , Sclerotinia and Club Root of crucifers. Applied as a soil injection, soil surface spray in front of a rotary tiller or through approved trickle irrigation systems.	-
<i>Bacillus amyloliquefaciens</i> Strain QST 713 (Serenade Prime Soil Ameliorant & Biofungicide) Bayer	BM 02	Biological	NR	P-A	ALL	Registered in vegetable crops for application to soil to improve bioavailability of soil resources to horticultural crops. Provides suppression of soil-borne diseases such as Black Scurf in potatoes and Pineapple Disease in sugarcane.	-
<i>Bacillus amyloliquefaciens</i> strain MBI 600 (Serifel) BASF	BM 02	Biological		P		Registered for control of <i>Botrytis</i> in grapes and strawberries. US registration for control of Bacterial Leaf Spot, <i>Botrytis</i> , <i>Cercospora</i> , Downy Mildew, Head and Leaf Drop, Pink Rot, Powdery Mildew, White Mould, White Rust, Bottom Rot and Verticillium Wilt in celery and control of Fusarium Wilt in artichoke, asparagus, brassica leafy vegetables, bulb vegetables, cucurbits, corn, fruiting vegetables, legume vegetables, oilseeds, soybeans, strawberry and root/tuber vegetables.	-

Disease / Active Ingredient (Trade Name)	Chemical group	Activity	WHP, days	Availability	States	Comments	Regulatory risk
Fluopyram + Trifloxystrobin (Luna Sensation) Bayer	7+11	Protectant & Curative		P		Registered in pome fruit, stone fruit, almonds & tropical and sub-tropical fruit for the control of various diseases, including Powdery Mildew, Anthracnose and Alternaria. US registration for suppression of Rhizoctonia in leafy petioles (including celery fennel (bulb) & rhubarb) & leafy greens except watercress.	-
NUL3163 Nufarm	TBC			P		New active in development from Nufarm with activity on Fusarium, Pythium & Rhizoctonia .	-
<i>Streptomyces lydicus</i> (Actinovate) Novozymes Bioag	BM 02	Biological		P		Registered in strawberries and tomato for control of Phytophthora and as a seed treatment in vegetables for control of Pythium, Fusarium and Rhizoctonia . Apply prior to onset of disease season.	-
Thiophanate-Methyl + Etridiazole (Banrot)	1+14	Systemic		P		Registered in container grown ornamentals and in ground bedding plants as a post plant soil drench for control of Pythium, Phytophthora, Rhizoctonia and <i>Thielaviopsis</i> .	-
Downy Mildew (<i>Plasmopara petroselin</i>)							
Priority: Low							
Downy Mildew was ranked as a moderate priority in TAS and as a low priority in VIC, QLD & SA. Characterised by a white downy fungal growth that develops on the underside of the leaf. Downy Mildew infections are common and are favoured by warm, moist weather conditions. Management options include general farm hygiene, crop rotation, planting space (to allow air movement) and the use of protectant and curative fungicide spray applications.							
Chlorothalonil (Bravo) PER82895	M5	Protective	7	A	ALL	Permitted for use in fennel (bulb) for control of Downy Mildew & Purple Blotch (<i>Alternaria porri</i>) . [Max. 4 applications per crop; re-treatment interval: 7 - 10 d]	R3
Oxathiapiprolin (Zorvec Enicade) Corteva	49	Protective	10	A	ALL	Registered in fennel (bulb) and Florence fennel for control of Downy Mildew . [Max. 3 applications per crop; re-treatment interval 10 d]	-
Phosphorous Acid (Agri-Fos) PER13698	-	Protective	1	A	ALL	Permitted for use in fennel (bulb) & bulb allium vegetables for suppression only of Downy Mildew . [Max. no. of applications and re-treatment interval not specified]	-

Disease / Active Ingredient (Trade Name)	Chemical group	Activity	WHP, days	Availability	States	Comments	Regulatory risk
Mancozeb	M3	Protective	14	P-A	TAS	Registered in Fennel (bulb) for control of Leaf Blight. Registered for control of Downy Mildew in brassica vegetables, cucurbits, bulb vegetables, grapes, lettuce, rhubarb, silver beet and spinach.	R2
Grey Mould (<i>Botrytis cinerea</i>)							
Priority: Low							
Grey Mould was ranked as a moderate priority in TAS and as a low priority in VIC & SA. <i>Botrytis</i> spp. which causes Grey Mould can affect plants at most stages of production. Affected parts get rapidly covered with a thick grey mould. <i>Botrytis</i> also causes secondary rots on fruit and vegetables in storage or transit and in the marketplace.							
Penthiopyrad (Fontelis) Corteva	7	Protectant	3	A	ALL	Registered in leafy vegetables including fennel (bulb) for control of Sclerotinia Rot, Grey Mould and Powdery Mildew. [Max. 3 applications per crop with no more than 2 consecutive; retreatment interval 7-10 d]	-
<i>Aureobasidium pullulans</i> (Botector) Nufarm	UN	Biological		P		Registered for control of Botrytis in berries and grapes. US registration for the control of Grey Mould and Anthracnose in celery.	-
<i>Bacillus amyloliquefaciens</i> (Serenade Opti) Bayer	BM 02	Biological		P		Registered for control of Botrytis in strawberries & grapes. US registration for control of Grey Mould in artichoke and for control of Pink Rot (<i>Sclerotinia sclerotiorum</i>) & Sclerotinia Head & Leaf Drop (<i>Sclerotinia</i> spp.) in celery.	-
<i>Bacillus amyloliquefaciens</i> strain MBI 600 (Serifel) BASF	BM 02	Biological		P		Registered for control of Botrytis in grapes and strawberries. US registration for control of Bacterial Leaf Spot, Botrytis , Cercospora, Downy Mildew, Head and Leaf Drop, Pink Rot, Powdery Mildew, White Mould, White Rust, Bottom Rot and Verticillium Wilt in celery.	-
Cyprodinil + Fludioxinil (Switch) Syngenta	9+12	Protective & Curative		P		Registered for control of Botrytis in alliums, fruiting vegetables, cucurbits, cut flowers, grapes, legume vegetables, lettuce, nursery stock, ornamentals and strawberries. US registration for control of Alternaria, Septoria, Botrytis , Sclerotinia, Basal Rot and suppression of Powdery Mildew in celery.	R3
DC-126 Bayer	TBC			P		New product from Bayer with Botrytis activity.	-

Disease / Active Ingredient (Trade Name)	Chemical group	Activity	WHP, days	Availability	States	Comments	Regulatory risk
Fenpyrazamine (Prolectus) Sumitomo	17	Protectant & Curative		P		Registered for Botrytis control in grapes.	-
Florypicoxamid (Adavelt) Corteva	21	Protective & Curative		P		New Mode of Action fungicide being developed in Australia. Corteva claims activity on Botrytis . Scheduled for JMPR evaluation in 2023.	-
Fluopyram + Trifloxystrobin (Luna Sensation) Bayer	7+11	Protectant & Curative		P		Registered in pome fruit, stone fruit, almonds & tropical and sub-tropical fruit for the control of various diseases, including Powdery Mildew, Anthracnose and Alternaria. US registration for control of Botrytis in artichoke, low growing berry except cranberry, Brassica vegetables, Brassica leafy vegetables, carrot cherry, dill seed, pome fruit, small vine climbing fruit except kiwi fruit, ginseng, herbs, hops, leafy greens, cucurbits, pistachio, fruiting vegetables & root vegetables except sugar beet.	-
NUL3195 Nufarm	TBC			P		New product from Nufarm with Botrytis activity.	-
Pydiflumetofen + Fludioxonil (Miravis Prime) Syngenta	7+12	Protectant & Curative		P		Registered for control of Botrytis in berries, grapes and strawberries and control of Botrytis and <i>Sclerotinia</i> in leafy vegetables, lettuce and potatoes.	R3
Bacterial Soft Rot (<i>Erwinia</i> spp.)							
Priority: Low							
Bacterial Soft Rot was ranked as a low priority in VIC, QLD, SA & TAS. Soft Rot is often attributed to bacteria which may be introduced in seed or in surviving undecomposed crop residue or other host plants. It can spread in water splash and so overhead irrigation should be avoided.							
<i>Bacillus amyloliquefaciens</i> (Serenade Opti) Bayer	BM 02	Biological		P		Registered for suppression of Bacterial Spot in capsicum ,chilli and tomato. US registration for control of Pink Rot (<i>Sclerotinia sclerotiorum</i>) & Sclerotinia Head & Leaf Drop (<i>Sclerotinia</i> spp.) in celery.	-

Disease / Active Ingredient (Trade Name)	Chemical group	Activity	WHP, days	Availability	States	Comments	Regulatory risk
<i>Bacillus amyloliquefaciens</i> strain MBI 600 (Serifel) BASF	BM 02	Biological		P		Registered for control of <i>Botrytis</i> in grapes and strawberries. US registration for control of Bacterial Leaf Spot, <i>Botrytis</i> , Cercospora, Downy Mildew, Head and Leaf Drop, Pink Rot, Powdery Mildew, White Mould, White Rust, Bottom Rot and Verticillium Wilt in celery and control of Fire Blight (<i>Erwinia amylovora</i>) in pome fruit and Aerial Stem Rot (<i>Erwinia carotovora</i>) in root/tuber vegetables.	-
Copper	M1	Protective		P		Registered for control of Leaf Spot and Bacterial Soft Rot in celery.	-
Powdery Mildew (<i>Erisiphae</i> spp.)							
Priority: Low							
Powdery Mildew was ranked as a low priority in VIC, QLD, SA & TAS. Causes a characteristic white, powdery growth on leaves and can reduce photosynthetic efficiency and damage produce quality.							
Penthiopyrad (Fontelis) Corteva	7	Protectant	3	A	ALL	Registered in leafy vegetables including fennel (bulb) for control of Sclerotinia Rot, Grey Mould and Powdery Mildew . [Max. 3 applications per crop with no more than 2 consecutive; retreatment interval 7-10 d]	-
Sulphur	M2	Protectant	NR	A	ALL	Registered in vegetables for control of Powdery Mildew and Rust. [Max. no. of applications not specified]	-
ADM1700F Adama	TBC			P		Fungicide in development from Adama with Powdery Mildew activity	-
BLAD (ProBlad Plus)	BM 01	Biological		P		Registered for control of Brown Rot & Blossom Blight in stone fruit. US registration for control of Powdery Mildew in cucurbits, fruiting vegetables, grapes, hops, pome fruit and strawberries.	-
Florypicoxamid (Adavelt) Corteva	21	Protectant & Curative		P		New Mode of Action fungicide being developed in AU. Corteva claim activity on Powdery Mildew . Scheduled for JMPR evaluation in 2023.	-

Disease / Active Ingredient (Trade Name)	Chemical group	Activity	WHP, days	Availability	States	Comments	Regulatory risk
Fluopyram + Trifloxystrobin (Luna Sensation) Bayer	7+11	Protectant & Curative		P		Registered for control of Powdery Mildew , Black Spot and <i>Alternaria</i> in apples. US registration for control of Powdery Mildew in artichoke, almond, low growing berry except cranberry, Brassica vegetables, Brassica leafy vegetables, carrot cherry, dill seed, pome fruit, small vine climbing fruit except kiwi fruit, ginseng, herbs, hops, leafy greens, cucurbits, pecan, leafy petioles (including celery fennel (bulb) & rhubarb) fruiting vegetables & root vegetables except sugar beet.	-
NUL3195 Nufarm	TBC			P		Fungicide in development from Nufarm with activity on Powdery Mildew and <i>Botrytis</i> .	-
Pydiflumetofen + Fludioxonil (Miravis Prime) Syngenta	7+12	Curative / Protectant		P		Registration pending in Australia for control of <i>Botrytis</i> , <i>Alternaria</i> , Powdery Mildew & Anthracnose in berries.	R3
Rust (<i>Puccinia menthae</i>)							
Priority: Low							
Maize rust was ranked a low priority issue in VIC, QLD, SA & TAS. Rusts are plant diseases caused by pathogenic fungi which are essentially parasitic in their behaviour. Although not fatal, they can severely limit growth.							
Sulphur	M2	Protectant	NR	A	ALL	Registered in vegetables for control of Powdery Mildew and Rust . [Max. no. of applications not specified]	-
Fluopyram + Trifloxystrobin (Luna Sensation) Bayer	7+11	Protectant & Curative		P		Registered in apples for control of Powdery Mildew, Black Spot and <i>Alternaria</i> . US registration for control of Rust in leafy petioles (including celery fennel (bulb) & rhubarb) almond, carrot, cherry, & root vegetables except sugar beet.	-

4.2 Insect and other pests of fennel bulb

4.2.1 Insect and other pest priorities

Common name	Scientific name
High	
Melon Thrips	<i>Thrips palmi</i>
Plague Thrips	<i>Thrips imagines,</i>
Western Flower Thrips	<i>Frankliniella occidentalis</i>
Green Peach Aphid	<i>Myzus persicae</i>
Moderate	
Rutherglen Bug	<i>Nysius vinitor</i>
Jassids	Cicadellidae
Vegetable Weevil	<i>Listroderes difficilis</i>
Low	
Green Mirid	<i>Creontiades spp.</i>
Cotton Bollworm / Corn Earworm	<i>Helicoverpa armigera</i>
Native Budworm	<i>Helicoverpa punctigera</i>
Looper Caterpillar	<i>Chrysodeixis spp.</i>
Snails & Slugs	<i>Helix spp.</i>

New incursions of an exotic pest which poses a potential threat and other non-ranked pests.

New Pest to Australia (unknown priority)	
Fall Armyworm	<i>Spodoptera frugiperda</i>
Vegetable Leafminer	<i>Liriomyza sativae</i>
Serpentine Leafminer	<i>Liriomyza huidobrensis</i>
American Serpentine Leafminer	<i>Liriomyza trifolii</i>

The high priority insect and other pests identified by the survey are Thrips, Green Peach Aphid and Rutherglen Bug. Available and potential products for all these insects and mites are in Section 4.2.2.

Resistance to some insect groups has reduced control options despite a range of actives registered. Additionally, not all actives have broad registrations across Lepidoptera. Growers should not exceed the maximum number of applications permitted on the insecticide label.

Resistance Management

There are several insecticide management strategies that apply to various vegetables on the CropLife website⁵, including Thrips & Aphids.

Further development and extension of IPM strategies and best management practices that can be implemented in the management of sucking insects and other pests may be warranted.

⁵ www.croplife.org.au/resources/programs/resistance-management/

4.2.2 Available and potential products for priority insects and other pests

TABLE KEY: Note that blank fields in the table indicate no information has been provided.

Availability		Regulatory risk (refer to Appendix 6)	
A	Available via either registration or permit approval	R1	Short-term: Critical concern over retaining access
P	Potential - a possible candidate to pursue for registration or permit	R2	Medium-term: Maintaining access of significant concern
P-A	Potential, already approved in the crop for another use	R3	Long-term: Potential issues associated with use - Monitoring required
Withholding Period (WHP) – Number of days from last treatment to harvest (H) or Grazing (G)			
Harvest	H	Not Required when used as directed	NR
Grazing	G	No Grazing Permitted	NG
IPM – indicative overall impact on beneficials (based on the Cotton Pest Management Guide 2018-19 and cotton use patterns)			
VL – Very low; L – Low; M – Moderate; H – High; VH – Very High; - not specified			

Pest / Active Ingredient (Trade Name)	Chemical group	Activity	WHP, days	Availability	States	Comments	Impact on beneficials	Regulatory risk
Plague Thrips (<i>Thrips imaginis</i>) Melon Thrips (<i>Thrips palmi</i>) Western Flower Thrips (<i>Frankliniella occidentalis</i>) Priority: High Thrips were ranked as a high priority in VIC & QLD and as a moderate priority in SA & TAS. It can be difficult to distinguish between thrips species in the field. Thrips cause direct feeding damage to foliage by piercing and rasping leaves.								
<i>Beauveria bassiana</i> (Velifer) BASF	UNF	Biological	NR	A	ALL	Registered in protected vegetables and ornamentals for suppression of various pests including: Western Flower Thrips, Onion Thrips , Greenhouse Whitefly, Silverleaf Whitefly, Sweet Potato Whitefly, Green Peach Aphid & Two-Spotted Spider Mites. [Max. 3 application per crop; re-treatment interval 3-14 d]	L Bee:L	-
Cyantraniliprole (Benevia) FMC	28	Ingestion	7	A	ALL	Registered in Bulb vegetables with a listing for Fennel (bulb) for suppression of Onion Thrips .	L Bee:L	-

Pest / Active Ingredient (Trade Name)	Chemical group	Activity	WHP, days	Availability	States	Comments	Impact on beneficials	Regulatory risk
Flonicamid (Mainman) UPL PER89185	29	Ingestion	7	A	ALL	Permitted for use in Bulb Vegetables (onions, shallots, chives, leeks, fennel (bulb) & spring onions for suppression of Onion Thrips & Western Flower Thrips . [Max 3 applications per crop; re-treatment interval 14 d]	M Bee:L	-
Garlic + Chilli + Pyrethrins + Piperonyl Butoxide	3A	Contact	1	A	ALL	Registered in vegetables for control of Ants, Aphids, Caterpillars, Earwigs, Whitefly, Thrips and Leafhoppers. Suitable for organic growers. Apply as a cover spray and re-apply as necessary every 2-3 weeks.	VH Bee:H	-
Petroleum Oil PER12221	UN	Contact	1	A	ALL (excl. VIC)	Permitted for use in alliums including fennel (bulb) for control of Aphids, Green Mirid, Green Vegetable Bug, Grey Cluster Bug, Leafhoppers, Mites, Rutherglen Bugs & Thrips . [Max. no. of applications and re-treatment interval not specified].	VL Bee:L	-
Potassium Salts of Fatty Acids (Natrasoap)	-	Contact	NR	A	ALL	Registered in vegetables for control of Aphids, Thrips , Mealybug, Mites, Spider Mite & Whitefly. Apply when temperatures are cooler. [Max no. of applications not specified; re-treatment interval 5-7 d]	L Bee:L	-
Pyrethrins (Pyganic) Sumitomo	3A	Contact	1	A	ALL	Registered in vegetables for control of Aphids, Thrips , Caterpillars, Ants, Earwigs, Whiteflies & Leafhoppers. Spray early in the morning or late evening. [Max. no. of applications and re-treatment intervals not specified]	VH Bee:H	-
Pyrethrins + Piperonyl Butoxide	3A	Contact	1	A	ALL	Registered in vegetables for control of Aphids, Thrips , Caterpillars, Ants, Flies, Earwigs, Whitefly & Leafhoppers. [Max no. of applications not specified; Re-treatment interval: 7 d]	VH Bee:H	-
Spinetoram (Success Neo) Corteva	5	Ingestion	1	P-A	ALL	Registered in stalk and stem vegetables for the control of <i>Helicoverpa</i> . Registered for control of Western Flower Thrips in beans, berries, brassica leafy vegetables, cotton, cucurbits, fruiting vegetables, leafy vegetables, legume vegetables, ornamentals, pome fruit, stone fruit, swede, sweet corn and turnip.	M Bee:H	-

Pest / Active Ingredient (Trade Name)	Chemical group	Activity	WHP, days	Availability	States	Comments	Impact on beneficials	Regulatory risk
Spinosad (Entrust Organic) Corteva	5	Ingestion	3	P-A	ALL	Registered in stalk & stem vegetables including fennel (bulb) for control <i>Helicoverpa</i> . Registered in US and Canada for control of a range of insect pests such as Ants, Caterpillars, Colorado Potato Beetle, Corn Earworms, Flea Beetle, Leaf miners, Loopers, Mites & Thrips in various vegetables.	L Bee:L	-
Acetamiprid + Pyriproxyfen (Trivor) Adama	4A+7C	Ingestion/ IGR		P		Registered for control of Kellys Citrus Thrips in citrus.	M Bee:M	R2
Dimpropridaz (Axalion) BASF	TBC			P		BASF applied in January to register a new insecticide Axalione (dimpropridaz), a pyrazole carboxamide with a novel mode of action, for the control of Whitefly, Aphid, and Thrips in leafy vegetables, brassica vegetables, fruiting vegetables, including cucurbits. Pending regulatory approvals, BASF expects first market introductions in Australia of Axalion-based products by late 2022 or early 2023.	-	-
Flupyradifurone (Sivanto Prime) Bayer	4D	Contact & Ingestion		P		Registered for control of Macadamia Lace Bug, Banana Spotting Bug, Fruit Spotting Bug and suppression of Scirtothrips in macadamia. US registration for control of Leafhoppers, Aphids and Whiteflies in leafy vegetables including fennel.	L Bee:VL	-
NUL3445 Nufarm	TBC			P		New product in development from Nufarm with activity on Lepidoptera, Bugs, Beetles/Weevils, Fruit Fly and Thrips .	-	-
Spirotetramat (Movento) Bayer	23	Ingestion		P		Registered for control of Western Flower Thrips in green beans, celery and rhubarb, fruiting vegetables, herbs, lettuce, and bulb vegetables and control of Plague Thrips in celery and rhubarb, herbs, bulb vegetables and grapes.	M Bee:VL	-

Pest / Active Ingredient (Trade Name)	Chemical group	Activity	WHP, days	Availability	States	Comments	Impact on beneficials	Regulatory risk
SYNFOI21 (Syngenta)	TBC			P		SYNFOI21 is not registered but the first global application is proposed for 2023 for Thrips, Bugs, Mites and Caterpillars . Hort Innovation Project ST20003 will be contracted in June 2021 to undertake the required data package to support a label registration in celery for various thrips including Plague Thrips & Western Flower Thrips.	-	-
Green Peach Aphid (<i>Myzus persicae</i>)								
Priority: High								
Green Peach Aphid was ranked as a high priority in VIC and as a moderate priority in QLD, SA & TAS. Green Peach Aphids suck on sap, causing loss of vigour, and in some cases yellowing, stunting or distortion of plant parts. Honeydew secreted by aphids can cause sooty mould to develop on leaves. Aphids can also be vectors for viruses.								
<i>Beauveria bassiana</i> (Velifer) BASF	UNF	Biological	NR	A	ALL	Registered in protected vegetables and ornamentals for suppression of various pests including: Western Flower Thrips, Onion Thrips, Greenhouse Whitefly, Silverleaf Whitefly, Sweet Potato Whitefly, Green Peach Aphid & Two-Spotted Spider Mites. [Max. 3 application per crop; re-treatment interval 3-14 d]	L Bee:L	-
Garlic + Chilli + Pyrethrins + Piperonyl Butoxide	3A	Contact	1	A	ALL	Registered in vegetables for control of Ants, Aphids , Caterpillars, Earwigs, Whitefly, Thrips and Leafhoppers. Suitable for organic growers. Apply as a cover spray and re-apply as necessary every 2-3 weeks.	VH Bee:H	-
Petroleum Oil PER12221	UN	Contact	1	A	ALL (excl. VIC)	Permitted for use in alliums including fennel (bulb) for control of Aphids , Green Mirid, Green Vegetable Bug, Grey Cluster Bug, Leafhoppers, Mites, Rutherglen Bugs & Thrips. [Max. no. of applications and re-treatment interval not specified].	VL Bee:L	-
Potassium Salts of Fatty Acids (Natrasoap)	-	Contact	NR	A	ALL	Registered in vegetables for control of Aphids , Thrips, Mealybug, Mites, Spider Mite & Whitefly. Apply when temperatures are cooler. [Max no. of applications not specified; re-treatment interval 5-7 d]	L Bee:L	-

Pest / Active Ingredient (Trade Name)	Chemical group	Activity	WHP, days	Availability	States	Comments	Impact on beneficials	Regulatory risk
Pyrethrins (Pyganic) Sumitomo	3A	Contact	1	A	ALL	Registered in vegetables for control of Aphids , Thrips, Caterpillars, Ants, Earwigs, Whiteflies & Leafhoppers. Spray early in the morning or late evening. [Max. no. of applications and re-treatment intervals not specified]	VH Bee:H	-
Pyrethrins + Piperonyl Butoxide	3A	Contact	1	A	ALL	Registered in vegetables for control of Aphids , Thrips, Caterpillars, Ants, Flies, Earwigs, Whitefly & Leafhoppers. [Max no. of applications not specified; Re-treatment interval: 7 d]	VH Bee:H	-
Emulsifiable Botanical Oil (Eco-Oil)	-	Contact	NR	P-A	ALL	Registered in vegetables for control of Greenhouse Whitefly and in tomatoes, cucumbers, capsicums, strawberries and ornamentals for control of Two-Spotted Mites & Aphids . [Max. 3 applications per crop]	L Bee:L	-
Fonicamid (Mainman) UPL PER89185	29	Ingestion	7	P-A	ALL	Permitted for use in Bulb Vegetables (onions, shallots, chives, leeks, fennel (bulb) & spring onions for suppression of Onion Thrips & Western Flower Thrips. Registered for control of Aphids in cucurbits, potatoes, apples, pears and cotton. US registration for control of Aphids , Plant Bugs and Greenhouse Whitefly in leaf petiole vegetable sub-group – includes celery, fennel (bulb) - Florence & rhubarb.	M Bee:L	-
Afidopyropen (Versys) BASF	9D	Ingestion		P		Registered for control of Green Peach Aphid in various vegetable groups including celery, rhubarb & artichoke.	L Bee:L	-
Dimpropridaz (Axalion) BASF	TBC			P		BASF applied in January to register a new insecticide Axalione (dimpropridaz), a pyrazole carboxamide with a novel mode of action, for the control of Whitefly, Aphid , and Thrips in leafy vegetables, brassica vegetables, fruiting vegetables, including cucurbits. Pending regulatory approvals, BASF expects first market introductions in Australia of Axalion-based products by late 2022 or early 2023.	-	-

Pest / Active Ingredient (Trade Name)	Chemical group	Activity	WHP, days	Availability	States	Comments	Impact on beneficials	Regulatory risk
Flupyradifurone (Sivanto Prime) Bayer	4D	Contact & Ingestion		P		Registered for control of Macadamia Lace Bug, Banana Spotting Bug, Fruit Spotting Bug and suppression of Scirtothrips in macadamia. US registration for control of Leafhoppers, Aphids and Whiteflies in leafy vegetables including fennel.	L Bee:VL	-
Pymetrozine (Chess) Syngenta	9B	Contact & Ingestion		P		Registered for control of Green Peach Aphid in tree nuts, brassica vegetables, beetroot, fruiting vegetables, lettuce, potato, leafy vegetables and stone fruit.	L Bee:VL	R3
Spirotetramat (Movento) Bayer	23	Ingestion		P		Registered for control of Green Peach Aphid in beans, peas, brassica vegetables, brassica leafy vegetables, celery and rhubarb, cucurbits, eggplant, peppers, tomatoes, herbs, leafy vegetables, lettuce, chicory, endive, radicchio, potatoes and sweet potatoes.	M Bee:VL	-
Sulfoxaflor (Transform) Corteva	4C	Contact & Ingestion		P		Registered for control of Green Peach Aphid in tree nuts, brassica vegetables, fruiting vegetables, cucurbits, lettuce, root vegetables, silver beet, stone fruit, strawberries and sweet corn.	M Bee:H	-

Rutherglen Bug (*Nysius vinitor*)

Priority: Moderate

Rutherglen Bug was ranked as a high priority in TAS and as a moderate priority in VIC, QLD, and SA. They breed up on weeds adjacent to cropping areas. It is important to monitor crops for eggs and nymphs by regular field scouting. Repeated influxes of migrating adults can make repeat insecticide applications necessary. Large numbers can cause significant feeding damage to foliage by sucking the sap and depleting the crop of nutrients.

Petroleum Oil PER12221	UN	Contact	1	A	ALL (excl. VIC)	Permitted for use in alliums including fennel (bulb) for control of Aphids, Green Mirid, Green Vegetable Bug, Grey Cluster Bug, Leafhoppers, Mites, Rutherglen Bugs & Thrips. [Max. no. of applications and re-treatment intervals not specified]	VL Bee:L	-
Pyrethrins (Pyganic) Sumitomo	3A	Contact	1	A	ALL	Registered in vegetables for control of Aphids, Thrips, Caterpillars, Ants, Earwigs, Whiteflies & Leafhoppers and as a clean-up spray in fennel for control of Rutherglen Bug . Spray early in the morning or late evening. [Max. 3 applications per crop; re-treatment interval 3 d]	VH Bee:H	-

Pest / Active Ingredient (Trade Name)	Chemical group	Activity	WHP, days	Availability	States	Comments	Impact on beneficials	Regulatory risk
Trichlorfon (Lepidex)	1B	Contact	2	A	ALL	Registered in vegetables for control of Green Vegetable Bug & Rutherglen Bug . [Max no. of applications not specified; re-treatment: 7-10 d]	H Bee:H	R2
Fonicamid (Mainman) UPL PER89185	29	Ingestion	7	P-A	ALL	Permitted for use in Bulb Vegetables (onions, shallots, chives, leeks, fennel (bulb) & spring onions for suppression of Onion Thrips & Western Flower Thrips. US registration for control of Aphids, Plant Bugs and Greenhouse Whitefly in leaf petiole vegetable sub-group – includes celery, fennel (bulb) - Florence & rhubarb.	M Bee:L	-
Flupyradifurone (Sivanto Prime) Bayer	4D	Contact & Ingestion		P		Registered for control of Macadamia Lace Bug, Banana Spotting Bug, Fruit Spotting Bug and suppression of Scirtothrips in macadamia. US registration for control of Leafhoppers, Aphids and Whiteflies in leafy vegetables including fennel.	L Bee:VL	-
NUL3445 Nufarm	TBC			P		New product in development from Nufarm with activity on Lepidoptera, Bugs , Beetles/Weevils, Fruit Fly and Thrips.	-	-
Sulfoxaflor (Transform) Corteva	4C	Contact & Ingestion		P		Registered for control of Rutherglen Bug in cucurbits, leafy vegetables, fruiting vegetables and root vegetables.	M Bee:H	-
SYNFOI21 (Syngenta)	TBC	TBC		P		SYNFOI21 is not registered but the first global application is proposed for 2020/21 for Thrips, Bugs and Caterpillars. Hort Innovation Project ST20003 will be contracted in June 2021 to undertake the required data package to support a label registration in celery for various thrips including, Plague Thrips & Western Flower Thrips.	-	-

Pest / Active Ingredient (Trade Name)	Chemical group	Activity	WHP, days	Availability	States	Comments	Impact on beneficials	Regulatory risk
Jassids / Leafhoppers (Cicadellidae)								
Priority: Moderate								
Jassids were ranked as a moderate priority in VIC, QLD, SA & TAS. Adult and nymph leafhoppers suck sap and inject toxins into the plant. Some leafhopper species transmit diseases such as viruses and phytoplasmas. Perimeter sprays may be an option to minimise vector transmission.								
Garlic + Chilli + Pyrethrins + Piperonyl Butoxide	3A	Contact	1	A	ALL	Registered in vegetables for control of Ants, Aphids, Caterpillars, Earwigs, Whitefly, Thrips and Leafhoppers . Suitable for organic growers. Apply as a cover spray and re-apply as necessary every 2-3 weeks.	VH Bee:H	-
Petroleum Oil PER12221	UN	Contact	1	A	ALL (excl. VIC)	Permitted for use in alliums including fennel (bulb) for control of Aphids, Green Mirid, Green Vegetable Bug, Grey Cluster Bug, Leafhoppers , Mites, Rutherglen Bugs & Thrips. [Max. no. of applications and re-treatment interval not specified].	VL Bee:L	-
Pyrethrins (Pyganic) Sumitomo	3A	Contact	1	A	ALL	Registered in vegetables for control of Aphids, Thrips, Caterpillars, Ants, Earwigs, Whiteflies & Leafhoppers . Spray early in the morning or late evening. [Max. no. of applications and re-treatment intervals not specified]	VH Bee:H	-
Pyrethrins + Piperonyl Butoxide	3A	Contact	1	A	ALL	Registered in vegetables for control of Aphids, Thrips, Caterpillars, Ants, Flies, Earwigs, Whitefly & Leafhoppers . [Max no. of applications not specified; Re-treatment interval: 7 d]	VH Bee:H	-
Flonicamid (Mainman) UPL PER89185	29	Ingestion	7	P-A	ALL	Permitted for use in Bulb Vegetables (onions, shallots, chives, leeks, fennel (bulb) & spring onions for suppression of Onion Thrips & Western Flower Thrips. US registration for control of Aphids, Plant Bugs and Greenhouse Whitefly in leaf petiole vegetable sub-group – includes celery, fennel (bulb) - Florence & rhubarb.	M Bee:L	-
Acetamiprid + Pyriproxyfen (Trivor) Adama	4A+7C	Ingestion/ IGR		P		Hort Innovation project ST16006 generating data to enable registration in Tropical and Sub-Tropical Fruits (inedible peel) for control of Spotting Bugs, Hoppers , Scale and Mealybug.	M Bee:H	R2

Pest / Active Ingredient (Trade Name)	Chemical group	Activity	WHP, days	Availability	States	Comments	Impact on beneficials	Regulatory risk
Buprofezin (Applaud) Corteva	16	Ingestion / IGR		P		Registered for control of Leafhoppers in citrus.	M Bee:L	-
Flupyradifurone (Sivanto Prime) Bayer	4D	Contact & Ingestion		P		Registered for control of Macadamia Lace Bug, Banana Spotting Bug, Fruit Spotting Bug and suppression of Scirtothrips in macadamia. US registration for control of Leafhoppers , Aphids and Whiteflies in leafy vegetables including fennel.	L Bee:VL	-
NUL3445 Nufarm	TBC			P		New product in development from Nufarm with activity on Lepidoptera, Bugs , Beetles/Weevils, Fruit Fly and Thrips.		
Sulfoxaflor (Transform) Corteva	4C	Contact & Ingestion		P		Registered for control of Aphids, Bugs, Mealybug, Greenhouse Whitefly, Psyllid and Scale in various crops. US registration for control of Leafhoppers in berries, cotton, root and tuber vegetables, pome fruit and small fruit vine climbing (except fuzzy kiwifruit).	M Bee:H	-
SYNFOI21 Syngenta	TBC			P		SYNFOI21 is not registered but the first global application is proposed for 2023 for Thrips, Bugs, Mites and Caterpillars. Hort Innovation Project ST20003 will be contracted in June 2021 to undertake the required data package to support a label registration in celery for various thrips including, Plague Thrips & Western Flower Thrips.	-	-
Vegetable Weevil (<i>Listroderes difficilis</i>)								
Priority: Moderate								
Vegetable Weevil has not been identified as a priority pest in the industry survey, however other industry sources indicate that it is a significant pest in fennel (bulb). Weevils can cause damage by tunnelling into leaves and reducing plant vigour. MT16009 IPM Project Recommends: Control broadleaf weed hosts (e.g. marshmallow) in the season prior to planting.								
Chlorpyrifos (Lorsban)	1B	Contact	3	A	WA	Registered in vegetables for control of Grasshoppers, Cutworm, Field Cricket, Mole Cricket & Vegetable Weevil . [Max no. of applications and re-treatment interval not specified].	H Bee:H	R1

Pest / Active Ingredient (Trade Name)	Chemical group	Activity	WHP, days	Availability	States	Comments	Impact on beneficials	Regulatory risk
Indoxacarb (Avatar eVo) FMC	22A	Ingestion	3	P-A	ALL	Registered in leafy vegetables including fennel (bulb) for control of <i>Helicoverpa</i> spp. Registered for control of Weevils in pome & stone fruits.	L Bee:H	R3
NUL3445 Nufarm	TBC			P		New product in development from Nufarm with activity on Lepidoptera, Bugs, Beetles/ Weevils , Fruit Fly and Thrips.	-	-
Tetraniliprole (Vayego) Bayer	28	Ingestion		P		Registered in Australia in multiple crops for various insect pests such as Beetles, Weevils & Lepidoptera. Hort Innovation Project ST17000 contracted 2018 to undertake the required data package to support a label registration in stalk & stem vegetables, including celery for Light Brown Apple Moth, <i>Helicoverpa</i> spp., Green Looper and other pests.	M Bee:VH	
Green Mirid (<i>Creontiades dilutus</i>)								
Priority: Low								
Green Mirids were ranked as a low priority in VIC, QLD & WA, and as a moderate priority in NSW & SA. The adults and nymphs pierce plant tissue and release a chemical that destroys cells in the feeding zone. Large numbers can cause significant feeding damage to foliage by sucking the sap and depleting the crop of nutrients.								
Petroleum Oil PER12221	UN	Contact	1	A	ALL (excl. VIC)	Permitted for use in alliums including fennel (bulb) for control of Aphids, Green Mirid , Green Vegetable Bug, Grey Cluster Bug, Leafhoppers, Mites, Rutherglen Bugs & Thrips. [Max. no. of applications and re-treatment interval not specified].	VL Bee:L	-
Fonicamid (Mainman) UPL PER89185	29	Ingestion	7	P-A	ALL	Permitted for use in Bulb Vegetables (onions, shallots, chives, leeks, fennel (bulb) & spring onions for suppression of Onion Thrips & Western Flower Thrips. Registered for control of Mirids in cotton. US registration for control of Aphids, Plant Bugs and Greenhouse Whitefly in leaf petiole vegetable sub-group – includes celery, fennel (bulb) - Florence & rhubarb.	M Bee:L	-
<i>Clitorea ternatia</i> extract (Sero-X) Innovate Ag	UN	Biological	NR	P		Registered for control of Green Mirid in cotton. Innovate Ag applied in January 2021 to the APVMA seeking to add new uses against Silverleaf whitefly and thrips in brassicas and cucurbits to its Sero-X Insecticide label.	L Bee:L	-

Pest / Active Ingredient (Trade Name)	Chemical group	Activity	WHP, days	Availability	States	Comments	Impact on beneficials	Regulatory risk
Flupyradifurone (Sivanto Prime) Bayer	4D	Contact & Ingestion		P		Registered for control of Macadamia Lace Bug, Banana Spotting Bug, Fruit Spotting Bug and suppression of Scirtothrips in macadamia. US registration for control of Leafhoppers, Aphids and Whiteflies in leafy vegetables including fennel.	L Bee:VL	-
NUL3445 Nufarm	TBC			P		New product in development from Nufarm with activity on Lepidoptera, Bugs , Beetles/Weevils, Fruit Fly and Thrips.	-	-
Sulfoxaflor (Transform) Corteva	4C	Contact & Ingestion		P		Registered for control of Green Mirid in cotton and strawberries.	M Bee:H	-
SYNFOI21 Syngenta	TBC			P		SYNFOI21 is not registered but the first global application is proposed for 2023 for Thrips, Bugs, Mites and Caterpillars . Hort Innovation Project ST20003 will be contracted in June 2021 to undertake the required data package to support a label registration in celery for various thrips including, Plague Thrips & Western Flower Thrips.	-	-

Cotton Bollworm / Corn Earworm (*Helicoverpa armigera*)

Native Budworm (*Helicoverpa punctigera*)

Priority: Low

Helicoverpa was ranked as a low priority in VIC, QLD, SA & TAS. *Helicoverpa armigera* is generally regarded as the more serious pest because of its greater capacity to develop resistance to insecticides, broader host range, and persistence in cropping areas from year to year. Larvae feed on leaves but are most damaging when feeding on growing terminals which would affect growth and reduce quality of produce.

<i>Bacillus thuringiensis subsp. kurstaki</i> (DiPel)	11A	Biological	NR	A	ALL	Registered in vegetables for control of Caterpillars, including Helicoverpa . [Apply a minimum of 2 sprays, 3 d apart; re-treatment interval 3-5 d]	VL Bee:L	-
Chlorantraniliprole (Coragen) FMC	28	Ingestion	3	A	ALL	Registered in stalk and stem vegetables for control of Cotton Bollworm and Native Budworm . [Max. 3 applications per crop with no more than 2 consecutive; min. re-treatment interval 7 d]	L Bee:VL	-
Flubendiamide (Belt) Bayer	28	Ingestion	1	A	ALL	Registered in stalk and stem vegetables for control of Helicoverpa spp. [Max. 3 applications per crop; re-treatment interval 7-14 d]	L Bee:L	-

Pest / Active Ingredient (Trade Name)	Chemical group	Activity	WHP, days	Availability	States	Comments	Impact on beneficials	Regulatory risk
Garlic + Chilli + Pyrethrins + Piperonyl Butoxide	3A	Contact	1	A	ALL	Registered in vegetables for control of Ants, Aphids, Caterpillars , Earwigs, Whitefly, Thrips and Leafhoppers. Suitable for organic growers. Apply as a cover spray and re-apply as necessary every 2-3 weeks.	VH Bee:H	-
Indoxacarb (Avatar eVo) FMC	22A	Ingestion	3	A	ALL	Registered in leafy vegetables including fennel (bulb) for control of Helicoverpa spp. [Max. 3 applications per crop; re-treatment interval 7 d]	L Bee:H	R3
Helicoverpa NPV (Vivus Max) AgBiTech	31	Biological	NR	A	ALL	Registered in stalk and stem vegetables for control of Helicoverpa spp. Effective on larvae of <7 mm. [Max no. of applications not specified; re-treatment interval 2-3 d]	VL Bee:L	-
Pyrethrins (Pyganic) Sumitomo	3A	Contact	1	A	ALL	Registered in vegetables for control of Aphids, Thrips, Caterpillars , Ants, Earwigs, Whiteflies & Leafhoppers. Spray early in the morning or late evening. [Max. no. of applications and re-treatment intervals not specified]	VH Bee:H	-
Pyrethrins + Piperonyl Butoxide	3A	Contact	1	A	ALL	Registered in vegetables for control of Aphids, Thrips, Caterpillars , Ants, Flies, Earwigs, Whitefly & Leafhoppers. [Max no. of applications not specified; Re-treatment interval: 7 d]	VH Bee:H	-
Spinetoram (Success Neo) Corteva	5	Ingestion	1	A	ALL	Registered in stalk & stem vegetables for control of Helicoverpa spp. [Max no. of applications not specified; re-treatment interval 7-14 d]	M Bee:H	-
Spinosad (Entrust Organic) Corteva	5	Ingestion	1	A	ALL	Registered in stalk & stem vegetables including fennel (bulb) for control of Helicoverpa spp. [Max. 4 applications per season; re-treatment interval 7-14 d]	L Bee:L	-
Broflanilide (Vedira) BASF	30	Contact & Ingestion		P		Pending registration as an ant bait. It also has potential uses as a seed treatment for the control of Wireworms, and a foliar treatment for the control of chewing pests in various crops.	-	-
Chlorfenapyr (Secure) BASF	13A	Ingestion / IGR		P		Registered for control of Helicoverpa in cotton.	H Bee:H	-

Pest / Active Ingredient (Trade Name)	Chemical group	Activity	WHP, days	Availability	States	Comments	Impact on beneficials	Regulatory risk
<i>Clitorea ternatia</i> extract (Sero-X) Innovate Ag	UN	Biological		P		Registered for control of <i>Helicoverpa</i> spp., Green Mirids and Silverleaf Whitefly in cotton and Diamondback moth in Brassicas. Innovate Ag applied in January 2021 to the APVMA seeking to add new uses against Silverleaf whitefly and thrips in brassicas and cucurbits to its Sero-X Insecticide label.	L Bee:L	-
Emamectin (Proclaim Opti) Syngenta	6	Ingestion		P		Registered for control of <i>Helicoverpa</i> spp. in brassica vegetables, fruiting vegetables, leafy vegetables, brassica leafy vegetables, legume vegetables, root and tuber vegetables, strawberries and sweet corn.	M Bee:H	-
Indoxacarb + Novaluron (Plemax) Adama	22A+15	Contact & Ingestion		P		Registered for control of various Lepidoptera including <i>Helicoverpa</i> spp. in brassica vegetables, leafy vegetables and fruiting vegetables.	M Bee:H	R3
Methoxyfenozide (Prodigy) Corteva	18	Insect growth regulator		P		Registered for control of Native Budworm in tomatoes, peppers, eggplant and okra.	VL Bee:VL	-
NUL3445 Nufarm	TBC			P		New product in development from Nufarm with activity on Lepidoptera , Bugs, Beetles/Weevils, Fruit Fly and Thrips.	-	-
SYNFOI21 (Syngenta)	TBC			P		SYNFOI21 is not registered but the first global application is proposed for 2023 for Thrips, Bugs, Mites and Caterpillars . Hort Innovation Project ST20003 will be contracted in June 2021 to undertake the required data package to support a label registration in celery for various thrips including, Plague Thrips & Western Flower Thrips.	-	-
Tetraniliprole (Vayego 200 SC) Bayer	28			P		Hort Innovation Project ST17000 contracted 2018 to undertake the required data package to support a label registration in stalk & stem vegetables, including celery for Light Brown Apple Moth, <i>Helicoverpa</i> spp. , Green Looper and other pests.	L-M Bee:VH	-

Pest / Active Ingredient (Trade Name)	Chemical group	Activity	WHP, days	Availability	States	Comments	Impact on beneficials	Regulatory risk
Looper Caterpillars (<i>Chrysodeixis</i> spp.)								
Priority: Low								
Looper Caterpillars were ranked as a low priority in VIC, QLD, NSW, WA & SA. The last two larval instars are the most voracious feeders and will usually eat the entire leaf but may avoid the midrib or other large veins. It is important to monitor crops for eggs and larvae by regular field scouting. Target sprays against mature eggs and larvae before pests become entrenched.								
<i>Bacillus thuringiensis subsp. kurstaki</i> (DiPel)	11A	Biological	NR	A	ALL	Registered in vegetables for control of Looper Caterpillars & <i>Helicoverpa</i> . [Apply a minimum of 2 sprays, 3 d apart; re-treatment interval 3-5 d]	VL Bee:L	-
Garlic + Chilli + Pyrethrins + Piperonyl Butoxide	3A	Contact	1	A	ALL	Registered in vegetables for control of Ants, Aphids, Caterpillars , Earwigs, Whitefly, Thrips and Leafhoppers. Suitable for organic growers. Apply as a cover spray and re-apply as necessary every 2-3 weeks.	VH Bee:H	-
Pyrethrins (Pyganic) Sumitomo	3A	Contact	1	A	ALL	Registered in vegetables for control of Aphids, Thrips, Caterpillars , Ants, Earwigs, Whiteflies & Leafhoppers. Spray early in the morning or late evening. [Max. no. of applications and re-treatment intervals not specified]	VH Bee:H	-
Pyrethrins + Piperonyl Butoxide	3A	Contact	1	A	ALL	Registered in vegetables for control of Aphids, Thrips, Caterpillars , Ants, Flies, Earwigs, Whitefly & Leafhoppers. [Max no. of applications not specified; Re-treatment interval: 7 d]	VH Bee:H	-
Chlorantraniliprole (Coragen) FMC	28	Ingestion	1	P-A	ALL	Registered in stalk and stem vegetables for control of Cotton Bollworm and Native Budworm. Registered for control of Loopers in brassica vegetables and brassica leafy vegetables.	L Bee:VL	-
Flubendiamide (Belt) Bayer	28	Ingestion	1	P-A	ALL	Registered in stalk and stem vegetables for control of <i>Helicoverpa</i> spp. Registered for control of loopers in brassica vegetables and brassica leafy vegetables.	L Bee:L	-
Indoxacarb (Avatar eVo) FMC	22A	Ingestion	3	P-A	ALL	Registered in leafy vegetables including fennel (bulb) for control of <i>Helicoverpa</i> spp. Registered for control of Loopers in fruiting vegetables.	L Bee:H	R3

Pest / Active Ingredient (Trade Name)	Chemical group	Activity	WHP, days	Availability	States	Comments	Impact on beneficials	Regulatory risk
Spinetoram (Success Neo) Corteva	5	Ingestion	1	P-A	ALL	Registered in stalk and stem vegetables for the control of <i>Helicoverpa</i> . Registered for control of Loopers in beans, berries, brassica leafy vegetables, brassica vegetables, kiwi fruit, leafy vegetables, legume vegetables, tropical fruits, pome fruit, and root and tuber vegetables.	M Bee:H	-
Spinosad (Entrust Organic) Corteva	5	Ingestion	3	P-A	ALL	Registered in stalk & stem vegetables including fennel (bulb) for control <i>Helicoverpa</i> . Registered for control of Loopers in berries, brassica leafy vegetables, brassica vegetables, root and tuber vegetables, culinary herbs, tropical and sub-tropical fruits, kiwi fruit, leafy vegetables, legume vegetables and pome fruit.	L Bee:L	-
Emamectin (Proclaim Opti) Syngenta	6	Ingestion		P		Registered for control of Loopers in brassica vegetables, root and tuber vegetables, leafy vegetables, brassica leafy vegetables, legume vegetables and strawberries.	M Bee:H	-
Methoxyfenozide (Prodigy) Corteva	18	Insect growth regulator		P		Registered for control of Loopers in pome fruit.	VL Bee:VL	-
NUL3445 Nufarm	TBC			P		New product in development from Nufarm with activity on Lepidoptera , Bugs, Beetles/Weevils, Fruit Fly and Thrips.	-	-
SYNFOI21 (Syngenta)	TBC			P		SYNFOI21 is not registered but the first global application is proposed for 2023 for Thrips, Bugs, Mites and Caterpillars . Hort Innovation Project ST20003 will be contracted in June 2021 to undertake the required data package to support a label registration in celery for various thrips including, Plague Thrips & Western Flower Thrips.	-	-
Tetraniliprole (Vayego) Bayer	28	Ingestion		P		Hort Innovation Project ST17000 contracted 2018 to undertake the required data package to support a label registration in stalk & stem vegetables, including celery for Light Brown Apple Moth, <i>Helicoverpa</i> spp., Green Looper and other pests.	M Bee:VH	

Pest / Active Ingredient (Trade Name)	Chemical group	Activity	WHP, days	Availability	States	Comments	Impact on beneficials	Regulatory risk
Slugs & Snails (Gastropoda)								
Priority: Low								
Slugs and snails were ranked as a low priority in VIC & NSW. They are active after dusk when chemical treatments can be most effective.								
Iron EDTA Complex	-	Contact & ingestion	NR	A	ALL	Registered in all plants for the control of Snails & Slugs . Spread pellets evenly on ground. [Max no. of applications & re-treatment not specified]	-	-
Metaldehyde	-	Contact & ingestion	7	A	ALL	Registered in vegetables for the control of Snails & Slugs . Spread pellets evenly on ground. [Max no. of applications & re-treatment not specified]	-	-
Methiocarb (Mesurol)	1A	Contact & ingestion		P		Registered for control of Common Garden Snails, Slugs, White Italian Snail & White Snail in artichoke, Brassica vegetables, lettuce & potatoes.	-	R2
Fall Armyworm (<i>Spodoptera frugiperda</i>)								
Priority: Unknown								
Fall Armyworm was not ranked as a pest in fennel (bulb). It is an exotic pest that is considered a potential threat that could affect most vegetable crops if allowed to spread. It is important to monitor crops for eggs and larvae of pest species by regular field scouting. Target sprays against mature eggs and newly hatched larvae before pests become entrenched.								
Chlorantraniliprole (Coragen) FMC PER89259	28	Ingestion	1	A	ALL (excl. VIC)	Permitted for use in field peas, faba beans, Brassica vegetables, Brassica leafy vegetables, Stalk & stem vegetables, Leafy vegetables, Fruiting vegetables (including cucurbits), Legume vegetables, Potatoes Sweet corn & Lettuce for control of Fall Armyworm . [Max. 3 applications per crop; 2 consecutive; re-treatment interval 7 d]	L Bee:VL	-
Methomyl (Lannate) PER89293	1A	Contact	14	A	ALL (excl. VIC)	Permitted for use in Spinach, Fennel (bulb), Brassica leafy vegetables, Bulb onions, Leeks & turf for control of Fall Armyworm . Field grown only. [Max. 3 application per crop; re-treatment interval not specified]	H Bee:H	R2

Pest / Active Ingredient (Trade Name)	Chemical group	Activity	WHP, days	Availability	States	Comments	Impact on beneficials	Regulatory risk
Spinetoram (Success Neo) Corteva PER89241	5	Ingestion	3	A	ALL (excl. VIC)	Permitted for use in Sweet corn, Brassica vegetables, Brassica leafy vegetables, Stalk & stem vegetables, Leafy vegetables, Fruiting vegetables (including cucurbits), Legume vegetables, Culinary herbs, Root & tuber vegetables & several fruits (field) for control of Fall Armyworm . [Max. 4 applications per crop; re-treatment interval 7-14 d]	M Bee:H	-
Spinosad (Entrust Organic) Corteva PER89870	5	Ingestion	1 G:14	A	ALL (excl. VIC)	Permitted for use in Brassica vegetables, Brassica leafy vegetables, Stalk and stem vegetables, Leafy vegetables, Fruiting vegetables, Legume vegetables (succulent seeds & immature pods only), Culinary herbs, Root and tuber vegetables and several fruits. (Protected cropping) for control of Fall Armyworm . [Max. 4 applications per season; re-treatment interval 7-14 d]	L Bee:L	-
Indoxacarb (Avatar eVo) FMC	22A	Ingestion	3	P-A	ALL	Registered in leafy vegetables including fennel (bulb) for control of <i>Helicoverpa</i> & Lucerne Leaf Roller. Permitted for control of Fall Armyworm in broccoli, brussels sprouts, cabbage (closed head varieties only), cauliflower, celery, capsicum, eggplant, peppers, tomato, leafy vegetables and Chinese leafy vegetables.	L Bee:H	R3
Amorphous Silica (Abrade) Grow Choice	-	Contact		P		Registered for control of <i>Spodoptera</i> in fruiting vegetables and permitted for control of Fall Armyworm in sweet corn.	L Bee:L	-
Broflanilide (Vedira) BASF	30	Contact & Ingestion		P		Registration submitted concurrently in Australia, Canada, USA, & Mexico as a soil application & seed treatment against chewing insects such as Ants, Cockroaches & <i>Spodoptera</i> spp. BASF are seeking registrations in amenity turf initially, then potential horticultural crops thereafter.	H Bee:VH	-
Emamectin (Proclaim Opti) Syngenta	6	Ingestion		P		Permitted for control of Fall Armyworm in leafy vegetables, Brassica leafy vegetables and celery.	M Bee:H	-
NUL3445 Nufarm	TBC			P		New product in development from Nufarm with activity on Lepidoptera , Bugs, Beetles/Weevils, Fruit Fly and Thrips.	-	-

Pest / Active Ingredient (Trade Name)	Chemical group	Activity	WHP, days	Availability	States	Comments	Impact on beneficials	Regulatory risk
<i>Spodoptera frugiperda</i> Multiple Nucleopolyhedrovirus (Fawligen) AgBiTech	31	Biological		P		Permitted for control of Fall Armyworm in legume vegetables, root & tuber vegetables & sweet corn.	VL Bee:L	-
SYNFOI21 Syngenta	TBC			P		SYNFOI21 is not registered but the first global application is proposed for 2023 for Thrips, Bugs, Mites and Caterpillars . Hort Innovation Project ST20003 will be contracted in June 2021 to undertake the required data package to support a label registration in celery for various thrips including, Plague Thrips & Western Flower Thrips.	-	-
Tetraniliprole (Vayego) Bayer	28	Ingestion		P		Registered in Australia in multiple crops for various insect pests such as Beetles, Weevils & Lepidoptera. Hort Innovation has several projects underway towards assisting registration in minor crops. Indonesia registration for control of <i>Liriomyza</i> Leafminers and Fall Armyworm in vegetable crops.	M Bee:VH	-
Leafminers (<i>Liriomyza</i> spp.)								
Priority: Unknown								
Leaf miners were not ranked as a pest in fennel (bulb). Dipteran Leaf miners (<i>Liriomyza</i> spp.) are exotic pests that have recently been detected and become problematic in Australia. For example, the Serpentine Leafminer was first detected in the Sydney area in October 2020 and has since been found in crops in SE Qld. As a group they are destructive pests and can cause significant economic loss through reduced yields and quality when uncontrolled.								
Cyantraniliprole (Benevia) FMC PER90387	28	Ingestion	7 NG	A	ALL (excl. VIC)	Permitted in bulb vegetables including Fennel (bulb) for control of <i>Liriomyza</i> Leafminers . [Max. 3 applications per crop; min. re-treatment interval 7 d]	L Bee:L	-
Cyromazine (Diptex 150 WP) PER81867	17	Insect growth regulator	7 NG	A	ALL	Permitted for use in stalk and stem vegetables for control of <i>Liriomyza</i> species , including: Vegetable Leaf Miner (<i>Liriomyza sativae</i>) & Serpentine Leaf Miner (<i>Liriomyza huidobrensis</i>) (field & protected) [Max. 6 applications per crop; re-treatment interval 7 d]	-	-

Pest / Active Ingredient (Trade Name)	Chemical group	Activity	WHP, days	Availability	States	Comments	Impact on beneficials	Regulatory risk
Spinosad (Entrust Organic) PER90928	5	Ingestion	1	A	ALL (excl. VIC)	Permitted for use in stalk and stem vegetables for control of <i>Liriomyza</i> species, including: Vegetable Leafminer (<i>Liriomyza sativae</i>), Pea Leaf Miner/Serpentine Leafminer (<i>Liriomyza huidobrensis</i>) & American Serpentine Leafminer (<i>Liriomyza trifolii</i>) (field & protected) [Max. 6 applications per crop; re-treatment interval 7 d]	L Bee:L	-
Chlorantraniliprole (Coragen) FMC	28	Ingestion	1	P-A	ALL	Registered in stalk and stem vegetables for control of Cotton Bollworm and Native Budworm. Permitted for control of Cabbage Leaf Miner (<i>Liriomyza</i> spp.) in spinach and silverbeet.	L Bee:VL	-
Spinetoram (Success Neo) Corteva	5	Ingestion	1	P-A	ALL	Registered in stalk and stem vegetables for the control of <i>Helicoverpa</i> . Permitted for control of Liriomyza Leafminers (<i>Liriomyza</i> spp.) in snow peas, sugar snap peas and green beans.	M Bee:H	-
Abamectin	6	Contact		P		Permitted for control of Liriomyza Leafminers (<i>Liriomyza</i> spp.) including Vegetable & Serpentine Leafminer in fruiting vegetables, cucurbits, leafy vegetables (except lettuce), legume vegetables, root and tuber vegetables, bulb onions, cabbage, celery and rhubarb and bulb vegetables.	M Bee:H	-
Emamectin (Proclaim Opti) Syngenta	6	Ingestion		P		Permitted for control of <i>Liriomyza</i> species, including: Vegetable Leafminer (<i>Liriomyza sativae</i>) in Brassica vegetables.	M Bee:H	-
Spirotetramat (Movento 240 SC) Bayer	23	Ingestion		P		Permitted for control of Liriomyza Leafminers (<i>Liriomyza</i> spp.) in various legume vegetables, lettuce, parsley, fruiting vegetables, celery and rhubarb.	M Bee:VL	-
Tetraniliprole (Vayego 200 SC) Bayer	28	Ingestion		P		Registered in Australia in multiple crops for various insect pests such as Beetles, Weevils & Lepidoptera. Hort Innovation has several projects underway towards assisting registration in minor crops. Indonesia registration for control of Liriomyza Leafminers and Fall Armyworm in vegetable crops.	M Bee:VH	-

4.3 Weeds in fennel bulb

4.3.1 Weed priorities

No weeds have been identified for Fennel (bulb) in the recently conducted industry survey.

Fennel (bulb) is normally transplanted but, in some cases, can be direct seeded. Fennel (bulb) in VIC is grown all year around but is generally considered to be a winter crop.

Growers generally use a pre-plant weed control (general knockdown herbicides) to prepare the paddock. Other management options include soil fumigation, spot spraying and using mechanical devices.

Resistance management

There are confirmed cases of resistance in Australia for Awnless Barnyard Grass (Group M at more than 200 sites), Feather Top Rhodes Grass (Group M at 4 sites) and Blackberry Nightshade (Group L at 2 sites).

Specific resistance management strategies for high resistance risk (A and B) and moderate resistance risk (C, D, F, G, I, J, K, L, M, N, Q and Z) herbicide modes of action are available on the CropLife Australia webpage⁶.

⁶ <https://www.croplife.org.au/resources/programs/resistance-management/herbicide-resistance-management-strategies-2/>

4.3.2 Available and potential products for weed control

TABLE KEY: Note that blank fields in the table indicate no information has been provided.

Availability			
A	Available via either registration or permit approval		
P	Potential – a possible candidate to pursue for registration or permit		
P-A	Potential, already approved in the crop for another use		
Resistance risk		Regulatory risk (refer to Appendix 6)	
		R1	Short-term: Critical concern over retaining access
**	Moderate resistance risk	R2	Medium-term: Maintaining access of significant concern
***	High resistance risk	R3	Long-term: Potential issues associated with use - Monitoring required
Withholding Period (WHP) – Number of days from last treatment to harvest (H) or Grazing (G)			
Harvest	H	Not Required when used as directed	NR
Grazing	G	No Grazing Permitted	NG

Active ingredient (Trade Name)	Chemical Group	Crop / Situation	Comment / Use / Weed	WHP (days)	Availability	States	Regulatory risk
Grass and Broadleaf Weeds							
Priority: Unknown							
Fennel (bulb) is normally transplanted but, in some cases, can be direct seeded. Herbicide options are limited for grass and broadleaf weed control.							
1,3-Dichloropropene + Chloropicrin (Telone C-35)	8B	Vegetables / Soil fumigant	Registered in various crops including vegetables for control of plant parasitic Nematodes, Symphylans, Wireworms, soil borne diseases & suppression of weeds. Do not plant for 7 days after soil treatment.	NR	A	ALL (Restricted use TAS, VIC & SA)	-
Glyphosate (Roundup)	M**	General seed bed preparation	Registered as a pre-plant spray for control of grass and broadleaf weeds.	NR	A	ALL	R3
Paraquat + Diquat (SpraySeed)	L**	General seed bed preparation	Registered as a pre-plant spray for control of grass and broadleaf weeds.	NR	A	ALL	R3

Active ingredient (Trade Name)	Chemical Group	Crop / Situation	Comment / Use / Weed	WHP (days)	Availability	States	Regulatory risk
Aclonifen (Emerger) Bayer	H**		Bayer is expected to seek registration for pre-emergent control of grass and broadleaf weeds in various vegetable crops. Registered in Europe for use in potatoes, legume vegetables and cereals.		P		-
Chlorthal-Dimethyl (Dacthal)	D**		Registered for control of grass and broadleaf weeds in various brassica vegetables, legume vegetables, brassica leafy vegetables, lettuce, bulb vegetables, root and tuber vegetables and strawberries.		P		-
Dimethenamid-P (Outlook) BASF	K**		Registered for control of grass and broadleaf weeds in green beans, green peas, kabocha, pumpkin and sweet corn.		P		-
S-Metolachlor (Dual Gold) Syngenta	K**		Registered for control of grass and broad leaf weeds in various brassica vegetables, brassica leafy vegetables, culinary herbs, rhubarb, spinach, silverbeet, spring onions, shallots, green beans, sweet corn, sweet potato and in fallows.		P		-
NUL3438 Nufarm	TBC		New active in development, Nufarm claims activity on broadleaf weeds.		P		-
Oxyfluorfen (Goal)	G**		Registered for control of grass and broadleaf weeds in various crops and fallow situations. Compatible with glyphosate and diquat/paraquat.		P		-
Prometryn (Gesagard)	C**		Registered in celery, for up to 4 weeks of transplanting, for control of competing grass & broadleaf weeds.		P		-

5. References

5.1 Information:

AgChem Access Priority Access Forum	https://www.agrifutures.com.au/national-rural-issues/agvet-chemicals/
Australian Pesticide and Veterinary Medicines Authority	www.apvma.gov.au
APVMA Chemical review	https://apvma.gov.au/chemicals-and-products/chemical-review/listing
APVMA MRLs	www.legislation.gov.au/Details/F2021C00380
APVMA Permit search	https://productsearch.apvma.gov.au/permits
APVMA Product search	https://productsearch.apvma.gov.au/products
AUSVEG	https://ausveg.com.au
Codex MRL database	http://www.fao.org/fao-who-codexalimentarius/codex-texts/dbs/pestres/en/
Cotton Pest Management Guide 2018-19	https://www.cottoninfo.com.au/publications/cotton-pest-management-guide
CropLife Australia (resistance management)	https://www.croplife.org.au/resources/programs/resistance-management/
Growcom – Infopest Database	www.infopest.com.au
Hort Innovation	www.horticulture.com.au

5.2 Abbreviations and Definitions:

APVMA	Australian Pesticides and Veterinary Medicines Authority
IPM	Integrated pest management
LOQ	Limit of quantification
MRL	Maximum residue limit (mg/kg or ppm)
Pesticides	Plant protection products (fungicide, insecticide, herbicide, nematicides, rodenticides, etc.)
Plant pests	Diseases, insects, nematodes, rodents, viruses, weeds, etc.
SARP	Strategic Agrichemical Review Process
TBC	To be confirmed
WHP	Withholding Period

5.3 Acknowledgements:

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

6. Appendices:

Appendix 1. Products available for disease control in fennel bulb

Appendix 2. Products available for control of insect and other pests in fennel bulb

Appendix 3. Products available for weed control in fennel bulb

Appendix 4. Current permits for use in fennel bulb

Appendix 5. Fennel bulb Maximum Residue Limits (MRLs)

Appendix 6. Fennel bulb Agrichemical Regulatory Risk Assessment

Appendix 1. Products available for disease control in fennel bulb

Active Ingredient (Trade Name)	Chemical group	Situation	Diseases / Comments	States	WHP Days	Regulatory risk
1,3-dichloropropene + Chloropicrin (Telone C-35)	8B	General fumigant	Plant parasitic Nematodes, Symphylans, Wireworms, soil borne diseases (including Fusarium and Verticillium Wilts, Rhizoctonia, Pythium) & suppression of weeds.	ALL (Restricted use TAS, VIC & SA)	NR	-
Chlorothalonil (Bravo) PER82895	M5	Fennel (bulb)	Downy Mildew & Purple Blotch (<i>Alternaria porri</i>)	ALL	7	R3
Mancozeb	M3	Fennel (bulb)	Leaf Blight (<i>Cercosporidium</i>)	TAS	14	R2
Metham Sodium	-	General pre-plant soil fumigation	Fungal diseases including <i>Rhizoctonia, Pythium, Fusarium, Phytophthora, Verticillium, Sclerotinia</i> and Club Root	ALL	NR	-
Oxathiapiprolin (Zorvec Enicade) Corteva	49	Fennel (bulb)	Downy Mildew	ALL	10	-
Penthiopyrad (Fontelis) Corteva	7	Leafy vegetables including fennel (bulb)	Sclerotinia Rot, Grey Mould & Powdery Mildew	ALL	3	-
Phosphorous Acid (Agri-Fos) PER13698	-	Fennel (bulb) & bulb vegetables	Downy Mildew	ALL (excl. VIC)	1	-
Sulphur	M2	Vegetables	Powdery Mildew & Rust	ALL	NR	-

Appendix 2. Products available for control of insect and other pests in fennel bulb

Active Ingredient (Trade Name)	Chemical group	Situation	Pests / Comments	States	WHP	Regulatory risk
<i>Bacillus thuringiensis subsp. kurstaki</i> (DiPel)	11A	Vegetables	Caterpillars, including Helicoverpa & Looper Caterpillars	ALL	NR	-
<i>Beauveria bassiana</i> (Velifer) BASF	UN	Protected Vegetables & Ornamentals	Suppression of various pests including: Western Flower Thrips, Onion Thrips, Greenhouse Whitefly, Silverleaf Whitefly, Sweet Potato Whitefly, Green Peach Aphid & Two-Spotted Spider Mites.	ALL	NR	-
Chlorantraniliprole (Coragen) FMC	28	Stalk & Stem Vegetables / Field & Protected Cropping	Cotton Bollworm Native Budworm	ALL	3	-
Chlorantraniliprole (Coragen) FMC PER89259	28	Stalk & Stem Vegetables / Field & Protected Cropping	Fall Armyworm	ALL (excl. VIC)	1	-
Chlorpyrifos (Lorsban)	1B	Vegetables	Wingless Grasshopper, Cutworm, Field Crickets, Mole Crickets & Vegetable Weevil	Variable refer to label	3	R1
Cyantraniliprole (Benevia) FMC	28	Fennel Bulb	Suppression of Onion Thrips	ALL	7 NG	-
Cyantraniliprole (Benevia) PER90387	28	Bulb Vegetables including Fennel	Liriomyza Leafminers	ALL (excl. VIC)	7 NG	-
Cyromazine (Diptex 150 WP) PER81867	17	Stalk and Stem Vegetables	<i>Liriomyza</i> spp. including Vegetable & Serpentine Leafminer	ALL	7 NG	-
Emulsifiable Botanical Oils (Eco-Oil)	-	Vegetables / Field & Protected Cropping	Greenhouse Whitefly	ALL	NR	-

Active Ingredient (Trade Name)	Chemical group	Situation	Pests / Comments	States	WHP	Regulatory risk
Fonicamid (Mainman) UPL PER89185	29	Bulb Vegetables (onions, shallots, chives, leeks, fennel (bulb) & spring onions)	Suppression of Onion Thrips & Western Flower Thrips.	ALL	7	-
Flubendiamide (Belt) Bayer	28	Stalk & Stem Vegetables	<i>Helicoverpa</i> spp.	ALL	1	-
Garlic + Chilli + Pyrethrins + Piperonyl Butoxide	3A	Vegetables	Ants, Aphids, Caterpillars, Earwigs, Whitefly, Thrips and Leafhoppers. Suitable for organic growers	ALL	1	-
Helicoverpa NPV (Vivus Max) AgBiTech	-	Stalk & Stem Vegetables	Corn Earworm, Native Budworm	ALL	NA	-
Indoxacarb (Avatar eVo) FMC	22A	Leafy Vegetables including Fennel (bulb) / Field Grown	<i>Helicoverpa</i> spp.	ALL	3	R3
Iron EDTA Complex	-	All Plants / Field Grown	Snails & Slugs	ALL	NR	-
Metaldehyde	-	Vegetables / Field Grown	Snails & Slugs	ALL	7	-
Methomyl (Lannate) PER89293	1A	Fennel (bulb) / Field Grown	Fall Armyworm	ALL (excl. VIC)	1	R2
Petroleum Oil PER12221	UN	Alliums including Fennel (bulb) / Field & Protected Cropping	Aphids, Green Mirid, Green Vegetable Bug, Grey Cluster Bug, Leafhoppers, Mites, Rutherglen Bugs & Thrips	ALL (excl. VIC)	1	-
Potassium Salts of Fatty Acids (Natrasoap)	-	Vegetables / Field & Protected Cropping	Aphids, Thrips, Mealybug, Mites, Spider Mite, & Whitefly.	ALL	NR	-
Propargite (Omite)	12C	Vegetables	Two-Spotted Mite Spider Mites	ALL QLD, WA	7	R3

Active Ingredient (Trade Name)	Chemical group	Situation	Pests / Comments	States	WHP	Regulatory risk
Pyrethrins (Pyganic) Sumitomo	3A	Vegetables / Field & Protected Cropping	Aphids, Thrips, Caterpillars, Ants, Earwigs, Whiteflies & Leafhoppers.	ALL	1	-
		Leafy Vegetables, including Fennel	Clean-up spray for control of insects that may be present just prior to harvest such as Fruitfly, Rutherglen Bug and Spiders.			
Pyrethrins + Piperonyl Butoxide	3A	Vegetables / Field & Protected Cropping	Ants, Aphids, Thrips, Caterpillars, Leafhoppers, & Whitefly.	ALL	1	-
Spinetoram (Success Neo) Corteva	3	Stalk & Stem Vegetables	<i>Helicoverpa</i> spp.	ALL	1	-
Spinetoram (Success Neo) Corteva PER89241	3	Stalk & Stem Vegetables / Field Grown	Fall Armyworm	ALL (excl. VIC)	1	-
Spinosad (Entrust Organic) Corteva	5	Stalk & Stem Vegetables	<i>Helicoverpa</i> spp.	ALL	1	-
Spinosad (Entrust Organic) Corteva PER89870	5	Stalk & Stem Vegetables / Protected	Fall Armyworm (<i>Spodoptera frugiperda</i>)	ALL	1 G:14	-
Spinosad (Entrust Organic) Corteva PER90928	5	Stalk & Stem Vegetables / Field & Protected Cropping	<i>Liriomyza</i> species, Vegetable Leaf Miner (<i>Liriomyza sativae</i>), Pea Leaf Miner/Serpentine Leaf Miner (<i>Liriomyza huidobrensis</i>) & American Serpentine Leaf Miner (<i>Liriomyza trifolii</i>)	ALL (excl. VIC)	1	-
Trichlorfon (Lepidex)	1B	Vegetables / Field & Protected Cropping	Green Vegetable Bug, & Rutherglen Bug	ALL	2	R2

Appendix 3. Products available for weed control in fennel bulb

Active ingredient (Trade Name)	Chemical Group	Situation	Comment / Use / Weed	WHP (days)	States	Regulatory risk
1,3-Dichloropropene + Chloropicrin (Telone C-35)	8B	Vegetables	Plant Parasitic Nematodes, Symphylans, Wireworms, soil borne diseases & suppression of weeds	NR	ALL	-
Glyphosate (Roundup)	M**	Field crops / General seed bed preparation and knockdown	Grass and broadleaf weeds as a pre-crop spray.	NR	ALL	R3
Paraquat + Diquat (SpraySeed)	L**	Field crops / Fallow / Direct drilling / General knockdown	Grass and broadleaf weeds as a pre-crop spray.	NR	ALL	R3

Chemical Group Resistance Risk: ** Moderate, *** High

Appendix 4. Current permits for use in fennel bulb

Permit No.	Description	Issued Date	Expiry Date	Permit Holder
PER90387	Cyantraniliprole (Benevia) / Various Vegetables including Bulb Vegetables / Liriomyza Leafminers	03-Dec-20	31-Dec-23	Hort Innovation
PER89259	Chlorantraniliprole (Coragen) / Stalk & Stem vegetables (field & protected cropping) / Fall Armyworm	06-Mar-20	31-Mar-23	Hort Innovation
PER82895 Version 2	Chlorothalonil (Bravo) / Fennel (bulb) / Downy mildew / Purple blotch (Alternaria)	04-Aug-17	31-Aug-25	Hort Innovation
PER81867 Version 2	Cyromazine (Diptex 150 WP) / stalk & stem vegetables / <i>Liriomyza</i> species, including: Vegetable Leafminer (<i>Liriomyza sativa</i>) and Serpentine Leafminer (<i>Liriomyza huidobrensis</i>)	2-Dec-19	30-Nov-23	Hort Innovation
PER89185	Fonicamid (Mainman) / Bulb Vegetables (onions, shallots, chives, leeks, fennel (bulb) & spring onions / Thrips	06-Aug-20	31-Aug-23	Hort Innovation
PER89293	Methomyl (Lannate) / Fennel (bulb) / Fall Armyworm	10-Apr-20	30-Apr-23	Hort Innovation
PER12221 Version 4	Petroleum oil / Alliums including Fennel (bulb) / Aphids, Green mirid, Green vegetable bug, Grey Cluster bug, Leafhoppers, Mites, Rutherglen bugs & Thrips, (field & protected cropping)	29-Jun-12	30-Nov-22	Hort Innovation
PER13698 Version 3	Phosphorous (Agri-fos) / Lettuce leafy (hydroponic), parsley, coriander Fennel (bulb) and Bulb (Allium) Vegetables / Downy Mildew	01-Oct-12	30-Sep-22	Hort Innovation
PER89241	Spinetoram (Success Neo and Delegate Insecticide) / Various Crops including Stalk & stem vegetables (field) / Fall Armyworm	06-Mar-20	31-Mar-23	Hort Innovation
PER89870	Entrust Organic Insecticide / Various Crops including Stalk & Stem Vegetables / Fall Armyworm	21-Jul-20	31-Jul-23	Hort Innovation
PER90928	Spinosad (Entrust Organic) / Various Crops including stalk & stem vegetables (field & protected) / Leaf Miners	23-Apr-21	30-Apr-24	Hort Innovation

Appendix 5. Fennel bulb Maximum Residue Limits (MRLs)

CODEX commodity groupings of Stalk and Stem vegetables (017):

HH 0731	Fennel, leaves
HS 0731	Fennel, seed
VS 0380	Fennel, bulb
VS 0078	Stalk and Stem Vegetables

APVMA Crop Groups

Crop Group	Subgroup	Commodity Name	Codex Code	Scientific Name
Crop Group 017: Stalk and stem vegetables VS 0078	Subgroup 017A, Stems and petioles	Fennel, Bulb	VS 0380	Foeniculum vulgare Mill. subsp. vulgare var. azoricum (Mill.) Thell- (Fennel Florance)
Crop Group 027: Herbs HH 0092	Subgroup 027A, Herbs (Herbaceous plants)	Fennel leaves	HH 0731	Foeniculum vulgare Mill.
Crop Group 028: Spices HH 0093	Subgroup 028A, Spices, seeds	Fennel, seed	HS 0731	Foeniculum vulgare Mill., syn: F. officinale All, F. capilaceum Gilib.

Note: Currently production of all Fennel (bulb) is for the Australian market and no exports are recorded. Available information indicates that in the absence specific limits in legislation the most countries defer to Codex, followed by EU MRL standards or applies a 0.01ppm default value. Food exported to New Zealand from Australia may be legally sold if it complies with Australian requirements. MRLs and legislation are subject to change; the values presented should not be relied on.

Chemical	Codex	Description	APVMA MRL mg/kg	Codex MRL mg/kg
1,3-dichloropropene		Soil fumigant / MRLs not required	NR	
2,4-D			NA	NA
Azoxystrobin	HS0731	Fennel seed	T50	-
Boscalid	VS0078	Stalk and stem vegetables		30
Chlorantraniliprole			NA	NA
Chloropicrin		Soil fumigant / MRLs not required	NR	
Chlorpyrifos		Vegetables	T*0.01	
Chlorothalonil	VA0380	Fennel (bulb)	5	-
	HH0731	Fennel, leaf	5	-
	HS0731	Fennel, seed	5	-
Chlorthal-dimethyl		Vegetables	5	
Clothianidin	VS0078	Stalk and stem vegetables	-	0.04
Cyromazine	VS 0078	Stalk and Stem Vegetables	T7	
Diazinon		Vegetables	0.7	
Diquat		Vegetables (some exceptions)	*0.05	
EPTC		Vegetables	*0.04	
Flubendiamide	VS 0078	Stalk and Stem Vegetables	5	-
Glyphosate	VS 0078	Stalk and Stem Vegetables	*0.01	-
Indoxacarb	HH0731	Fennel, leaf	5	

Chemical	Codex	Description	APVMA MRL mg/kg	Codex MRL mg/kg
Iron EDTA		MRLs not required	NR	
Linuron		Vegetables	*0.05	
Metalaxyl		Vegetables	T0.1	
Metaldehyde		Vegetables	1	
Metham Sodium			NR	
Methiocarb		Vegetables	0.1	
Methomyl	VA0380	Fennel (bulb)	T0.2	
	HH0731	Fennel, leaf	T3	
Metolachlor	HS0731	Fennel, seed	T*0.05	-
Oxathiapiprolin			NA	NA
Paraquat		Vegetables (some exceptions)	*0.05	
Penthiopyrad			NA	NA
Petroleum oil		MRLs not required	NR	
Phosphorous acid	HH0731	Fennel, leaf	T300	NA
Piperonyl Butoxide		Vegetables	8	
Pirimicarb		Vegetables (some exceptions)	1	
Potassium salts of fatty acids		MRLs not required	NR	
Prometryn		Vegetables	*0.1	
Pyrethrins		Vegetables	1	
Rotenone		MRLs not required	NR	
Spinetoram	HS0731	Fennel, seed	5	-
	VS 0078	Stalk and Stem Vegetables	2	-
Spinosad	HS0731	Fennel, seed	5	-
Sulphur		MRLs not required	NR	
Pendimethalin	VA0380	Fennel (bulb)		*0.05
Trichlorfon		Vegetables	0.1	
Trifluralin	VA0380	Fennel (bulb)	T0.5	-
	HS0731	Fennel, seed	T*0.05	-

NOTE: MRLs are constantly under review and subject to change. Check for current MRLs and do not rely on the values stated above. (Code for Fennel (bulb) in Table 1 of the APVMA MRL Standard to be updated to VS 0380 to align with updated Codex Commodity Code)

* Indicates that an MRL is at the Limit of Quantitation (LOQ)

NR - Uses of substances where MRLs are not necessary / required.

NA – MRLs are not in place.

T =Temporary MRL

E = The MRL is based on extraneous residues

Sources: APVMA MRLs: Agricultural and Veterinary Chemicals Code (MRL Standard) Instrument 2019. Compilation 4. Prepared 26 April 2021. CODEX MRLs: CODEX Alimentarius International Food Standards database (February 2020), <http://www.fao.org/fao-who-codexalimentarius/codex-texts/dbs/pestres/en/>

Appendix 6: Fennel bulb Agrichemical Regulatory Risk Assessment

Fennel (bulb) Agrichemical Regulatory Risk Assessment

October 2020

Regulatory pressures on agrichemicals are increasing globally, with many being either restricted or withdrawn from use. For older agrichemicals these pressures are often the result of reconsiderations involving new or refined risk assessment methodologies that require the generation of new data. A consequence of which can be that many of these chemicals are not meeting contemporary risk assessment standards as the necessary data is unavailable, or where data is available, the risk posed is considered unacceptable.

The use of farm chemicals can also be impacted through differences in standards between trading partners. The lack of an appropriate pesticide maximum residue limit (MRL) in an importing country can, for practical purposes, effectively prohibiting the use in the exporting country to ensure compliance, as breaches of MRLs would adversely affect market access.

The effects of the above are greater pressure placed on the availability and use of individual chemicals or chemical groups. As a consequence, it is possible that the number of approved agrichemical options could be adversely impacted.

To assist strategic planning, with respect to future pest management options, the following tables have been developed to highlight the regulatory threats to agrichemicals currently approved for the management of the pests and diseases in leeks as well as current initiatives aimed at addressing identified pest management deficiencies.

Fennel bulb Agrichemical Regulatory Risk Assessment

R1	Short-term: Critical concern over retaining access
R2	Medium-term: Maintaining access of significant concern
R3	Long-term: Potential issues associated with use - Monitoring required

Problem	Active Constituents	Chemical Group	Comment	Actions
INSECT AND MITE PESTS				
Aphids				
Aphids	Petroleum oil (PER12221)	-		
Beetles				
Spotted vegetable weevil	Chlorpyrifos	1B	APVMA: Under review. Potential issues w.r.t. environmental loading and worker exposure. EU: No authorisation in place Canada: Cancellation of most uses. USA: EPA decision to allow continued use	
Vegetable weevil	Chlorpyrifos	1B		
Caterpillars/Lepidoptera				
Armyworm	<i>B thuringiensis</i>	11A		
Budworms: Native (<i>Helicoverpa punctigera</i>)	<i>B thuringiensis</i>	11A		
	Flubendiamide	28		
Corn earworm/Cotton bollworm (<i>Helicoverpa armigera</i>)	Helicoverpa NPV	31		
	Spinetoram	5		
	Spinosad	5		
Cabbage moth	Trichlorfon	1B	APVMA: nominated for review Codex: No MRLs Europe: deregistered US: No MRLs	
Caterpillars	Diazinon	1B	EU: No authorisation in place Codex: To be reviewed by 2020/21.	
	Spinetoram	5		

Problem	Active Constituents	Chemical Group	Comment	Actions
Cutworms	Chlorpyrifos	1B	APVMA: Under review. Potential issues w.r.t. environmental loading and worker exposure. EU: No authorisation in place Canada: Cancellation of most uses. USA: EPA decision to allow continued use	
Fall armyworm	Chlorantraniliprole (PER89259)	28		
	Methomyl (PER89293)	1A	APVMA: nominated for review Canada: Re-evaluation completed (2018). Majority of uses removed EU: No authorisations in place	
	Spinetoram (PER89241)	5		
	Spinosad (PER89870)	5		
Loopers	<i>B thuringiensis</i>	11A		
	Malathion/Maldison	1B	APVMA: Under review: chemistry Codex: Re-evaluation scheduled for 2022/23	
Grasshoppers/Locusts				
Field crickets	Chlorpyrifos	1B	APVMA: Under review. Potential issues w.r.t. environmental loading and worker exposure. EU: No authorisation in place Canada: Cancellation of most uses. USA: EPA decision to allow continued use	
Mole crickets	Chlorpyrifos	1B	APVMA: Under review. Potential issues w.r.t. environmental loading and worker exposure. EU: No authorisation in place Canada: Cancellation of most uses. USA: EPA decision to allow continued use	
Jassids/Plant bugs				
Green mirids	Petroleum oil (PER12221)	-		
Green vegetable bug	Petroleum oil (PER12221)	-		
	Trichlorfon	1B	APVMA: nominated for review Codex: No MRLs Europe: deregistered US: No MRLs	
Grey cluster bug	Petroleum oil (PER12221)	-		
Leafhoppers	Petroleum oil (PER12221)	-		

Problem	Active Constituents	Chemical Group	Comment	Actions
Rutherglen bug	Petroleum oil (PER12221)	-		
	Trichlorfon	1B	APVMA: nominated for review Codex: No MRLs Europe: No authorisation in place US: No MRLs	
Mites				
Mites	Petroleum oil (PER12221)	-		
Spider mites	Propargite	12C	APVMA: nominated for review	
Thrips				
Onion (cotton seedling) thrips	Cyantraniliprole	28	Listed on label under bulb vegetables	
Thrips	Fonicamid (PER89185)	29	Listed on label under bulb vegetables	
	Petroleum oil (PER12221)	-		
Other				
Fungus gnats	<i>B thuringiensis</i> (PER14694)	11A		
Leaf miner	Cyromazine (PER81867)			
	Spinosad (PER90928)	5		
Slugs and Snails				
Slugs/Snails	Iron	-		
	Metaldehyde	-		
	Methiocarb	1A	EU: No authorisations	

Problem	Active Constituents	Chemical Group	Comment	Actions
DISEASES				
Downy mildew	Chlorothalonil (PER82895)	M5	APVMA: Nominated for review Canada: Review recently completed, continued use considered acceptable Europe: Deregistered ⁱ .	
	Oxathiapiprolin	49	Listed on label under bulb vegetables	
	Phosphorous acid (PER13698)	33		
Leaf blight	Mancozeb	M3	APVMA: Nominated for review Canada: Many uses cancelled Codex: To be reviewed 2022/23 EU: Authorisation not renewed	
Leaf diseases	Copper	M1	EU: Candidate for substitution	
Purple blotch	Chlorothalonil (PER82895)	M5	APVMA: Nominated for review Canada: Review recently completed, continued use considered acceptable Europe: Deregistered.	
WEEDS				
Broadleaf weeds and grasses	Diquat	L	APVMA: Currently under review EU: No authorisation in place	
	Glyphosate	M	Ongoing issues internationally	
	Metolachlor (PER14158)	K		
	Paraquat	L	APVMA: Currently under review EU: No authorisation in place Rotterdam Convention: nomination	

MT17019 – Regulatory support and coordination. This multi-industry project has been funded by Hort Innovation using industry research and development levies and contributions from the Australian Government. Hort Innovation is the grower-owned, not-for-profit research and development corporation for Australian horticulture.

ⁱ Chlorothalonil - Withdrawal authorisations by 20 November 2019. Max period of grace: 20 May 2020. Commission Implementing Regulation (EU) 2019/677 <https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32019R0677&from=EN>