Liriomyza sativae Contingency Plan

Prepared for Horticulture Innovation Australia, as part of Project MT16004 (*RD&E program for control, eradication and preparedness for vegetable leafminer*)

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CONTINGENCY PLAN

VEGETABLE LEAFMINER (*LIRIOMYZA SATIVAE*)

Images: Elia Pirtle, Cesar Australia Pty Ltd

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Disclaimer

Further information

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Plant Health Australia Limited (Version 1, 2020) Contingency Plan for Vegetable leafminer (*Liriomyza sativae*).

1. PURPOSE AND BACKGROUND OF THIS CONTINGENCY PLAN

Vegetable leafminer (*Liriomyza sativae*) has recently been discovered in the Torres Strait (2008) and the northern tip of Cape York Peninsula in Queensland (2015) (IPPC 2015; 2017).

This Contingency Plan provides background information on vegetable leafminer to assist in determining the requirements for the initial response to a detection of this species in other regions of Australia. Only key information for immediate response is provided in this document.

Additional information can be found in the following supporting material:

- Awareness material such as the fact sheets from Plant Health Australia (PHA), AUSVEG, and commonwealth, state and territory jurisdictions.
    - www.planthealthaustralia.com.au/pests/vegetable-leaf-miner/
    - www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/crop-growing/priority-pest-disease/vegetable-leafminer
    - www.agriculture.gov.au/biosecurity/australia/naqs/naqs-target-lists/vegetable_leaf_miner
    - www.agriculture.gov.au/pests-diseases-weeds/plant/leaf-miner
    - https://ausveg.com.au/biosecurity-agrichemical/biosecurity/mt16004/
- Overseas websites with additional information
    - https://gd.eppo.int/taxon/LIRISA
    - www.cabi.org/cpc/datasheet/30960
    - https://cipotato.org/riskatlasforafrica/liriomyza-sativae/
    - http://entnemdept.ufl.edu/creatures/veg/leaf/vegetable_leafminer.htm
    - http://ipm.ucanr.edu/PMG/r783300911.html

2.PEST DETAILS

Common name:	Vegetable leafminer
Scientific name:	*Liriomyza sativae* Blanchard
Synonyms:	*Agromyza subpusilla* *Lemurimyza lycopersicae* *Liriomyza canomarginis* *Liriomyza guytona* *Liriomyza minutiseta* *Liriomyza munda* *Liriomyza propepusilla* *Liriomyza pullata* *Liriomyza subpusilla* *Liriomyza verbenicola*
Taxonomic position:	Class: Insecta Order: Diptera Family: Agromyzidae Genus: *Liriomyza* Species: *Liriomyza sativae*

2.1 Background and impact of pest

The Agromyzidae are a well-known group of small, morphologically similar flies whose larvae feed internally on plants, often as leaf and stem miners. Nearly all species are very host-specific, but a few highly polyphagous species have become important pests of agriculture and horticulture in many parts of the world.

The vegetable leafminer (*L. sativae*) is of concern as it has a wide host range including many horticulture crops in which it can cause significant yield losses and quality reductions (see Appendix 1). Vegetable leafminer has also been reported to vector the potyviruses Celery mosaic virus and Watermelon mosaic virus, both viruses have been reported from Australia and affect celery and cucurbits respectively (Zitter and Tsai 1977). The vegetable leafminer is widespread overseas being present in North and South America, Asia, Africa, and occasional outbreaks in Europe.

This species was first detected in the Torres Strait (August 2008) and has recently been detected on mainland Australia near the north Queensland town of Seisia (May 2015) (IPPC 2015; 2017). There appears to have been multiple introductions of this pest into the Torres Strait (Blacket et al., 2015). This genetic diversity may have management implications. Due to its presence in far North Queensland there is a significant risk that it may be able to spread south into production regions where it may have major impacts on Australian plant industries, especially the vegetable, production nursery and melon industries.

2.2 Life cycle

The lifecycle (Figure 1) of the vegetable leafminer consists of an egg inserted by a female just under the surface of a leaf of a host plant. The egg hatches in 2-5 days. The larvae then begin to feed within the leaf creating tunnels or mines that get larger as the larvae moult and mature. After passing through three larval stages in 4-7 days, the larva leaves the plant to form a puparium in the soil underneath the host plant. Larvae may also occasionally fail to leave the leaf and pupate on the leaf surface or may potentially fall from the plant to pots/trays underneath. After 7-14 days an adult emerges and begins to reproduce.

The times taken to complete each life stage vary depending on host and temperature. For example, Haghani et al. (2007), studied development times on cucumber at different temperatures. They found that total development time ranged between 40.4 and 9.3 days, with development time decreasing with increasing temperatures. They also reported that the limits of development were 10 and 40°C. Similarly, a study by Cost-Lima et al., (2010) examined vegetable leafminer development on cowpea at different temperatures and relative humidity levels. They found that adult longevity decreased with increasing temperatures.

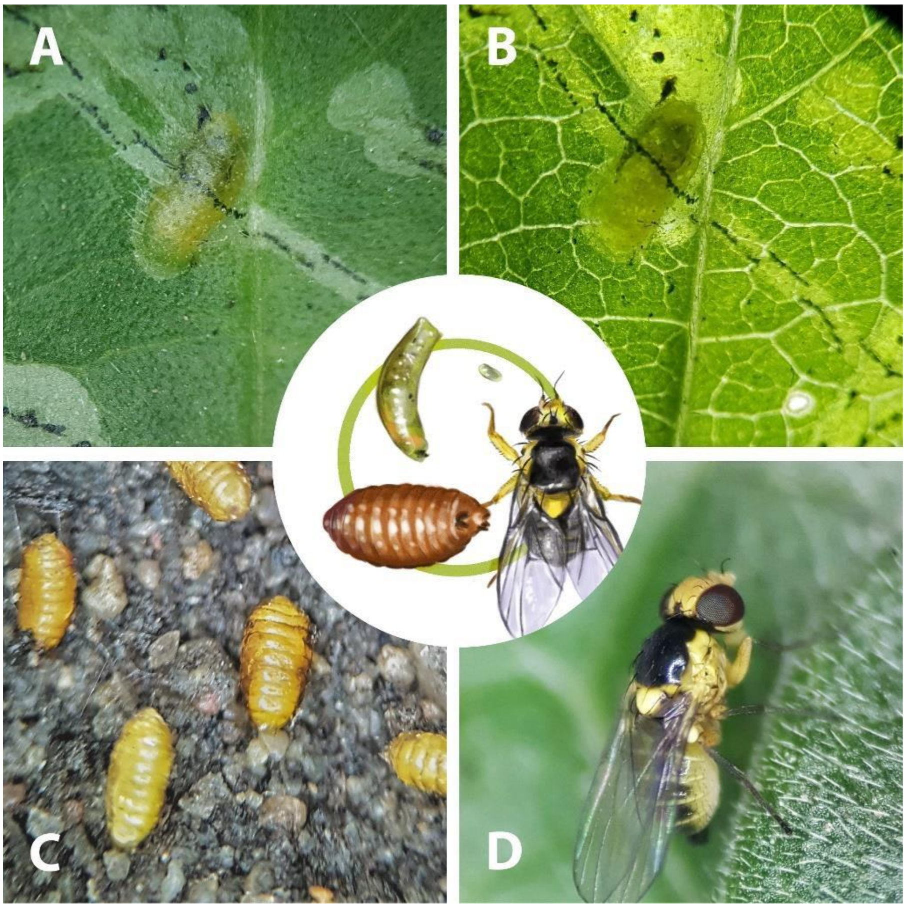

Figure 1 A larvae visible within a leaf mine, with top down lighting (A), and backlighting (B); pupa in the soil (C) and adult (D). Images: Elia Pirtle, Cesar Australia *Pty Ltd*

2.3 Host range

Vegetable leafminer is a polyphagous pest of many agricultural and ornamental hosts (see Appendix 1). It has been recorded from 120 plant species representing at least 23 plant families, although its preferred hosts tend to be in the Cucurbitaceae, Fabaceae and Solanaceae families (Spencer 1973, 1990).

Important agricultural hosts include: brassica vegetables, leafy vegetables (e.g. spinach and lettuce), cucurbits (e.g. pumpkins, cucumbers), melons, legume vegetables and pulse crops, tomatoes, potatoes, capsicum, a wide range of ornamental species (e.g. petunia, chrysanthemum and marigold), cotton, lucerne, herbs (e.g. basil), onions and clover..

A detailed host list is included in Appendix 1.

2.4 Signs and symptoms

Adult flies are small (1.5-1.6 mm long with a wing length of 1.3-1.8 mm) with a shiny black mesonotum and yellow markings on the head and body (Figure 2).

Female flies use their ovipositor to puncture the leaves of the host plants causing wounds which serve as sites for feeding (by both males and females) or oviposition. Feeding punctures appear as white speckles on the upper leaf surface and are ~0.2 mm in diameter (Figure 4). The appearance of the punctures does not differ between *Liriomyza* species so cannot be used to separate species.

Pale coloured leaf mines are created by the feeding larvae and are the most obvious symptom of infestations of *Liriomyza* spp. Larvae produce leaf mines that are serpentine and increase in size along their length (Figure 3 and Figure 4).

Factsheets with more information on what to look for in the field can be found at the following websites:

- www.planthealthaustralia.com.au/pests/vegetable-leaf-miner/
- www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/crop-growing/priority-pest-disease/vegetable-leafminer
- www.agriculture.gov.au/biosecurity/australia/naqs/naqs-target-lists/vegetable_leaf_miner
- http://entnemdept.ufl.edu/creatures/veg/leaf/vegetable_leafminer.htm
- https://ausveg.com.au/app/uploads/2019/07/Vegetable-leafminer.pdf

Figure 2. Adult vegetable leafminer. Image: Elia Pirtle, Cesar Australia *Pty Ltd*

Figure 3. Vegetable leafminer leaf mines on siratro left(left) and cucurbit (right,), note mines increase in width as the larvae ages. Images: Elia Pirtle, Cesar Australia *Pty Ltd*

Figure 4 Stippling and leaf mines on snake bean caused by vegetable leafminer. Images: Elia Pirtle, Cesar Australia *Pty Ltd*

2.5 Dispersal

Typically, *Liriomyza* leafminers are considered to have invaded countries via the movement of infested plants (generally ornamentals such as chrysanthemum) (Spencer 1989). While fully formed mines should be readily visible, signs of early infestations are much less obvious and are easily overlooked (Spencer 1989).

Agromyzid flies are considered as "moderate fliers" (Yoshimoto and Gressitt 1964) and in agricultural situations, the flies tend to remain close to their target crops, often only moving very short distances between host plants (Zehnder and Trumble 1984a; Fenoglio et al., 2019). Lei et al., (2002) reported that in a flight mill experiment vegetable leafminer could fly up to 8.22 km but average flight distances of <1.0 km were reported at 18-36ºC. Moreover, agromyzids such as vegetable leafminer may have the capacity to move longer distances by wind dispersal (White 1970; Glick 1960).

However, windborne dispersal is likely to be a minor pathway of leafminer dispersal in Australia, and human-mediated pathways should be prioritised, particularly given the accumulation of research pointing to this as a major contributor to the movement of invasive species (Capinha et al. 2015; Wichmann et al. 2009). Such pathways include transport of contaminated produce, or "hitch-hiking" adults associated with the large volume of human movement.

In recent years, the vegetable leafminer has spread from New Guinea, through several islands in the Torres Strait to Seisia on the northern tip of Cape York Peninsula, possibly by the spread of plant material or natural dispersal. This suggests that there is the potential to spread from Seisia south into other horticulture regions, particularly during the tourist season in Far North Queensland. Plant material should be considered as a potential pathway for the southward spread of this pest. There are currently movement restrictions in place to stop the movement of plant material south from the far north of Cape York Peninsula, however there is still a risk that the pest could spread southwards.

2.6 Current geographic distribution

The vegetable leafminer is thought to have originated in the Americas and since spread to Asia, and Africa. Small outbreaks have also been reported in Europe, which have been eradicated each time (CABI/EPPO, date unknown). The current status of the distribution worldwide is listed in the EPPO (2020) database.

The current distribution of this pest is presented in Table 1.

Table 1. Countries where vegetable leafminer is known to occur

COUNTRY/REGION	REFERENCE
American Samoa	Blacket et al., (2015); Kroschel et al., (2016); PHA (2008)
Antigua and Barbuda	Kroschel et al., (2016)
Argentina	Civelek (2002); Kroschel et al., (2016); PHA (2008); Scheffer and Lewis (2005)
Australia (only reported from Torres Strait, and Far North Queensland)	IPPC (2015; 2017)

COUNTRY/REGION	REFERENCE
Bahamas	Kroschel et al., (2016); PHA (2008)
Bangladesh	Bhuiya et al., (2011)
Barbados	Alam (1985); Kroschel et al., (2016); PHA (2008)
Brazil	Araujo et al., (2013); Kroschel et al., (2016); PHA (2008)
Cameroon	Civelek (2002); Kroschel et al., (2016); Martinez and Bordat (1996); PHA (2008)
Canada (glasshouses in Ontario)	Kroschel et al., (2016); McClanahan (1980); PHA (2008)
Chile	Gonzalez (1989); Kroschel et al., (2016); PHA (2008)
China	Blacket et al., (2015); Kroschel et al., (2016); PHA (2008); Scheffer and Lewis (2005); Tran et al., (2007)
Colombia	Kroschel et al., (2016); PHA (2008); Scheffer and Lewis (2005)
Cook Islands	Blacket et al., (2015); Kroschel et al., (2016); PHA (2008)
Costa Rica	Kroschel et al., (2016); PHA (2008); Spencer (1983)
Cuba	Kroschel et al., (2016); PHA (2008)
Democratic Republic of the Congo[1]	Kroschel et al., (2016)
Dominica	Kroschel et al., (2016); PHA (2008)
Dominican Republic	Kroschel et al., (2016); Martinez et al., (1993); PHA (2008)
Egypt	PHA (2008); Scheffer and Lewis (2005)
Ethiopia[1]	Kroschel et al., (2016)
Federated States of Micronesia	Blacket et al., (2015); Kroschel et al., (2016); PHA (2008)
French Guiana	Kroschel et al., (2016); PHA (2008)
French Polynesia	Blacket et al., (2015); PHA (2008)
Guadeloupe	Kroschel et al., (2016); PHA (2008); Spencer et al., (1992)
Guam	Blacket et al., (2015); Kroschel et al., (2016); PHA (2008)
Guatemala	Kroschel et al., (2016); PHA (2008); Scheffer and Lewis (2005)
Honduras	Kroschel et al., (2016); PHA (2008); Scheffer and Lewis (2005)
India	Blacket et al., (2015); Kroschel et al., (2016); PHA (2008)
Indonesia	Blacket et al., (2015); Kroschel et al., (2016); PHA (2008)
Iran	Kroschel et al., (2016); PHA (2008); Saryazdi et al., (2014)
Israel	Kroschel et al., (2016); PHA (2008); Scheffer and Lewis (2005)
Jamaica	Civelek (2002); Kroschel et al., (2016); PHA (2008)

[1] Kroschel et al., (2016) infer presence based on overseas interceptions on crops originating from this country

COUNTRY/REGION	REFERENCE
Japan	Kroschel et al., (2016); Blacket et al., (2015): PHA (2008); Tran et al., (2007)
Jordan	Kroschel et al., (2016); PHA (2008)
Kenya	Gitonga et al., (2010); Kroschel et al., (2016)
Malaysia	Blacket et al., (2015); Kroschel et al., (2016); PHA (2008); Scheffer and Lewis (2005)
Martinique	Etienne and Martinez (2013); Kroschel et al., (2016); PHA (2008)
Mexico	Kroschel et al., (2016); PHA (2008); Trumble and Alvarado-Rodriguez (1993)
Montserrat	Kroschel et al., (2016); PHA (2008)
Netherlands Antilles	Kroschel et al., (2016); PHA (2008)
New Caledonia	Blacket et al., (2015); Kroschel et al., (2016); PHA (2008)
Nicaragua	Kroschel et al., (2016); PHA (2008); Piedrahita and Fabio (2016)
Nigeria	Civelek (2002); Kroschel et al., (2016); PHA (2008)
Northern Mariana Islands	Blacket et al., (2015); Kroschel et al., (2016); PHA (2008)
Oman	Civelek (2002); Kroschel et al., (2016); PHA (2008)
Panama	Kroschel et al., (2016); PHA (2008)
Papua New Guinea	Blacket et al., (2015)
Peru	Civelek (2002); Mujica and Kroschel (2011); Kroschel et al., (2016); PHA (2008)
Philippines	PHA (2008); Scheffer and Lewis (2005)
Puerto Rico	Acosta et al., (1986); Kroschel et al., (2016); PHA (2008)
Samoa	Blacket et al., (2015); Kroschel et al., (2016); PHA (2008)
Saudi Arabia	PHA (2008); Scheffer and Lewis (2005)
South Africa[2]	Kroschel et al., (2016); PHA (2008)
Sri Lanka	Blacket et al., (2015); Kroschel et al., (2016); PHA (2008); Scheffer and Lewis (2005)
St. Kitts and Nevis (on the Island of Saint Kitts/Saint Christopher)	Etienne and Martinez (2003); Kroschel et al., (2016); PHA (2008)
St. Lucia	CABI/EPPO (date unknown); PHA (2008)
St. Vincent and Grenadines	Kroschel et al., (2016)
Sudan	Civelek (2002); Kroschel et al., (2016); Martinez and Bordat (1996); PHA (2008)

[2] Kroschel et al., (2016) infer presence based on overseas interceptions on crops originating from this country

COUNTRY/REGION	REFERENCE
Tanzania[2]	Kroschel et al., (2016)
Thailand	Blacket et al., (2015): Kroschel et al., (2016); PHA (2008)
Timor Leste	Brito and Supartha (2016); PHA (2008)
Trinidad and Tobago	Kroschel et al., (2016); PHA (2008)
Turkey	Civelek (2002); Kroschel et al., (2016); PHA (2008)
United States of America (various mainland states and Hawaii)	Kroschel et al., (2016); PHA (2008); Scheffer and Lewis (2005)
Uganda[2]	Kroschel et al., (2016)
Uzbekistan	Drugova and Zlobin (2003); Kroschel et al., (2016); PHA (2008)
Vanuatu	Blacket et al., (2015); Kroschel et al., (2016); PHA (2008)
Venezuela	Civelek (2002); Kroschel et al., (2016); PHA (2008); Scheffer and Lewis (2005)
Vietnam	Blacket et al., (2015); Kroschel et al., (2016); PHA (2008); Scheffer and Lewis (2005); Tran et al., (2007)
Yemen	Civelek (2002); Kroschel et al., (2016); PHA (2008)
Zimbabwe	Kroschel et al., (2016); PHA (2008)

2.7 Risk of establishment in Australia

Detailed studies of overwintering of vegetable leafminer pupae in China found no indication of pupal diapause and suggested the -2°C isotherm of the minimum mean temperature of January (northern hemisphere winter) was the overwintering range limit for vegetable leafminer (Chen & Kang 2005 a, b).

Cesar Australia has created a model of the potential geographic distribution of the vegetable leafminer in Australia, the results of which are summarised below (Figure 5). A copy of the relevant reports and/or published manuscripts are available from Hort Innovation or from Cesar Australia (http://cesaraustralia.com/contact-us/).

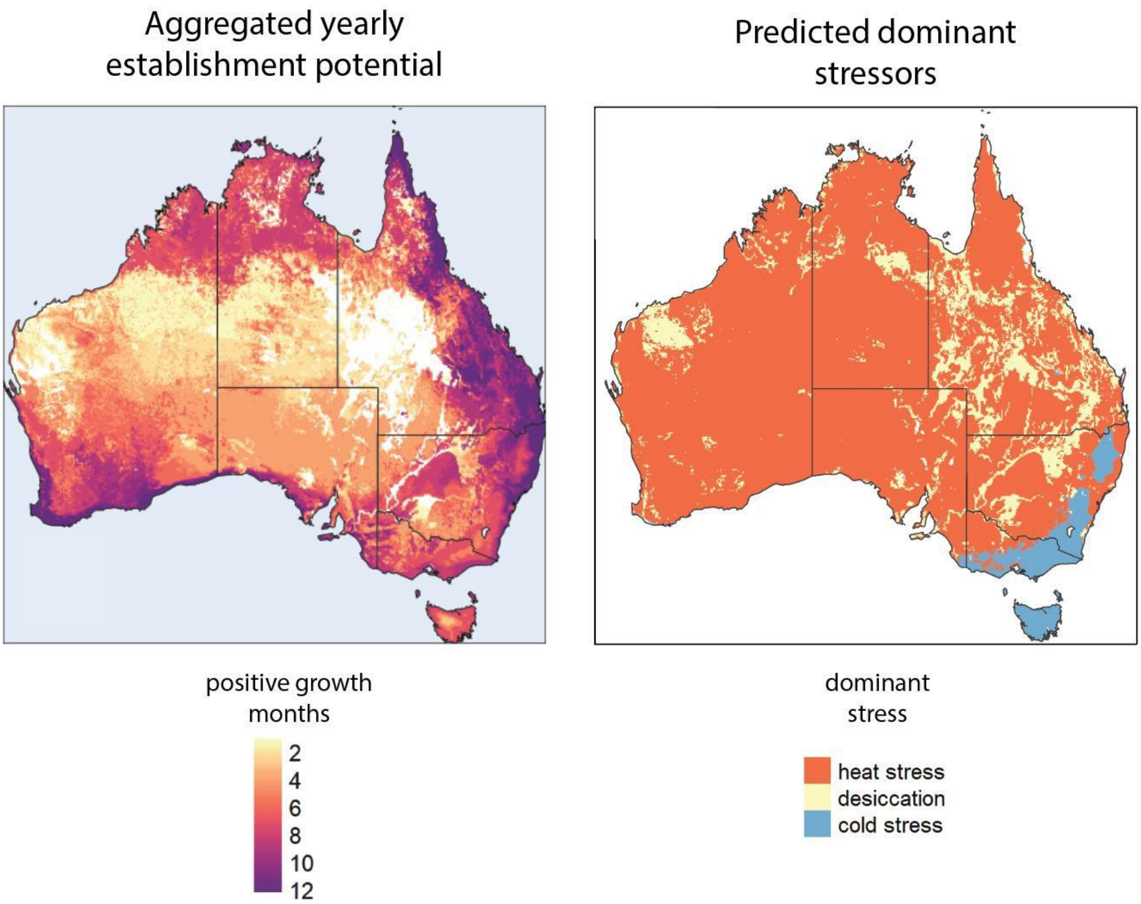

Figure 5 Aggregated yearly establishment potential of vegetable leafminer as the number of months across the year with increasing population sizes) based on temperature and moisture constraints (left) and predicted dominant stressors based on the highest mortality rate from desiccation, cold, and heat stress across the year (right).

2.8 Risk of spread within Australia

2.8.1 Risk pathways – international and domestic

This species could potentially enter new areas by natural spread and by hitchhiking on goods, aircraft, vehicles, or the movement of plant material (DAWR 2016). Table 2 lists some of the potential international risk pathways and control measures in place. These may also broadly applicable to other *Liriomyza* species.

Table 2 International risk pathways for the spread of the pest and control measures

RISK PATHWAY	DESCRIPTION	CONTROL MEASURES
Cut flowers on regulated imports	Infested cut flowers moved to residential dwellings that contain suitable hosts and the insect transfers to a host.	Border inspections
Infected plant material on passenger or mail pathways	Infested plant material moved to residential dwellings that contain suitable hosts and the insect transfers to a host.	Border inspections
Natural dispersal from PNG	Ongoing spread from PNG to Torres Strait and/or Far North Queensland via traditional movements, winds or flight.	Ongoing surveillance via the Northern Australia Quarantine Strategy Domestic quarantine
Infested plant material and natural spread of vegetable leafminer from FNQ	Plant material or pupae in soil spread to new areas in baggage, vehicles or camping equipment.	Domestic quarantine

Additionally, as the larvae of *Liriomyza* spp. leave the plant to pupate, pupae may also be spread with crop debris or soil associated with infested areas. Table 3 lists some of the potential risk pathways and potential domestic control measures to reduce the spread of vegetable leafminer. These are also broadly applicable to other *Liriomyza* species.

Table 3. Risk pathways for the spread of the pest and potential domestic control measures

RISK PATHWAY	DESCRIPTION	POTENTIAL DOMESTIC CONTROL MEASURES
Cut flowers (host plants)	Cut flowers that are a host of vegetable leafminer (see Appendix 1) pose a significant risk. The life of cut flowers is long enough to allow the completion of the pest's lifecycle (CABI and EPPO, date unknown). Eggs may be present within leaves but are never visible. Larvae may be present and visible within leaves. Hitchhiking adults and pupae may be transported on cut flowers.	The application of systemic insecticides may be required before allowing cut flowers grown in an infested area to be moved outside the infested area. Further information on chemical control is provided in Section 5.3. 3. All cut flowers leaving infested areas will also need to be visually inspected for signs of leafminers before leaving the area.

RISK PATHWAY	DESCRIPTION	POTENTIAL DOMESTIC CONTROL MEASURES
Cut flowers (non-host plants)	Cut flowers that are not a host of vegetable leafminer poses significantly less risk for the spread of this pest, but is still a potential pathway, particularly if the non-host cut flowers are transported with or spent time in close proximity with host cut flowers. Eggs, larvae and pupae will not spread with non-host stock. Adults may potentially spread with non-host stock as a hitchhiker.	To reduce the risk of spread, cut flowers that are not a host plant for vegetable leafminer should be inspected and/or treated as a precaution if grown in an area known to be infested with vegetable leafminer.).
Nursery Stock (containerised host plants)	Nursery stock that is a host plant for vegetable leafminer (see Appendix 1) poses a significant risk for the spread of this pest. Containerised nursery stock can carry all life stages of the pest. Eggs may be present within leaves but are never visible. Larvae may be present and visible within leaves. Pupae may also be present in the soil of containerised stock. Larvae emerge from the leaf and pupate in the soil under host plants meaning potting mix/soil can also potentially spread the pest. Larvae very occasionally attach to leaves or surrounding non-soil surfaces to pupate. Adults may potentially spread with containerised nursery stock as a hitchhiker.	Visual inspection of containerised nursery stock for the presence of adults resting on leaves, larvae creating leaf mines and pupae in the soil (see Figure 3, however pupae will be very hard to detect as they are mixed into the substrate) or attached to leaves and container surfaces. To reduce the risk of spread, containerised nursery stock that is a host plant for vegetable leafminer should not be moved from infested to non-infested areas without being treated with an appropriate systemic insecticide. Treatment of growing media using appropriate pesticides (eg Cyromazine-PER83506) should also be considered. Further information on chemical control is provided in Section 5.3.3.

RISK PATHWAY	DESCRIPTION	POTENTIAL DOMESTIC CONTROL MEASURES
Nursery Stock (bare rooted host plants)	Nursery stock that is a host plant for vegetable leafminer (see Appendix 1) poses a significant risk for the spread of this pest. Bare rooted nursery stock can carry all life stages of the pest. Eggs may be present within leaves but are never visible. Larvae may be present and visible within leaves. Pupae are less likely to be present in bare rooted stock than containerised stock. However, upon emergence, if larvae are unable to find a substrate to bury into, they will attach to any surface available (including tray walls or plant leaves) meaning pupae can potentially still spread via bare rooted stock. Adults may potentially spread with bare rooted nursery stock as a hitchhiker.	Visual inspection of bare rooted nursery stock for the presence of adults resting on leaves, larvae creating leaf mines and pupae attached to leaves or surfaces surrounding the roots (see Figure 3). To reduce the risk of spread, bare rooted nursery stock that is a host plant for vegetable leafminer should not be moved from infested to non-infested areas without being treated with an appropriate systemic insecticide. Further information on chemical control is provided in Section 5.3.3.
Nursery Stock (non-host plants)	Nursery stock that is not a known host plant of vegetable leafminer poses significantly less risk for the spread of this pest, but is still a potential pathway, particularly if the non-host stock spent time in close proximity with host stock. Eggs, larvae and pupae will not spread with non-host stock. Adults may potentially spread with non-host stock as a hitchhiker.	Visual inspection of nursery stock for the presence of adults resting on leaves. To reduce the risk of spread, nursery stock that is not a host plant for vegetable leafminer should be inspected and/or treated as a precaution if grown in an area known to be infested with vegetable leafminer. Treatment of growing media using appropriate pesticides (eg Cyromazine-PER83506) may also be considered as a precaution to limit the potential for spread.

RISK PATHWAY	DESCRIPTION	POTENTIAL DOMESTIC CONTROL MEASURES
Non-commercially grown seedlings and plants	People and small businesses selling/trading seedlings at a local level (e.g. at farmers markets, school fetes, roadside stalls, etc.) pose similar threats to those posed by nursery stock, (i.e. plants can spread eggs, larvae, pupae and potentially adults via host plants to new areas). However, being less regulated this is a difficult pathway to control and therefore potentially poses a higher risk than commercial production nursery businesses.	Should an incursion occur, effort will be needed to identify those involved in the non-commercial trade of seedlings to reduce the risks that they pose. Similar to commercial nursery stock, host plants should not be moved from infested to non-infested areas without being inspected and treated with an appropriate systemic insecticide. Likewise, non-host crops grown in proximity to host plants should be inspected and/or treated as a precaution if grown in an area known to be infested with vegetable leafminer, as there is a small risk that non-host crops could potentially spread adult leafminers as hitchhikers. Treatment of growing media using appropriate pesticides (eg Cyromazine-PER83506) may also be considered. Further information on chemical control is provided in Section 5.3.3.
Plant material including hay, plant debris and crop waste	Hay, plant debris and crop waste could potentially spread pupae and adults to new areas. Larvae are not expected to be able to survive long after plant debris begins to wilt and rot (once they cannot feed on the plant, the larvae must vacate the leaf to begin pupation or die), however pupae will survive in plant debris and crop waste. Adults may also hitchhike on hay, plant debris and crop waste.	Visual inspection for the presence of adults, larvae and pupae should be carried out. To reduce the potential risk of spread, plant material should not be moved from infested to non-infested areas without being treated with an appropriate insecticide. Further information on chemical control is provided in Section 5.3.3.
Soil	Larvae emerge from the leaf and pupate in the soil under host plants (Capinera 2014). Soil therefore poses a potential risk for moving the pest to new areas.	Minimise potential spread by reducing the spread of soil off infested sites (e.g. by cleaning down machinery between properties).
Tools, equipment,	Tools, equipment, and machinery	Clean tools, equipment and

RISK PATHWAY	DESCRIPTION	POTENTIAL DOMESTIC CONTROL MEASURES
and machinery	used on farm in the vicinity of host plants pose a low risk of spreading the pest, however, may transport pupae via soil deposits, or may transport adults.	machinery before moving off infested sites.
Transport vehicles	Vehicles in the vicinity of host plants could allow the pest to hitchhike (in cabins etc.) to new areas (DAWR 2016).	Clean vehicles before moving off infested sites.
Conveyances (includes crates, boxes, bins, pallets)	Crates, bins, pallets, etc. that are clean of soil are unlikely to spread leafminers.	As a precaution, clean conveyances before moving between sites to reduce any risk of spread.
Seed	There are no expected pathways for leafminer spread by the movement of seed.	Not applicable.
Fruit (without leaves)	There are no expected pathways for leafminer spread by the movement of fruit (without leaves). It is expected the process of harvesting and cleaning fruit will remove leaf and soil material that could spread larvae and pupae and would cause adults to disperse rather than hitchhike with fruit to new areas.	Not applicable.
Fresh leafy or green vegetables (including peas)	Mines can occur on leaves of a wide range of green vegetables. There is therefore a risk that leafminer eggs or larvae (and potentially pupae and hitchhiking adults) could be spread to a new area via the movement of infested leafy vegetables. Mines do not occur on fruiting structures, with the exception that *Liriomyza huidobrensis* can form mines in the pods of snow peas and disrupt market access (Gitonga et al. 2010). It is not clear if this risk extends to *Liriomyza sativae*, though there is photographic evidence of *L. sativae* mining in field pea pods (Cranshaw 2005).	Visual inspection for the presence of adults, larvae and pupae should be carried out. To reduce the potential risk of spread, plant material should not be moved from infested to non-infested areas without undertaking suitable treatments to reduce the risk of pest spread.

2.8.2 Predicting spread potential

Cesar Australia has created a model of the potential rate of area invasion by the vegetable leafminer at entry points across Australia, the results of which are summarised below (Figure 6). A copy of the relevant reports and/or published manuscripts are available from Hort Innovation or from Cesar Australia (http://cesaraustralia.com/contact-us/).

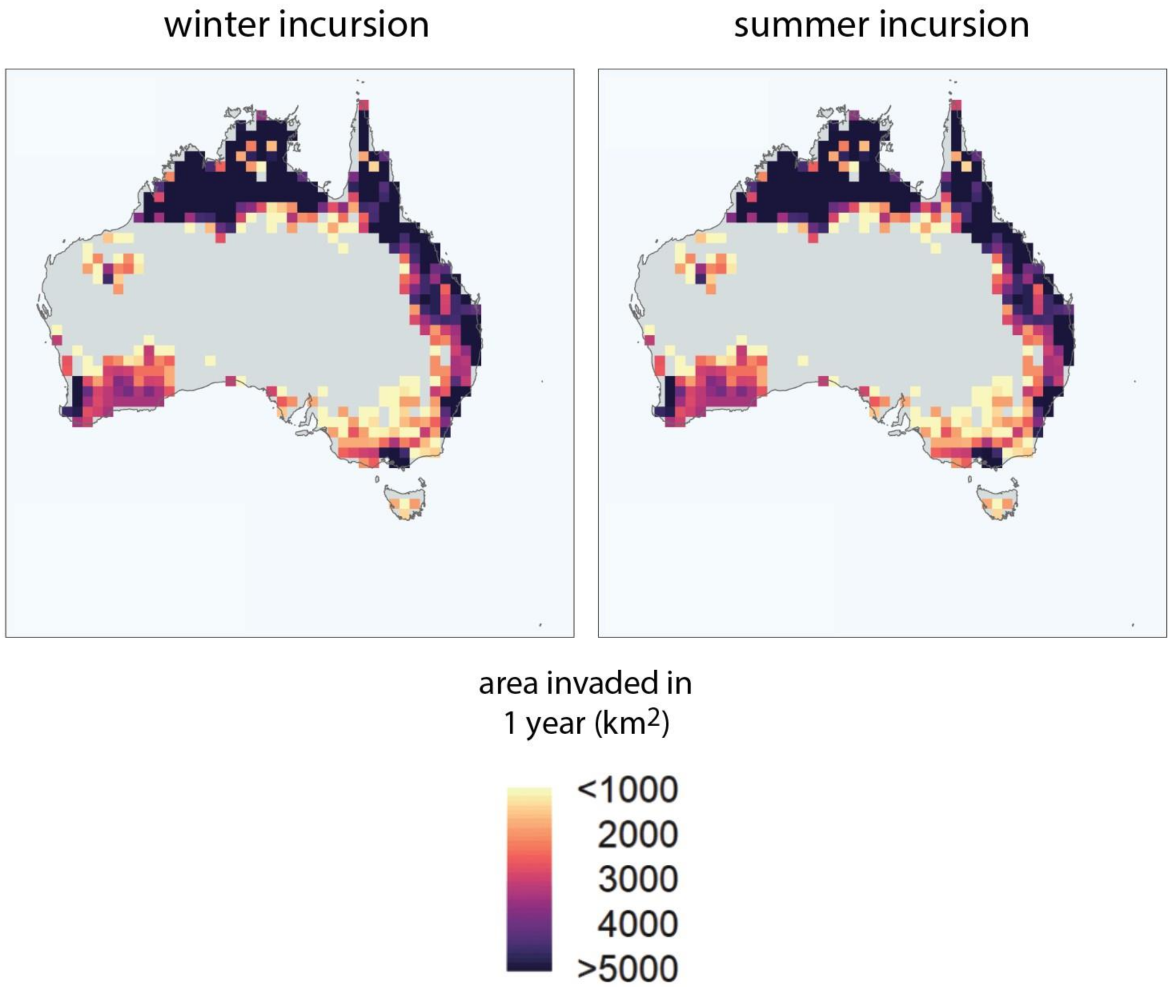

Figure 6 Rate of spread from locations across Australia. For each grid cell an incursion is simulated with the mean predicted area invaded by L. sativae in one year shown by the colour gradient. The mean predicted area is estimated from 10 replicated simulations. Incursions were commenced in July for a winter incursion and January for a summer incursion.

2.9 Risk of economic impact within Australia

Cesar Australia has created a model of the potential economic impacts of the vegetable leafminer in Australia, the results of which are summarised below (Table 4, Table 5 and Figure 4Figure 7). A copy of the relevant reports and/or published manuscripts are available from Hort Innovation or from Cesar Australia (http://cesaraustralia.com/contact-us/).

Table 4 Impact potential of Vegetable leafminer on affected commodities in terms of international collated reports of proportions crop value lost due to direct feeding damage.

Host crop	Proportion crop value lost			Sources
	Min	Max	Mean	
Beans	0.10	1.00	0.55	Mujica 2016
Capsicum	0.18	1.00	0.18	Wolfenbarger et al. 1963
Celery	1.00	1.00	1.00	Guzman et al 1979
Cucumber	0.30	1.00	0.30	Zhao and Kang 2000
Potatoes	0.10	1.00	0.43	Wolfenbarger et al. 1948; Mujica 2016
Tomatoes	0.02	1.00	0.23	Johnson et al. 1983; Wolfenbarger et al. 1966; Schuster 1977; Waterhouse and Norris 1987; Wyatt et al. 1984; Mujica 2016
Alfalfa	0.80	1.00	0.80	Spencer 1973
Eggplant	0.10	1.00	0.55	Mujica 2016
Musk melon	0.30	1.00	0.30	Zhao and Kang 2000
Okra	0.10	1.00	0.55	Mujica 2016
Peas	0.10	1.00	0.55	Mujica 2016
Squash	0.01	1.00	0.17	Sharma et al. 1980
Watermelon	0.30	1.00	0.65	Palumbo 2020; Zhao and Kang 2000

Table 5 Australia wide accumulated unmitigated impacts in millions of dollars after 3 years resulting from a spring (September) incursion of L. sativae *at key entry points across Australia. Simulations were replicated 10 times with means and standard deviations shown in parentheses. The proportion crop impact was fixed at 10% in order to explore variability due to incursion location and the size and distribution of different industries. Thus, host preferences of the pests do not influence the predicted crop impacts, and impacts of low preferences hosts may be overestimated while impacts of high preference hosts may be underestimated. Predictions were made using ESIM framework and are the culmination of the establishment, spread and impact modules (with each level of risk building upon the previous). For impacts calculated at state levels, see Appendix 4, Table 18 for additional information. All cells with a value of 0.00 represent unmitigated impacts less than $10,000.*

	Incursion location					
Crop	***Bundaberg***	***Darwin***	***Devonport***	***Melbourne***	***Perth***	***Sydney***
Beans	13.23 (0.44)	5.82 (1.36)	3.36 (1.80)	0.87 (0.42)	0.63 (1.35)	4.27 (1.17)
Broccoli	11.70 (1.02)	6.24 (1.73)	8.17 (2.00)	8.91 (0.22)	2.92 (0.73)	5.66 (1.90)
Brussels	1.86 (1.06)	0.41 (0.32)	1.52 (0.27)	1.28 (0.06)	0.03 (0.08)	0.67 (0.19)
Cabbages	6.53 (0.24)	3.94 (0.69)	2.69 (1.12)	1.59 (0.49)	0.92 (0.58)	4.59 (0.64)
Capsicum	5.76 (0.22)	1.02 (0.48)	2.61 (0.36)	0.81 (0.08)	0.90 (0.02)	0.94 (0.58)
Carrots	9.32 (0.56)	7.46 (2.52)	6.98 (2.54)	0.59 (0.48)	7.48 (1.13)	4.34 (0.96)
Cauliflowers	5.13 (0.55)	2.82 (0.78)	4.55 (0.99)	4.35 (0.14)	1.04 (0.27)	2.98 (0.88)
Flowers	31.46 (1.22)	17.69 (1.53)	21.14 (4.83)	16.83 (2.75)	5.18 (1.82)	25.52 (1.27)
Lettuces	16.37 (1.29)	8.08 (1.39)	11.32 (2.40)	10.83 (0.48)	3.73 (1.03)	8.11 (2.03)
Melons	4.90 (0.27)	1.68 (0.46)	0.20 (0.38)	0.02 (0.02)	1.14 (0.11)	0.31 (0.10)

	Incursion location					
Crop	***Bundaberg***	***Darwin***	***Devonport***	***Melbourne***	***Perth***	***Sydney***
Nurseries	73.02 (2.58)	39.89 (5.61)	36.68 (10.16)	30.38 (4.10)	14.43 (4.82)	43.98 (4.01)
Onions	5.77 (0.38)	3.83 (1.41)	6.13 (1.30)	0.48 (0.29)	2.77 (0.63)	2.40 (0.57)
Peas	0.82 (0.09)	0.17 (0.19)	1.22 (0.20)	0.39 (0.11)	0.01 (0.02)	0.27 (0.16)
Potatoes	10.59 (0.65)	4.18 (1.65)	12.43 (1.99)	3.76 (0.64)	3.34 (0.43)	4.50 (0.89)
Pumpkins	4.27 (0.19)	2.13 (0.59)	0.64 (0.60)	0.14 (0.16)	0.53 (0.43)	1.52 (0.42)
Tomatoes	19.40 (1.04)	3.98 (1.53)	4.97 (1.70)	5.16 (0.89)	0.40 (0.30)	5.10 (1.22)
Total	**220.12 (6.35)**	**109.34 (17.84)**	**124.60 (27.90)**	**86.40 (9.78)**	**45.45 (13.02)**	**115.19 (14.71)**

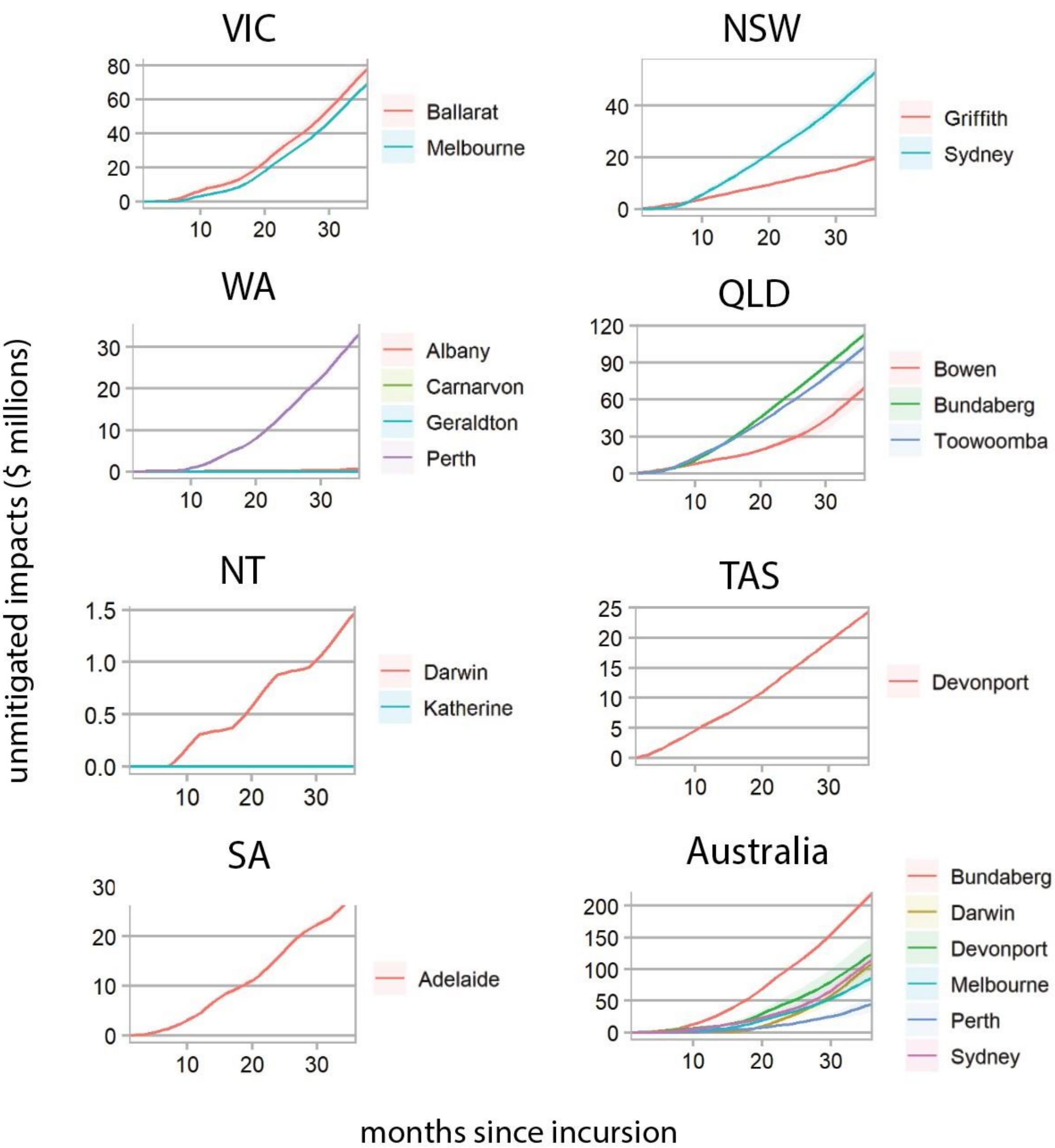

Figure 7 State level accumulating unmitigated impacts in millions of dollars across all host crops after 3 years resulting from a spring incursion of L. sativae at key entry and establishment points. For state level impact accumulation by crop type, see Appendix 4, Figure 11 for more information.

3. DIAGNOSTIC INFORMATION

Morphological diagnosis to a species level requires adult male flies. These can be collected by sweep netting, yellow sticky traps or collecting leaves with larvae in them and allowing the larvae to develop into adults. Alternatively, molecular tools can be used to identify larvae, pupae and adult flies.

An International Plant Protection Convention (IPPC) Diagnostic Protocol (IPPC 2016) and a European and Mediterranean Plant Protection Organization (EPPO) diagnostic protocol for *Liriomyza* spp. (EPPO 2005) are available and should be referred to for the diagnosis of suspected *Liriomyza* spp. It should be noted that these protocols do not include information on environmental DNA (eDNA). Additional information on the use of eDNA for *Liriomyza* spp. leafminer diagnosis can be found at Pirtle et al., *in press*.

An information portal for polyphagous agromyzid leafminer identification is available at https://keys.lucidcentral.org/keys/v3/leafminers/index.htm, which includes species-specific fact sheets, and a pictorial Lucid3 key that allows users to make a preliminary identification of pest agromyzids and to be able to distinguish these species from non-pest endemic agromyzids. A factsheet for *Liriomyza sativae* is accessible here: https://keys.lucidcentral.org/keys/v3/leafminers/key/Polyphagous%20Agromyzid%20Leafminers/Media/Html/Liriomyza_sativae.htm

3.1 Diagnostic considerations

Considerations when triaging samples of suspected vegetable leafminer for diagnostics include:

- One of the greatest challenges in detection and subsequent management of *Liriomyza* species overseas has been the difficulty in correctly identifying the species (Reitz et al., 2013), which can have considerable overlap in adult morphology, host range and damage symptoms left on a plant. In the presence of indigenous leafminer, it may be difficult to detect a new incursion, or determine the limits of an infestation (Powell 1981).
- There are also several difficult to distinguish Agromyzid species present within Australia that are morphologically indistinguishable from vegetable leafminer to a non-expert (including *L. brassicae* and *L. chenopodii*). This is also true for some Agromyzids that are exotic to Australia (including *L. trifolii* and *L. huidobrensis*). In many cases, specimens must be distinguished by expert taxonomists, or via molecular means.
- Within Australia, there at least 50 leafminer species (family Agromyzidae) (and presumably many more that have not yet been described) that create leaf mines that look similar to vegetable leafminer and may appear on the same host plants. Some of the most common include *Liriomyza brassicae* (which shares several brassica hosts with vegetable leafminer), *Liriomyza chenopodii* (which shares cultivated beets with vegetable leafminer), and *Phytomyza syngenesiae* (which shares cultivated asters with vegetable leafminer, but the adult form is readily distinguishable from vegetable leafminer) (Appendix 2). Moreover, there are an unknown number of additional Dipteran and Lepidopteran (Figure 10) species that share the leaf mining habit.
- Of these species that create similar leaf mining damage, some can be distinguished from vegetable leafminer via their mine characteristics, and their pupal or adult forms. (see Appendix 2, IPCC 2016, Salvo and Valladares 2004). However, the high degree of individual variation between each leaf mine means there can always be exceptions to these guidelines. For example, while vegetable leafminer pupate outside the leaf, there are rare instances where a larva will fail to emerge and complete pupation within the leaf mine.
- Due to the high degree of morphological overlap of adults and visual overlap of damage, sample collection (of flies of any life stage and/or leaf mines) will be paramount for identifying and delimiting potential vegetable leafminer incursions.

- Surveyors should be familiar with the vegetable leafminer host plant list (Appendix 1), as well as with commonly observed signs of indigenous leafminer damage and the extent of known overlap with indigenous Agromyzids for common host genera (Appendix 2) before conducting vegetable leafminer surveillance. For example, damage caused by the closely related *L. brassicae* is essentially indistinguishable from vegetable leafminer and is very common on brassica crops (Appendix 2). Crops such as tomato, cucumbers and melons, on the other hand, have little to no reported overlap with indigenous Agromyzids (Appendix 2). Mines detected on these crops during surveillance activities should be considered highly suspicious.
- Molecular techniques can be used for diagnostics of Liriomyza spp. IPPC 2016) and have the advantage of being able to be used on all life stages of the insect. If using molecular techniques, it is important that surveyors understand what material to collect and how to preserve specimens appropriately, refer to Section 4.2.2 for further information.

4. SURVEILLANCE AND COLLECTION OF SAMPLES

4.1 Surveillance

4.1.1 Technical information for planning surveys

Detection and delimiting surveys are required to determine the extent of outbreaks, ensure areas free of the pest retain market access, and ensure appropriate quarantine zones are established to contain outbreaks.

Initial surveillance priorities for vegetable leafminer should consider the following:

- Visual surveillance for the leaf mines created by vegetable leafminer is expected to be the most reliable way to detect new incursions. This is because the serpentine leaf mines created by leafminer larvae persist permanently on a leaf, extending the detection window beyond the lifespan of the fly itself. In comparison, sweep netting requires active populations, as do yellow sticky traps. While sticky traps can be left in place for extended periods to increase the chance of catching an adult, in open field settings, relying solely on sticky traps would be impractical due to the very large number of traps that would be needed to be placed and processed, to reach a statistically acceptable detection likelihood for small or isolated populations.
- In closed cropping systems, sticky traps become much more practical, but should still be accompanied by visual surveillance.
- Sticky traps will have a high level of bycatch (i.e. other insects will be caught in the trap), which can increase processing time for manual identification. However, molecular diagnostic methods are also available for bulk invertebrate samples collected via a sticky trap (see Section 4.2.2.2).
- When undertaking visual surveillance in plant crops, the serpentine leaf mines are the most conspicuous symptoms to look for, though stippling from oviposition and feeding may also be apparent.
- Mines are expected to be more common on the edges of fields and in the upper portions of the plant (Weintraub 2001).
- The vegetable leafminer has an extensive list of broad leaf weed hosts (see Section 2.3) and therefore surveillance in broadleaf weeds (such as siratro, castor bean, sow thistles, etc.) as well as cultivated crops should be conducted.
- Larvae, pupae and adults can be identified using molecular methods (refer to Section 3).
- Only adult male leafminers can be identified using morphological methods.
    - Adults can be captured using yellow sticky traps, sweep netting (IPPC 2016), or rearing from infested material. The latter is the most practical and reliable method for collecting adult flies. Infested leaves can be placed into an insectarium to develop into adults (IPPC 2016). Techniques for rearing Agromyzids are described in Griffiths (1962) and Fisher et al., (2005).
- Collectors should be made aware of common signs of leafminers and note symptomatic plants when conducting surveillance for vegetable leafminer.

- Australia is already home to several leaf miner species, both native and naturalised, which can be confused for vegetable leafminer. Surveyors should be made aware of the native and naturalized species they might expect to see in the particular region and crops they are surveying.
- Early detection surveillance will be most effective if timed when vegetable leafminer population growth potential is greatest. The seasonality of pea leafminer activity at major centers is provided in Table 6. A biophysical risk forecasting tool has been developed that allows users to explore changing vegetable leafminer growth potential and spread risk across the year at any location in Australia. The interactive version of this tool can be accessed here.

Table 6 Major Australian growing regions showing risk seasonality for L. sativae *activity across the year. Green means highest establishment risk (where the population growth potential was greater than 50% of the maximum predicted growth rate) yellow means lower establishment risk (where the population growth potential was between 1 and 50% of the maximum), and red means lowest establishment risk (where predicted growth rates are negative, meaning populations are predicted to decline).*

State	**Incursion point**	**Seasonality**											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Western Australia	Perth	Red	Red	Red	Green	Green	Green	Yellow	Yellow	Green	Green	Yellow	Red
	Geraldton	Red	Red	Red	Red	Red	Green	Yellow	Yellow	Green	Green	Red	Red
	Carnarvon	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red
	Bunbury	Red	Red	Green	Green	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green	Green
	Albany	Green	Green	Green	Green	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green
Victoria	Thorpdale	Green	Green	Green	Yellow	Red	Red	Red	Red	Red	Yellow	Green	Green
	Melbourne	Green	Green	Green	Green	Yellow	Red	Red	Red	Red	Green	Green	Green
	Ballarat	Green	Green	Green	Green	Yellow	Red	Red	Red	Red	Green	Green	Green
Tasmania	Smithton	Green	Green	Green	Yellow	Yellow	Red	Red	Red	Red	Yellow	Green	Green
	Devonport	Green	Green	Green	Yellow	Red	Red	Red	Red	Red	Yellow	Green	Green
South Australia	Mt. Gambier	Green	Green	Green	Green	Yellow	Red	Red	Red	Red	Yellow	Green	Green
	Loxton	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red
	Adelaide	Red	Red	Red	Red	Red	Red	Yellow	Yellow	Green	Green	Red	Red
Queensland	Toowoomba	Yellow	Red	Green	Green	Yellow	Yellow	Yellow	Yellow	Red	Yellow	Green	Green
	Bundaberg	Green	Red	Red	Green	Green	Yellow	Green	Green	Red	Green	Green	Green
	Bowen	Green	Yellow	Green	Green	Green	Green	Green	Green	Red	Red	Yellow	Red
	Atherton	Green	Green	Green	Green	Green	Yellow	Green	Green	Yellow	Yellow	Green	Yellow
Northern Territory	Katherine	Green	Yellow	Red	Yellow	Red	Green	Red	Red	Red	Red	Red	Red
	Darwin	Green	Green	Green	Green	Green	Green	Red	Red	Red	Red	Red	Red
New South Wales	Sydney	Red	Red	Green	Green	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Red	Red
	Griffith	Red	Red	Yellow	Green	Yellow	Red	Red	Red	Yellow	Green	Yellow	Red

Further information on factors to consider when conducting surveillance, including some information on trap placement in different crops, can be found in the "Early detection toolkit for surveillance of the vegetable leafminer (*Liriomyza sativae*)" a report prepared by Cesar Australia as part of the Horticulture Innovation funded project MT16004. A copy of the report is available by contacting Hort Innovation or from Cesar Australia (http://cesaraustralia.com/contact-us/).

4.1.1.1 Surveillance tools

Yellow sticky traps and sweep netting can be used as supplementary methods to visual searches during delimiting surveillance activities, particularly when suspicious damage has been observed, or for monitoring existing outbreaks.

- Sweep netting is expected to be most effective when employed near recently active leaf mines, and is less effective near old leaf mines (see Figure 8).

Figure 8. Younger mines (on the left) are more white-coloured with more distinct black trails of frass. Frass becomes less distinct as mines age, and mines develop a brown colour (right). Younger mines are expected to give the best sweep netting success. Images: Elia Pirtle, Cesar Australia *Pty Ltd*

- Agromyzid flies are attracted to the colour yellow (Chandler 1981, Affeldt et al., 1983, Yudin et al., 1987), and can therefore be captured on yellow sticky traps. Yellow sticky traps are more effective for *Liriomyza* adults than other types of traps, such as funnel traps and yellow water pans (Chavez and Raman 1987). Vacuum sampling has also been shown to be a less effective means of sampling adult leafminer (Weintraub 2001).
- A great deal of effort overseas has been dedicated to improving the effectiveness of yellow sticky traps for *Liriomyza* adults (Heinz et al 1992) including the modifications of size, shape, adhesives, lures, height and orientation. For example, several studies report a strong effect of trap height on the number and species trapped (Trumble and Nakakihara 1983, Zehnder and Trumble 1984a, Zoebisch and Schuster 1990), however these results do not always appear consistent and may be difficult to extrapolate across different crop types. Moreover, optimal height may vary considerably between *Liriomyza* species (Zehnder and Trumble 1984a). See the "Early detection toolkit for surveillance of the vegetable leafminer (*Liriomyza sativae*)" for more information. General guidelines are:
    - Traps should be placed (vertically oriented) at the edges of paddocks, preferably on the upwind side of paddocks, and near broadleaf weed reservoirs if possible.
    - Optimal trap height may vary with crop type, but generally speaking traps should be placed around canopy height.

  - Traps should be placed in the afternoon, and left for a minimum of 24 hours, to ensure traps are active during the peak flight time for vegetable leafminer, which occurs between 7:00am and 11:00am.
  - Traps may be left in place for up to one month, at which point they should be collected, to prevent excessive degradation of DNA and allow for molecular confirmation of vegetable leafminer caught on the trap. If traps are placed outdoors and exposed to the elements and/or high levels of bycatch they should be collected sooner than one month.
- Experimental lures developed from the extracted volatiles of known plant hosts have been shown to be attractive to vegetable leafminer in field trapping trials (e.g. Wei et al., 2005). Methyl salicylate has been shown to attract *Liriomyza bryoniae* when used on a yellow sticky trap (Būda and Radžiute 2008), while lures made from spruce, basil, juniper or clove oil have been shown to attract *L. huidobrensis* (Gorski 2005). See the "Early detection toolkit for surveillance of the vegetable leafminer (*Liriomyza sativae*)" for more information.

4.1.2 Delimiting surveys in the event of an incursion into new areas

Following a new detection of vegetable leafminer, the following guidelines are recommended for delimiting surveillance:

- Surveillance to delimit a detection of vegetable leafminer should take into account tracing information as outlined in Section 5.1 to determine potential pathways for movement of material from the site of the initial detection.
- Surveillance should be a combination of the following:
  - Visual inspection in high risk areas (e.g. areas with suitable hosts).
  - Sweep nets to collect adults around infested host plants.
  - Yellow sticky traps, particularly in closed cropping systems and near infested plants.
- Surveillance should be accompanied with awareness material, signs and personal visits to households and businesses within the surveillance zone and any buffer zones.

The suggested surveillance protocol for vegetable leafminer is as follows:

1. Delimiting surveillance should be conducted immediately upon detection of any incursions within a radius within 1 km of the incursion site, based on natural spread dynamics of agromyzid leafminer. The Surveillance zone may be increased as deemed necessary for the individual response.
2. At each site, choose a crop that is a preferred host plant of vegetable leafminer (refer to Section 2.3).
3. Choose a survey path that preferences the following areas if possible:
   - Paddocks and weeds near transport routes and unloading areas. These are preferred, because a major long-distance pathway of leafminer spread is human assisted movement.
   - Paddock edges should be included in the survey path, with the 'incoming wind side' preferred, as short distance movements of leafminer can be driven by wind.

- Weeds along paddocks should be included in the survey path (broadleaf weeds, but not grasses).

4. Leafminer damage may be patchy at low densities.
5. At low densities, leaf mines have a relatively low detectability, despite their characteristic appearance. Slower search speeds will improve detection likelihood, however, when time is limited, search speed trades off with the total area covered (reducing the number of possible encounters). This trade-off is important in realistic paddock monitoring scenarios.
   - *When time is not limited*: To achieve a detection probability of 20%, 50%, and 80% respectively, when leaf mine density is about 1% of plants affected, the mean (and 95% CI) search time required per metre is 11.2 (4.8, 20.5), 34.8 (15.0, 63.8), and 80.8 (34.9, 148.2) seconds spend 1 minute searching per 1 m^2 of area (based on data collected during vegetable leafminer survey effort trials).
   - *When time is limited*: The optimal search speed, balancing area coverage with sensitivity, when leaf mine density is about 1% of plants, is about 10 seconds per 1 m^2 of area. Further benefits are not achieved by increasing search speed beyond this level to achieve greater area coverage.
6. A survey plan should take into consideration any variables regarding the environment or surveyor that might reduce detectability and increase the effort spent accordingly. These variables might include:
   - *Plant type*
     i. *Leaf density:* leafminer damage may be harder to spot in plants that are very dense and leafy, than in plants with larger, sparser or flatter leaves.
     ii. *Plant age:* it may be easier to spot leaf mines in young plants with few leaves and more open space between plants than in larger mature, overlapping plants.
     iii. *Colour:* leafminer damage may be harder to spot against light coloured leaves than against darker leaves.
     iv. *Height*: Leafminer damage in plants that are at eye level may be easier to spot than crops that are low to the ground.
     v. *Time of day/direction of survey relative to the sun*: Survey success may be higher when surveyors are walking with their back to the sun, rather than walking into the sun.
   - *Residues on plants:* Chemical residue on plants may reduce the contrast between the mine and the leaf, or obscure mine patterns with background residue patterns.
   - *Damage from other pests/disease on plants:* damage caused by other pests or disease may obscure leaf mines, or lead to false positive detections.
   - *Surveyor experience:* Inexperienced surveyors may have a learning curve.
   - *Weather conditions:* Surveys during poor weather should be avoided when possible.
7. If suspicious damage is detected, samples should be collected (see Section 4.2), and yellow sticky traps should be placed around the affected area, in an attempt to capture adults and diagnose the fly responsible for the damage.
   a. If vegetable leafminer are confirmed, visual surveillance along with sticky traps should be used to monitor the edges of the outbreak zone.

8. If no suspicious damage is detected, the initial round of delimiting surveillance should be followed with a second round occurring after one week.
    a. This second round is necessary as leafminer eggs are undetectable in the leaf, and hatch after about 2-5 days. A crop that appears clean during the initial survey may still develop symptoms within a week.
    b. After the first revisit, any further revisits should occur on a monthly basis. One lifecycle of the vegetable leafminer is estimated to take 2 to 4 weeks.

4.1.3 Activities for general surveillance immediately following a detection

Given the wide host range of this pest and its noticeable impact it may be a suitable target for general surveillance programs that request submission of images and/or samples from the public.

To establish a general surveillance program, the following will be required:

- Use of online or app reporting tools such as MyPestGuide to promote the submission of reports of suspected detections.
- Factsheets to provide information on the pest, symptoms, impacts and reporting mechanisms.
- Media releases to describe the impact of the pest, surveillance programs and activities within the response program.
- Information for industry communication channels including articles for industry newsletters, magazines and websites, information for Twitter feeds and Facebook, and presentations for industry talks.
- A website to provide information for the public and for commercial businesses and links to other relevant sites.
- Release and promotion of information on details for physical sample collection and submission, as well as information on how to take and submit images of flies/leaf mines
- Broader awareness campaigns should consider literature (brochures and factsheets) in several languages.
- A non-expert friendly surveillance and sample collection guide for vegetable leafminer, as well as other useful information, can be found here.

4.2 Collection and treatment of samples

4.2.1 If collecting for morphological diagnosis

Of the four life stages (egg, larva, pupa and adult) only adult males are identifiable to a species level using morphological features.

4.2.1.1 Collection of adult male specimens

Adult flies can be collected with a vacuum sampler or sweep net. Adult flies are normally found on the foliage. However, the most practical and reliable method is the collection of leaves with mines containing pupae or mature larvae which can then be reared until adult flies emerge (refer to Section 4.2.1.3).

4.2.1.2 How to collect sticky traps for identification

Sticky traps should be left in the field for up to one month (but preferably 2 weeks or less), to allow morphological identifications. Upon collection, sticky traps should be folded lightly in half sticky side inwards (not pressed shut), and placed in a sealed, padded plastic bag. Traps should be sent within a week of collection (and kept in cool, dry place in the meantime, but not frozen).

4.2.1.3 How to collect plant samples for rearing

For rearing of adult flies, mined leaves containing pupae or mature larvae can be collected into an insectarium and kept in a constant-temperature room for regular checking. Simple insectariums include sealed partially inflated ziplock bags, or sealed rigid plastic containers or jars. A piece of paper towel should be placed into the insectarium along with the infested leaves to regulate humidity. Once pupae emerge from the leaves, they should be transferred carefully with a wet paintbrush to a new rigid container, which contains a layer of damp sand but no leaf material. Pupae can be placed directly onto the damp sand. Techniques for rearing Agromyzids are described in the IPCC diagnostic protocol for *Liriomyza* (IPPC 2016, available from here), in Griffiths (1962) and Fisher et al., (2005).

4.2.1.4 How to preserve plant samples for identification

Identifying the plant species affected by suspected vegetable leafminer damage can aid diagnoses, particularly when surveying in weeds. To preserve a plant for identification, leaves can be stored between sheets of dry newspaper. However, if plant material with suspected leaf mines is pressed and dried, there will be no chance of rearing out adult flies from those leaf mines. Therefore, whenever plant identity is in question, infested material should be stored in an insectarium for rearing, and an accompanying pressed sample of uninfested leaves should be taken to facilitate for identification of the host.

4.2.1.5 How to preserve leafminers

Adults caught in sweep nets or reared in insectariums can be placed in 70% ethanol and stored indefinitely for morphological purposes. For adults reared in insectariums, it is advised to collect these adults in the afternoon, as emergences tend to occur in the morning, and enough time should be given for wings to fully expand before collection.

4.2.1.6 How to transport leafminers

Vials of ethanol should be sealed to avoid leakage and packed with cushioning material in a strong box.

For information on what can or cannot be sent by post refer to the Australia Post website: https://auspost.com.au/content/dam/auspost_corp/media/documents/dangerous-and-prohibited-goods-guide.pdf.

4.2.1.7 How to transport plant samples

Plant samples may be collected if the host needs to be identified. Queensland Herbarium (2016) provides information on how to collect and preserve herbarium specimens. Samples should then be taken to state herbaria for identification.

For information on what can or cannot be sent by post refer to the Australia Post website: https://auspost.com.au/content/dam/auspost_corp/media/documents/dangerous-and-prohibited-goods-guide.pdf.

4.2.2 If collecting for molecular diagnosis

All life stages can potentially be diagnosed using molecular methods, including empty leaf mines.

4.2.2.1 Collection of specimens

Adult flies can be collected with a vacuum sampler or sweep net. Adult flies are normally found on the foliage. However, as other life stages can be diagnosed using molecular methods, leaves with mines containing pupae or mature larvae should also be collected for analysis. Rearing these life stages in an insectarium is not necessary.

4.2.2.2 How to collect sticky traps

Upon collection, sticky traps should be either:

- Placed inside a plastic sleeve that has been cut along one long side and along the bottom, the trap and sleeve can then be sealed in a plastic zip lock bag.
- Folded in half, sticky side inwards, and placed in a sealed plastic bag.

Traps should be sent within a week of collection (and kept in a cool, dry place in the meantime, but never frozen).

4.2.2.3 How to collect plant samples

Plant samples with suspected vegetable leafminer damage should be collected for molecular confirmation. If it is possible to discern a live larvae inside a leaf mine (which can be spotted through the leaf mine as a small yellow maggot, either by eye or with a hand lens, see Figure 9), these samples are always preferable. However, mined leaves that appear empty can also be collected. At least three samples should be collected to provide a 90% probability of detecting trace DNA that is present (assuming three technical qPCR test replicates are conducted, and the mines were stored into 100% ethanol immediately after collection) (Pirtle et al *in press*). Empty mine samples that look youngest should be preferred, as they have the greatest chance of containing a live larva, however DNA can successfully be extracted even from mines that are up to one month old (See Figure 8).

Figure 9. A larva inside a leaf mine. Larvae are visible to the eye in later stages of development. Images: Elia Pirtle, Cesar Australia *Pty Ltd*

4.2.2.4 How to preserve plant samples

Mined leaves containing pupae, mature larvae, or mined leaves that appear empty can all be placed straight into 100% Ethanol. Small mined leaves should be rolled and placed into the tube of absolute ethanol. For larger leaves, the mine should be cut out, with care taken to avoid cutting across the mine, and the cut out should be rolled and placed into the tube of absolute ethanol. These samples should be frozen and mailed within a week of collection.

Due to the very small amounts of DNA within leaf mines, the odds of sample contamination is much higher than when working with whole flies. Careful hygiene must be employed when collecting and preserving suspicious leaf mine samples. Mines from different host plants or different locations should never be stored in the same container. Samples should either be immediately preserved into on site, or should be placed into unused, clean, sealed plastic bags on site and preserved within the day. If samples from multiple hosts or sites are being processed together at a field lab location, all equipment must be sterilised between each host/location (i.e. cleaning counter tops, sterilizing tweezers and other tools).

Leaf mines may also be preserved onto FTA cards, however DNA quality is somewhat lower than for preservation into 100% ethanol (Pirtle et al *in press*). To preserve leaf mines onto FTA cards, remove the mined leaf from plant and push the leaf mine face down onto the FTA card. Smear the mine thoroughly on the FTA card, for about 30 seconds, and then close the card and place in small sealed plastic bag. Do not rub mines from different host plants/sites onto the same FTA card, and do not store FTA cards from different host plants/sites in the same sealed bag. Store the FTA cards in a cool, dark, dry place and send for analysis within a week of collection

4.2.2.5 How to preserve leafminers

Specimens required for molecular diagnostic work, including larvae, pupae or adults, should be killed and preserved in absolute ethanol, frozen at -80°C, or preserved on an FTA card.

4.2.2.6 How to transport leafminers and plant samples

Vials of ethanol should be sealed to avoid leakage and packed with cushioning material in a strong box.

For information on what can or cannot be sent by post refer to the Australia Post website: https://auspost.com.au/content/dam/auspost_corp/media/documents/dangerous-and-prohibited-goods-guide.pdf.

5. IMMEDIATE RESPONSE TO DETECTION

5.1 Tracing

Detection and delimiting surveys are required to delimit the extent of the outbreak, ensure areas free of the pest retain market access, and ensure that appropriate quarantine zones are established.

Extensive tracing (trace forward and trace back) may be feasible as *Liriomyza* spp. can be readily dispersed by the movement of infested plant material, soil and crop debris. The focus should be on high risk linkages including premises linked directly with the initial detection, particularly where movements of plant material (such as nursery plants and seedlings), or soil have occurred as these pathways may move vegetable leafminers over long distances.

Further information on possible risk pathways are presented in Section 0 and in Table 3.

5.2 Quarantine and movement controls

If Restricted or Quarantine Areas are practical, no plant material should be moved from the infested to non-infested areas without first being inspected and appropriately treated. The size of the Restricted or Quarantine Area will be dependent on the type and scale of the incursion. However, a zone 1 km in radius should be considered for initial delimiting surveillance activities Section 4.1.2). This zone can then be expanded as needed depending on the specific situation.

Voluntary movement control should be considered for urban/residential detections. Voluntary controls would involve negotiation with residents to undertake inspection and treatment of goods prior to movement from infested areas. Residents should be advised on measures to minimise the inadvertent transport of the pest from the infested area to non-infested areas. Voluntary compliance is likely to be implemented for urban areas using awareness campaigns to highlight high risk goods/situations and appropriate treatments.

5.3 Destruction strategy

5.3.1 Priorities and considerations

If eradication of an outbreak is considered feasible, the priority will involve the destruction of the pest. Adult leafminers may be present around host plants; eggs, larvae and pupae may be present in the leaves of host plants, and pupae may be present within the first 5 cm of soil under host plants.

Considerations include:

- The infested plants may need to be sprayed with a suitable insecticide (refer to Section 5.3.3), then bagged and then buried (or tilled/ploughed directly into the soil if a large area is affected).
- Other host plants in the immediate area should be inspected and treated as needed.
- Soil and plant media in greenhouses should be treated (heat or chemically) to destroy any pupae that may be present in the soil.
- Machinery and equipment used on site may need to be washed down to minimise the potential risk of spreading the pest between sites.

5.3.2 Decontamination of tools and equipment

Machinery, equipment, tools and clothes should be cleaned and disinfected between sites to minimise the potential to spread vegetable leafminer, and other pests and diseases that may be present on the site, to new areas.

For points to consider when decontaminating, refer to the PLANTPLAN Guideline document:

Disinfection and Decontamination (PHA, 2015[3]). which includes guidelines for the destruction and decontamination of tools used when working with emergency plant pests.

Several state agriculture departments have also produced publications on cleaning down machinery and vehicles and should be referred to if decontamination is required, examples include:

- www.dpi.nsw.gov.au/_data/assets/pdf_file/0010/545554/procedure-decontamination-vehicles-and-equipment.pdf.
- www.daf.qld.gov.au/__data/assets/pdf_file/0011/58178/cleandown-procedures.pdf.
- http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/weeds/weedstop-vehicle-hygiene-program/machinery-hygiene.

5.3.3 Chemical control

Overseas, *Liriomyza* leafminers are most damaging when parasitoids are removed due to the use of non-selective insecticides (Cesar Australia 2018a; Murphy and LaSalle 1999). For the ongoing management of leafminers it will therefore be important that chemicals are selected that are reasonably selective and have low toxicity towards key parasitoids.

EPPO (2009) provides guidance on how to manage and eradicate vegetable leafminer infestations in Europe. The EPPO recommends that foliar sprays are applied at weekly intervals until control has been achieved. Importantly they suggest rotating chemicals and modes of action (where possible) each treatment (Table 7). In greenhouse environments the use of a suitable space treatment is also suggested (EPPO 2009). Based on this, it would be ideal if pesticides from different mode of action groups are available for each host crop, as this would allow pesticides to be rotated rather than relying on a single product being continuously used to manage/treat the pest.

[3] www.planthealthaustralia.com.au/biosecurity/incursion-management/plantplan/

Table 7. An ideal chemical rotation schedule used for eradication of Liriomyza leafminers in Europe (refer to EPPO 2009)

WEEK	PESTICIDE USED TO TREAT INFESTED AREA
Week 1	Chemical A
Week 2	Chemical B
Week 3	Chemical C
Week 4 onwards	Repeat above sequence

In 2017-18 Cesar Australia carried out a literature review on the chemical control of vegetable leafminer considering pesticides based on their efficacy and their impact on Integrated Pest Management (IPM) systems (Cesar Australia 2018b). A copy of the report is available by contacting Hort Innovation or from Cesar Australia (http://cesaraustralia.com/contact-us/).

The report notes that vegetable leafminer populations in Indonesia and Vietnam have developed resistance to synthetic pyrethroids. The report also identified several potential pesticides that would fit in with IPM systems (i.e. are not too damaging to biocontrol organisms) and are effective at controlling the pest overseas.

APVMA permits have been applied for a variety of pesticides based on the literature review's findings and considering the similarity of overseas and Australian use patterns with respect to rate, application methods, etc. Table 8 provides a summary of the permits that have been granted to date and also notes mode of action, and leafminer life stages targeted by the pesticide.

As the vegetable leafminer can affect many plant species (including agricultural and ornamental species) (refer to Section 2.3), it is important that all potential hosts are covered by at least one, but preferably multiple, pesticide permits. Appendix 3 provides a summary of the pesticides that can be used on each crop type and host and should be used as a guide when treating new vegetable leafminer outbreaks, or if eradication is unsuccessful, managing the pest. As permits are approved, they will be available from the APVMA permit database: https://portal.apvma.gov.au/permits or by contacting the APVMA directly.

Table 8. Insecticide permits that have been applied for or granted by the APVMA for the control of vegetable leafminer in Australia (as of July 2020)

CHEMICAL	CHEMICAL ACTIVITY	LIFECYCLE STAGES CONTROLLED	CROPS COVERED[4]	PROPOSED RATE	PERMIT NUMBER	EXPIRATION DATE
Abamectin (Mode of Action (MOA) 6)	Contact and translaminar activity	Very effective against adults and larval stages. All larval stages appear susceptible (Cesar Australia 2018b). There are also some reports of ovicidal activity against the related *L. trifolii* (Saryazdi et al., 2012) and *L. huidobrensis* (Mujica et al., 1999).	Fruiting vegetables-cucurbits	600-1,200 ml/ha (suppression only)	PER81876	30/4/2024
			Fruiting vegetables – other than cucurbits (excluding sweet corn and mushroom)	600-1,200 ml/ha (suppression only)		
			Leafy vegetables (except lettuce)	600-1,200 ml/ha (suppression only)		
			Legume vegetables	600-1,200 ml/ha (suppression only)		
			Root and tuber vegetables	600-1,200 ml/ha (suppression only)		
			Bulb onions	600-1,200 ml/ha (suppression only)		
			Cabbage	600-1,200 ml/ha (suppression only)		
			Celery	600-1,200 ml/ha (suppression only)		
			Rhubarb[5]	600-1,200 ml/ha (suppression only)		
			Bulb vegetables except onions (including leeks, spring onion)	600 ml/ha (suppression only)		

[4] Refer to Appendix 4 for detailed information on chemical control options.
[5] Note: Rhubarb is not a recorded host for vegetable leafminer but may be a host of other exotic *Liriomyza* spp. and is part of the 'Stalk and Stem Vegetable Crop Group' that the permit covers.

CHEMICAL	CHEMICAL ACTIVITY	LIFECYCLE STAGES CONTROLLED	CROPS COVERED[4]	PROPOSED RATE	PERMIT NUMBER	EXPIRATION DATE
Cyromazine (MOA 17)	Contact and translaminar activity	Not effective against adults but being an insect growth regulator is very effective against larval stages (Cesar Australia 2018b). Experiments on the related *L. trifolii* found that Cyromazine was very effective against first and second instar but less effective against late instar larvae (Yathom et al., 1986).	Nursery stock (non-food)	333 g in 20 L water/10 tonne potting mix	PER83506	31/10/2022
			Fruit trees (non-bearing)	950 g/ha or 95 g/100 L applied in 1,000 L/ha.		
			Broccoli	1 kg/ha or 150g/100L water	PER81867	30/11/2023
			Fruiting vegetables – cucurbits			
			Fruiting vegetables – other than cucurbits (excluding mushrooms and corn)			
			Head lettuce			
			Legume vegetables			
			Root and tuber vegetables			
			Stalk and stem vegetables			
			Brassicas (excluding broccoli) **Note: this crop must be destroyed if treated and must not be made available for human consumption**			

CHEMICAL	CHEMICAL ACTIVITY	LIFECYCLE STAGES CONTROLLED	CROPS COVERED[4]	PROPOSED RATE	PERMIT NUMBER	EXPIRATION DATE
Cyromazine (MOA 17)	Contact and translaminar activity	Not effective against adults but being an insect growth regulator is very effective against larval stages (Cesar Australia 2018b). Experiments on the related *L. trifolii* found that Cyromazine was very effective against first and second instar but less effective against late instar larvae (Yathom et al., 1986).	Leafy vegetables (excluding head lettuce) **Note: this crop must be destroyed if treated and must not be made available for human consumption**	1 kg/ha or 150g/100L water	PER81867	30/11/2023
Dimethoate (MOA 1B)	Contact and systemic activity	Dimethoate is reported to control *Liriomyza* spp. adults and larvae however resistance is known overseas (Tran and Takagi 2005)	Pulse crop (grains)	75ml (400 g a.i/L products)/100L water	PER89184	31/3/2025
Emamectin benzoate (MOA 6)	Contact and translaminar activity	Same mode of action as abamectin. Reported efficacy against larvae, adults and eggs (**cesar** 2018b)	Brassica vegetables (including broccoli, Brussels sprouts, cabbage, cauliflower)	250 to 300 g/ha (44 g a.i/kg products); or 650 to 780 mL/ha (17 g a.i/L products) (suppression only)	PER87563	30/6/2024

CHEMICAL	CHEMICAL ACTIVITY	LIFECYCLE STAGES CONTROLLED	CROPS COVERED[4]	PROPOSED RATE	PERMIT NUMBER	EXPIRATION DATE
Spinetoram (MOA 5)	Contact, systemic and translaminar activity	Spinetoram has shown efficacy against vegetable leafminer adults and larvae (Shimokawatoko et al., 2012)	Vegetable legumes (peas and beans)	400 ml (48 g a.i)/ha	PER87878	28/2/2023
Spirotetramat (MOA 23)	Contact, systemic and translaminar activity	Affects the development of larvae and has little impact on adults (Ring 2019)	Capsicum	400ml (96 g a.i)/ha	PER88640	31/5/2023
			Celery			
			Chili			
			Eggplant			
			Green beans			
			Lettuce (head and leafy)			
			Parsley			
			Rhubarb			
			Snow & sugar snap peas			
			Tomato			

Research undertaken as part of the Hort Innovation project MT16004 has identified the suitability of the following as potential control options for *Liriomyza* spp.:

- Azadirachtin (a systemic insecticide that acts as an insect growth regulator, MOA unknown) on ornamental and floriculture plants.
- Cyantraniliprole (a systemic insecticide, MOA 28) on bulb vegetables, fruiting vegetables, cucurbits, melons, and potatoes (note residue data will be required to support this use pattern).
- Diazinon (a contact insecticide, MOA 1B) on beans, melons, beetroot, lettuce, parsnips, tomatoes, and potatoes. Note can have significant impact on beneficial insects meaning it would likely be more suited to use in eradication programs than ongoing management of the pest.
- Dimethoate (a systemic insecticide, MOA 1B) on green beans, peas, tomatoes, capsicums, and potatoes. Note can have significant impact on beneficial insects and not fit well with IPM systems.
- Emamectin Benzoate (an insecticide with contact and translaminar activity, MOA 6) on brassicas, leafy vegetables, fruiting vegetables, cucurbits, and melons
- Indoxocarb (an insecticide with contact and some translaminar activity, MOA 22A) on tomatoes.

- Permethrin (an insecticide with contact activity, MOA 3A) on tomatoes. Note can have significant impact on beneficial insects meaning it would likely be more suited to use in eradication programs than ongoing management of the pest.
- Pyrethrins (an insecticide with contact activity but very limited residual activity, MOA 3A) on brassicas, leafy vegetables, lettuce, fruiting vegetables, and legume vegetables.
- Spinetoram (an insecticide with contact, systemic and translaminar activity, MOA 5) on cotton.

Permits for these use patterns have not been applied to date. However, in the event of an incursion, emergency permits for these use patterns could be developed.

5.3.4 Physical control options

Destruction of host plants and deep ploughing of crop residues can assist with leafminer control as adult leafminers have difficulty emerging from pupae buried deeply in soil.

Removal of weed and volunteer hosts of the leafminer and planting susceptible crops away from weed hosts can also assist with the ongoing management of the pest by removing potential leafminer reservoirs.

5.3.5 Biological control

Although not specifically for eradication, biological controls will assist in lowering leafminer populations and will be an important part of the management of vegetable leafminer should eradication not be possible in the event of an outbreak.

Parasitoids often provide effective suppression of leafminers in the field when non-selective insecticides are not used (Ridland et al., 2020). History has also shown that invading *Liriomyza* populations are rapidly exploited by endemic Agromyzid parasitoids (Ridland et al., 2020). For these reasons it will be important that any pesticides used for the ongoing management of leafminers are compatible with Integrated Pest Management (IPM) systems.

Seventy-one parasitoid species have been recorded from vegetable leafminer (Ridland et al., 2020). Agromyzid parasitoids tend not to be very host-specific and Australia already has several endemic species that would likely be effective against the vegetable leafminer. *Diglyphus isaea* is one such parasitoid that occurs in Australia and is one of two parasitoids (the other being *Dacnusa sibirica*) that are mass reared overseas for the biological control of *Liriomyza* species (Ridland et al., 2020).

The importation of biological control agents is not warranted at this time as the adventive parasitoids such as *D. isaea*, already occur in Australia and would likely be suitable for the management of leafminers assuming pesticides are selected appropriately and are compatible with IPM systems.

5.4 Decision support for eradication

A summary of key activities associated with different scenarios associated with a detection of vegetable leafminer is provided in Table 9. Differing physical detection scenarios have been chosen to highlight operational differences in urban environments compared with agricultural and horticultural environments.

A summary of factors to be considered for eradication or alternative action is provided in Table 10.

Table 9. Recommended responses and considerations for differing scenarios of detection of vegetable leafminer

DETECTION SCENARIO	RECOMMENDED ERADICATION/ CONTROL TREATMENTS – SEE SECTION 5.3	RECOMMENDED MOVEMENT CONTROLS – SEE SECTION 5.2	RECOMMENDED SURVEILLANCE OPTIONS – SEE SECTION 4
Commercial glasshouse/ protected cropping setting	➢ Destruction of hosts within glasshouses could be considered to limit food sources or refuges (see Section 5.3.4). ➢ Chemical sprays to eradicate larvae and adults (see Section 5.3.3). ➢ Surveillance within 1 km radius of the detection and in glasshouses managed by the same business as the infested glasshouse (use visual inspections, sweep netting and yellow sticky traps for surveillance).	➢ No movement of equipment or produce without permit. ➢ Permits to include information on inspection, decontamination or destruction requirements.	➢ Minimum 1 km surveillance zone around the Infected Premises (IP). ➢ Focus on known hosts. ➢ Surveillance at linked properties. ➢ See Section 4 for points to consider when establishing a surveillance program. Key points for glasshouses are: • Undertake visual surveillance of all host plants. • Consider using visual surveys, sweep nets and yellow sticky traps.
Open agricultural/ horticultural setting	➢ Spray infested area using appropriate insecticide (see Section 5.3.3). ➢ Surveillance within 1 km radius of the detection and survey jointly managed properties (use visual inspections, sweep netting and yellow sticky traps for surveillance).	➢ No movement of equipment or produce without permit. ➢ Permits to include information on inspection, decontamination or destruction requirements.	➢ Minimum 1 km surveillance zone around each IP. ➢ Yellow sticky traps, visual inspections and sweep netting should be undertaken in the 1 km zone. ➢ General surveillance awareness campaigns may be beneficial. ➢ Surveillance at linked properties should occur.

DETECTION SCENARIO	RECOMMENDED ERADICATION/ CONTROL TREATMENTS – SEE SECTION 5.3	RECOMMENDED MOVEMENT CONTROLS – SEE SECTION 5.2	RECOMMENDED SURVEILLANCE OPTIONS – SEE SECTION 4
Urban environment	➢ Chemical sprays to eradicate larvae and adults. ➢ Surveillance within 1 km radius of the detection (use visual inspections, sweep netting and yellow sticky traps for surveillance).	➢ Movement controls in infested areas could be undertaken by permit or as voluntary movement controls (coupled with awareness campaign for urban areas).	➢ Surveillance on host plants within 1 km zone around IP (noting leaf mines, feeding and oviposition punctures are the most easily seen plant symptoms). ➢ Surveillance to be undertaken in conjunction with awareness campaigns for households providing information on the pest and symptoms. ➢ Yellow sticky traps, visual inspections and sweep netting should be undertaken in the 1 km zone. ➢ Surveillance at linked properties.
Open natural environment (e.g. detection on roadsides or national park)	➢ Treatment of detections in a 1 km zone pending delimiting surveillance. ➢ Surveillance within 1 km radius of the detection (use visual inspections, sweep netting and yellow sticky traps for surveillance).	➢ Movement controls on plant material from infested areas could be undertaken by permit or as voluntary movement controls. ➢ Movement restrictions may be considered pending outcomes of delimiting surveillance.	➢ Surveillance on host plants within 1 km zone around IP (noting leaf mines, feeding and oviposition punctures are the most easily seen plant symptoms). ➢ Yellow sticky traps, visual inspections and sweep netting should be undertaken in the 1 km zone. ➢ General surveillance and awareness campaigns should be considered. ➢ Surveillance should be undertaken at linked properties.

Table 10. Summary of factors to be considered in determining whether eradication or alternative action will be taken for an incursion of a vegetable leafminer

FACTORS TO CONSIDER REGARDING THE TECHNICAL FEASIBILITY OF ERADICATION
• **The population size and population structure associated with the initial detection.** • **The cost effectiveness of recommended control technique options.** - Multiple applications of several different pesticides over a period of time (weeks/months) may be required to successfully eradicate vegetable leafminer populations. • **The ability to remove or destroy all vegetable leafminer by the recommended control techniques.** - Permission to enter private premises for surveillance and treatment must be considered. - Determination of whether treatments can effectively eradicate populations within premises or environments. • **The recommended control techniques are publicly acceptable.** - Chemical treatments in residences or backyards may not be acceptable or will require negotiation with residents. • **Whether emergency containment measures can effectively be put in place to contain the outbreak.** • **Whether there are control methods, commonly employed for endemic pests, that may prevent the establishment of, or be impacted by the treatment, for vegetable leafminer.** • **Legislative impediments to undertaking an eradication response.** - If not a prescribed pest, confirmatory diagnosis will be required under legislation in some jurisdictions before powers to enter premises and undertake treatments can be enacted. - Delimiting surveillance in urban environments may be restricted to front yards and environs rather than entry into premises (unless permission from the resident can be negotiated). - Emergency permits will be required for chemical treatments. Amendments to chemical labels will be required for longer term management of the pest if eradication is not possible. • **The ability to delimit the known area of infestation.** - Determination of linked properties in an urban detection may be unfeasible given the ability of adult leafminers to disperse at a local level. High risk linkages such as the recent purchase of seedlings, cut flowers or other commodities that could vector the pest should be investigated. • **The ability to identify and close the pathway for entry of the pest into Australia or from Cape York Peninsula into southern production areas of Australia.** - Pathways into Australia such as on nursery plants from overseas are managed via Post Entry Quarantine. - Natural dispersal is a possible pathway from neighbouring countries into northern Australia. Northern Australia Quarantine Strategy (NAQS) surveys offer an early detection mechanism to detect natural introductions from the north. If an outbreak is detected, the pathway will need to be identified and closed, where possible. - Pathways into southern production areas are regulated. For example, the Coen Information and Inspection Centre asks that fruit and plant material be surrendered to reduce the risk of pests moving south from Coen. - If an outbreak occurs south of Cape York Peninsula, it could be due to the existing population moving south or it could be due to a new incursion from overseas. In both cases the pathway will need to be identified and closed. • **The dispersal ability of the pest.** - Vegetable leafminer has the ability to naturally spread over short distances through flight or wind assisted dispersal. - Nursery material that is a host of vegetable leafminer (including containerised plants, seedlings, bare rooted plants, etc.; see Appendix 1 for host list) and cut flowers that are host plants are the most likely means of spread to new areas. They may carry all life stages of the

pest and will need to be managed to reduce the spread of the pest to new areas. Nursery material and cut flowers that are not a host of vegetable leafminer are at significantly lower risk (but may still transport adults across short periods if they have been in close proximity with host plants).

- Plant material (potentially including fresh hay and crop debris) and soil could also facilitate the spread of the pest (via adults and pupae) to new areas. Tools, equipment, machinery and vehicles are lower risk but may still transport hitchhiking adults or pupae via soil deposits.
- Vegetable leafminer is considered unlikely to travel with harvested fruit (without leaves) as the process of harvesting or moving produce is likely to cause adults to disperse and, provided soil and leaf material is absent, it is unlikely to spread larvae and pupae. Leafminer are also not expected to travel via the movement of seed.
- Fresh green or leafy vegetables or fresh legume vegetables (e.g. snow peas) may allow the spread of eggs and larvae and potentially adults and pupae. Therefore, movement restrictions or mandatory treatments may be needed for some vegetable crops.
- See Table 3 for further details on possible dispersal pathways.

- **The capability to detect vegetable leafminer at very low densities for the purpose of declaring freedom, and that all sites affected by the pest have or can be found.**
  - Experimental lures for vegetable leafminer exist (see Section 4.1.1.1). However, surveillance typically relies on the use of yellow sticky traps as well as sweep netting and visual inspection of host plants for mining activity.
- **The ability to put into place surveillance to confirm proof of freedom.**
  - Surveillance options are available for vegetable leafminer and include visual inspection of host plants for mines, yellow sticky traps and sweep netting.
- **Whether community consultation activities have or will be undertaken.**
  - In an urban environment, community consultation will be critical to assist in securing public support for delimiting surveillance and an eradication program.
  - Given the symptoms caused by this pest on a wide range of plants, general surveillance activities should be implemented comprising of awareness material, media releases, web-based reporting tools and the Exotic Plant Pest Hotline (1800 084 881).

6. EMERGENCY PLANT PEST RESPONSE DEED AND PLANTPLAN

The Emergency Plant Pest Response Deed (EPPRD) and PLANTPLAN should be referred to, in conjunction with this contingency plan when developing a Response Plan in the event of a vegetable leafminer detection outside its current range.

6.1 Emergency Plant Pest Response Deed

PHA is the custodian of the EPPRD. This is a formal legally binding agreement between PHA, the Australian Government, all state and territory governments and national plant industry body signatories.

It covers the management and funding of responses to Emergency Plant Pest (EPP) incidents, including the potential for Owner Reimbursement Costs for growers. It also formalises the role of plant industries' participation in decision making, as well as their contribution towards the costs related to approved responses.

Under the EPPRD an EPP is defined as a pest that meets one or more of the following criteria:

a) It is a known exotic Plant Pest the economic consequences of an occurrence of which would be economically or otherwise harmful for Australia, and for which it is considered to be in the regional and national interest to be free of the Plant Pest.
b) It is a variant form of an established Plant Pest which can be distinguished by appropriate investigative and diagnostic methods and which, if established in Australia, would have a regional and national impact.
c) It is a serious Plant Pest of unknown or uncertain origin which may, on the evidence available at the time, be an entirely new Plant Pest or one not listed in Schedule 13 and which if established in Australia is considered likely to have an adverse economic impact regionally and nationally.
d) It is a Plant Pest already found in Australia that:
   (i) is restricted to a defined area through the use of regulatory measures intended to prevent further spread of the pest out of the defined area or into an endangered area; and
   (ii) has been detected outside the defined area; and
   (iii) is not a native of Australia; and
   (iv) is not the subject of any instrument for management which is agreed to be effective risk mitigation and management at a national level; and
   (v) is considered likely to have an adverse economic impact such that an emergency response is required to prevent an incident of regional and national importance.

See: www.planthealthaustralia.com.au/biosecurity/emergency-plant-pest-response-deed/ for more information and the most recent version of the EPPRD.

6.2 PLANTPLAN

Underpinning the EPPRD is PLANTPLAN, the agreed technical response plan for an EPP incident. It provides nationally consistent guidelines for response procedures, outlining the phases of an incursion, as well as the key roles and responsibilities of industry and government during each of the phases.

See: www.planthealthaustralia.com.au/biosecurity/emergency-plant-pest-response-deed/ for more information and the most recent version of PLANTPLAN.

7. REFERENCES

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Addendum:

Gitonga ZM, Chabi-Olaye A, Mithöfer D, Okello JJ & Ritho CN. 2010. Control of invasive *Liriomyza* leafminer species and compliance with food safety standards by small scale snow pea farmers in Kenya. *Crop Protection* 298: 1472-1477.

8. APPENDICES

Appendix 1: Known hosts of vegetable leafminer

The vegetable leafminer (*Liriomyza sativae)* is highly polyphagous, with a wide host range across at least 15 families (Table 11). In order to facilitate trade and market access decisions, a thorough review was conducted as part of the Horticulture Innovation Australia funded Project MT16004 (R&E program for control, eradication and preparedness for vegetable leafminer), with a focus on evidence for lifecycle completion in the field. The results of this review, including commercial, ornamental and non-cultivated hosts of the vegetable leafminer (*L. sativae*), are presented in Table 12, Table 13, and Table 14 below. No guarantee can be made that these lists are exhaustive. Each record was scrutinized based on evidence provided showing completion of lifecycle within the field, and then included within the appropriate table. It is important to note that non-cultivated plants often serve as important reservoirs for *Liriomyza* pests (e.g. Schuster et al. 1991), and upon incursion into a new region, host ranges may expand to include native plant species. Moreover, host preferences may vary considerably across populations. For example, although chili (*Capsicum* spp.) is widely reported internationally as a favoured host of *Liriomyza sativae*, the population of *L. sativae* which has established within the Torres Strait (IPPC 2017) has very rarely been observed to attack chili (despite it being an abundant garden host in the region) (Elia Pirtle pers. comm).

Number of host records for the vegetable leafminer (*Liriomyza sativae*) within plant families.

Only records with either comprehensive or partial evidence of lifecycle completion in the field are included (see Table 12 and Table 13). Multiple records of the same species are included. Thus, the number of records does not indicate total number of affected species within each family. *Liriomyza sativae* is highly polyphagous and no guarantee can be made that this list is exhaustive.

Table 11 Number of host records for the vegetable leafminer (Liriomyza sativae) within plant families.

Family	Number of records
Fabaceae	44
Asteraceae	26
Cucurbitaceae	22
Solanaceae	22
Brassicaceae	13
Lamiaceae	9
Malvaceae	9
Passifloraceae	7
Amaranthaceae	5
Apiaceae	4
Plantaginaceae	4
Amaryllidaceae	3
Verbenaceae	3

Family	Number of records
Araliaceae	2
Cleomaceae	2
Euphorbiaceae	2
Moringaceae	2
Ranunculaceae	2
Bignoniaceae	1
Caryophyllaceae	1
Convolvulaceae	1
Gentianaceae	1
Orchidaceae	1
Poaceae	1
Polemoniaceae	1
Polygonaceae	1
Rosaceae	1

Commercial, ornamental and non-cultivated plants for which comprehensive evidence of lifecycle completion in the field for the vegetable leafminer (*Liriomyza sativae*) has been provided within the scientific literature

This includes all records where the following conditions were met:

(1) Adults were reared from plant material infested with eggs or from larvae collected in the field; and
(2) Emerging adults were subsequently identified via morphology or molecular diagnostics; and
(3) Scientific names of hosts are reported

In addition, all records from Kenneth Spencer, the foremost authority on leafminer taxonomy, are included. Records for plants identified only to the genus level (sp. or spp.) that did not meet the above conditions are included only if there are other records for species within this genus that met both conditions. Records for specific varieties within a species that did not meet the above conditions are included only if there are other records confirming lifecycle completion for that same species that met both conditions. Scientific names in the table appear as they were originally cited. A number of these names are now recognised as synonyms, however for brevity, we are not reporting the currently accepted names for these taxa (refer to WorldFloraOnline.org, Australian Plant Census, or Catalogue of Life for current taxonomic decisions). All common names associated with each scientific name, across all reports, are included. Additionally, many plants labelled as commercial and ornamental have escaped cultivation and naturalised in Australia. Records that report only partial confirmations of lifecycle completion are included in Table 13, while unverified records are included in Table 14. *Liriomyza sativae* is highly polyphagous and no guarantee can be made that this list is exhaustive.

Table 12 Commercial, ornamental and non-cultivated plants for which comprehensive evidence of lifecycle completion in the field for the vegetable leafminer (Liriomyza sativae) has been provided within the scientific literature

Host type	Common names	Scientific name	Variety	Family	Notes	Records with comprehensive evidence	All other records (partial and unverified records)
Commercial	Spinach; Silverbeet	*Spinacia oleracea*		Amaranthaceae	Light mining (Oatman 1959)	Foba et al. (2015)	Oatman (1959); Stegmaier (1968); Andersen et al. (2008)
Commercial	Celery	*Apium graveolens*		Apiaceae	Leafminers damage leaves reducing marketability and quality (Palumbo 2016)	Zehnder and Trumble (1984)	Oatman (1959); Stegmaier (1968); Andersen et al. (2008)

Host type	Common names	Scientific name	Variety	Family	Notes	Records with comprehensive evidence	All other records (partial and unverified records)
Commercial	Lettuce; Garden lettuce	*Lactuca sativa*		Asteraceae	Leaf mines make leaves unmarketable. Damage usually worse when planted near other hosts (Palumbo 2016)	Andersen et al. (2008); Reported affected in TS and CYP	Andersen et al. (2002); Parish et al. (2017)
Commercial	Leaf mustard; Mustard greens; Radish; Chinese mustard; Indian mustard; Mustard	*Brassica juncea*		Brassicaceae		Andersen et al. (2002); Andersen et al. (2008); Tran (2009)	Scheffer et al. (2006)A barcoding…)
Commercial	Gai lan; Cabbage; Broccoli; Caisin; Cabbage; Cauliflower; Field cabbage	*Brassica oleracea*		Brassicaceae	Broccoli and cauliflower can be attacked, impact most significant when plants are young (Palumbo 2016)	Andersen et al. (2008); Reported affected in TS and CYP	Stegmaier (1968); Parish et al. (2017)
Commercial	Kale	*Brassica oleracea*	*acephala*	Brassicaceae		Foba et al. (2015)	
Commercial	Cabbage	*Brassica oleracea*	*capitata*	Brassicaceae		Stegmaier (1966)	Scheffer et al. (2006)A barcoding…)
Commercial	Turnip; Rinsho; Chinese cabbage; Bokchoy	*Brassica rapa*		Brassicaceae	A common host in Vietnam (Andersen et al., 2008)	Stegmaier (1966); Reported affected in TS and CYP	Stegmaier (1968); Scheffer et al. (2006); Andersen et al. (2008)

Host type	Common names	Scientific name	Variety	Family	Notes	Records with comprehensive evidence	All other records (partial and unverified records)
Commercial	Pak choi; Pechay; Chinese cabbage	*Brassica rapa*	*chinensis*	Brassicaceae		Andersen et al. (2008)	Andersen et al. (2002)
Commercial	Smooth leaf mustard; Mustard; Leaf mustard; Cabbage; Sweet crucifera; Chinese cabbage	*Brassica* sp./spp.		Brassicaceae		Stegmaier (1966); Spencer (1973); Andersen et al. (2008)	Oatman (1959); Stegmaier (1968); Andersen et al. (2008); Parish et al. (2017)
Commercial	Radish; Chinese radish (Daikon); Wild radish; Garden radish; White radish	*Raphanus sativus*		Brassicaceae	Light mining (Oatman 1959)	Andersen et al. (2008); Tran (2009)	Oatman (1959); Stegmaier (1968)
Commercial	Radish	*Raphanus* sp.		Brassicaceae		Reported affected in TS and CYP	Andersen et al. (2008)
Commercial	Wax gourd; White goard; Chinese melon; China squash; Ash gourd	*Benincasa hispida*		Cucurbitaceae		Rauf et al. (2000); Andersen et al. (2002); Andersen et al. (2008)	Andersen et al. (2008)
Commercial	Watermelon	*Citrullus lanatus*		Cucurbitaceae	Can cause seedling deaths	Rauf et al. (2000); Andersen et al.	

Host type	Common names	Scientific name	Variety	Family	Notes	Records with comprehensive evidence	All other records (partial and unverified records)
					(Palumbo 2016)	(2002); Andersen et al. (2008); Tran (2009); Foba et al. (2015); Reported affected in TS and CYP	
Commercial		*Citrullus lanatus*	*lanatus*	Cucurbitaceae			Scheffer et al. (2006)A barcoding…)
Commercial	Melon	*Cucumis* sp.		Cucurbitaceae		Spencer (1990)	Scheffer and Lewis (2005)
Commercial	Melon; Cantaloupe; Muskmelon; Honey melon; Cassaba melon	*Cucumis melo*		Cucurbitaceae	Damages leaves; can cause defoliation resulting in sunburnt fruit (Palumbo 2016); Heavy mining (Oatman 1959)	Stegmaier (1966); Spencer (1973); Scheffer and Lewis (2005); Andersen et al. (2008); Tran (2009)	Oatman (1959); Stegmaier (1968); Kox et al (2005); Guimarães et al. (2009)
Commercial	Cucumber	*Cucumis sativus*		Cucurbitaceae	Leaf mining and female puncturing reduces	Stegmaier (1966); Spencer (1973); Spencer (1983); Rauf et al. (2000);	Oatman (1959); Stegmaier (1968); Parish et al. (2017)

Host type	Common names	Scientific name	Variety	Family	Notes	Records with comprehensive evidence	All other records (partial and unverified records)
					photosynthesis (Basji et al., 2011); Moderate mining (Oatman 1959)	Andersen et al. (2002); Scheffer and Lewis (2005); Andersen et al. (2008); Tran (2009); Nakamura et al. (2013); Reported affected in TS and CYP	
Commercial		*Cucumis sativus*	*sativus*	Cucurbitaceae			Scheffer et al. (2006)A barcoding…)
Commercial	Squash	*Cucurbita sp.*		Cucurbitaceae		Stegmaier (1966); Spencer (1990)	Stegmaier (1968); Scheffer et al. (2006)A barcoding…)
Commercial	Pumpkin; Winter squash; Squash	*Cucurbita maxima*		Cucurbitaceae	Light mining (Oatman 1959)	Andersen et al. (2002); Foba et al. (2015); Reported affected in TS and CYP	Oatman (1959); Stegmaier (1968); Andersen et al. (2008)
Commercial	Butternut squash; Pumpkin; Crookneck squash	*Cucurbita moschata*		Cucurbitaceae		Spencer (1973); Tran (2009)	
Commercial	Courgette; Zucchini; Pumpkin	*Cucurbita pepo*		Cucurbitaceae	The removal of leafminers using pesticides improved Californian	Stegmaier (1966); Spencer (1973); Scheffer and Lewis (2005); Foba et al. (2015); Reported	Stegmaier (1968)

Host type	Common names	Scientific name	Variety	Family	Notes	Records with comprehensive evidence	All other records (partial and unverified records)
					squash yields by 32-62% (Sharma et al., 1980)	affected in TS and CYP	
Commercial		*Cucurbita pepo*	*pepo*	Cucurbitaceae			Scheffer et al. (2006)A barcoding…)
Commercial	Bottle gourd	*Lagenaria siceraria*		Cucurbitaceae		Andersen et al. (2008)	
Commercial	Angled luffa; Sing kwa; Towelsponge; Angled luffa	*Luffa acutangula*		Cucurbitaceae		Rauf et al. (2000); Andersen et al. (2008); Tran (2009)	Scheffer et al. (2006)A barcoding…)
Commercial	Sponge gourd; Ridge gourd	*Luffa aegyptiaca*		Cucurbitaceae		Andersen et al. (2008)	
Commercial	Bitter gourd; Balsam pear	*Momordica charantia*		Cucurbitaceae		Andersen et al. (2008); Tran (2009)	
Commercial		*Ricinus* sp.		Euphorbiaceae		Spencer (1973)	
Commercial		*Cajanus* sp.		Fabaceae		Spencer (1990)	
Commercial	Pidgeon pea	*Cajanus cajan*		Fabaceae		Stegmaier (1966); Spencer (1973)	Stegmaier (1968)
Commercial	Chickpea	*Cicer arietinum*		Fabaceae		Avalos et al. (2013); Medina et al. (2014)	
Commercial	Soybean; Soya bean	*Glycine max*		Fabaceae		Rauf et al. (2000)	Valladares (1984); Parish et al. (2017)
Commercial	Lentil; Lentil bean	*Lens culinaris*		Fabaceae		Scheffer and Lewis (2005)	
Commercial	Lupine	*Lupinus* sp./ spp.		Fabaceae	Heavy mining (Oatman 1959)	Stegmaier (1966); Spencer (1973)	Oatman (1959); Stegmaier (1968);

Host type	Common names	Scientific name	Variety	Family	Notes	Records with comprehensive evidence	All other records (partial and unverified records)
							Scheffer and Lewis (2005)
Commercial		*Medicago* sp.		Fabaceae		Spencer (1990)	
Commercial	Alfalfa; Lucerne	*Medicago sativa*		Fabaceae	Heavy mining (Oatman 1959)	Spencer (1973); Spencer (1990)	Oatman (1959); Stegmaier (1968); Valladares (1984); Salvo and Valladares (1997)
Commercial	Sieva; Lima bean; Lima bean	*Phaseolus lunatus*		Fabaceae		Stegmaier (1966); Spencer (1973)	Stegmaier (1968)
Commercial	Beans; Grean beans; Pole beans	*Phaseolus* sp.		Fabaceae		Stegmaier (1966)	Stegmaier (1968); Scheffer et al. (2006)A barcoding…)
Commercial	Green bean; French bean; Kidney bean; Bean; Common bean; Snap bean	*Phaseolus vulgaris*		Fabaceae	Leaves tend to be the only part affected. Leaf mines reduce photosynthetic capacity of plant (Johnson 1993)	Spencer (1983); Rauf et al. (2000); Andersen et al. (2002); Scheffer and Lewis (2005); Andersen et al. (2008); Tran (2009); Foba et al. (2015)	Stegmaier (1968); Kox et al (2005); Musundire et al. (2012); Parish et al. (2017)
Commercial	Snow pea	*Pisum* sp.		Fabaceae		Spencer (1990)	
Commercial	Garden pea; Pea; Snow pea; Sugar snap	*Pisum sativum*		Fabaceae		Andersen et al. (2008); Foba et al. (2015)	Oatman (1959); Stegmaier (1968)
Commercial		*Trifolium* sp.		Fabaceae		Spencer (1990)	
Commercial	Crimson clover	*Trifolium*		Fabaceae		Stegmaier (1966)	Stegmaier (1968)

Host type	Common names	Scientific name	Variety	Family	Notes	Records with comprehensive evidence	All other records (partial and unverified records)
		incarnatum					
Commercial		*Vicia* sp.		Fabaceae		Spencer (1973)	
Commercial	Broad bean; Faba bean; Fava bean	*Vicia faba*		Fabaceae		Rauf et al. (2000); Scheffer and Lewis (2005); Andersen et al. (2008)	Musundire et al. (2012)
Commercial	Mungbean; Green gram	*Vigna radiata*		Fabaceae		Andersen et al. (2002); Tran (2009)	Andersen et al. (2008)
Commercial	Red bean; Black eyed pea; Cowpea	*Vigna sinensis*		Fabaceae		Stegmaier (1966); Spencer (1973); Rauf et al. (2000)	Stegmaier (1968)
Commercial	Walp Cowpea; Yard-long bean; Long bean; Snakebean; Cowpea	*Vigna unguiculata*		Fabaceae		Rauf et al. (2000); Andersen et al. (2002); Scheffer and Lewis (2005); Andersen et al. (2008); Tran (2009); Foba et al. (2015)	Scheffer et al. (2006)A barcoding...)
Commercial	Snake bean	*Vigna unguiculata*	*sesquipedalis*	Fabaceae		Pirtle et al. (in review); Reported affected in TS and CYP**	
Commercial	Basil; Sweet basil; Thai basil	*Ocimum basilicum*		Lamiaceae	Infested basil is frequently reported in Europe from imported material (Bragard	Pirtle et al. (in review); Reported affected in TS and CYP**	Andersen et al. (2008); Andersen and Hofsvang (2010)

Host type	Common names	Scientific name	Variety	Family	Notes	Records with comprehensive evidence	All other records (partial and unverified records)
					et al 2020)		
Commercial		*Abelmoschus* sp.		Malvaceae		Spencer (1990)	
Commercial	Okra	*Abelmoschus esculentus*		Malvaceae		Andersen et al. (2008); Foba et al. (2015)	Scheffer et al. (2006)A barcoding…)
Commercial	Cotton	*Gossypium* sp.		Malvaceae		Spencer (1973)	Stegmaier (1968)
Commercial	Passionfruit	*Passiflora edulis*		Passifloraceae		Pirtle et al. (in review); Reported affected in TS and CYP**	
Commercial		*Passiflora* sp.		Passifloraceae		Stegmaier (1966)	
Commercial	Plantain	*Plantago* sp.		Plantaginaceae		Stegmaier (1966)	Stegmaier (1968)
Commercial	Sweet pepper	*Capsicum*		Solanaceae		Foba et al. (2015)	
Commercial	Chili	*Capsicum annum*		Solanaceae		Spencer (1983)	
Commercial	Pepper; Sweet pepper; Green pepper; Chili; Capsicum	*Capsicum annuum*		Solanaceae		Spencer (1973)	
Commercial	Sweet pepper; Pepper; Chilli	*Capsicum sp.*		Solanaceae		Pirtle et al. (in review)	Stegmaier (1968)
Commercial	Tomato	*Lycopersicum esculentum*		Solanaceae	Up to 70% losses reported in Vanuatu (Murphy and LeSalle 1999). Hawaiian tomato yield losses were	Spencer (1973); Spencer (1983); Zehnder and Trumble (1984); Rauf et al. (2000); Scheffer and Lewis (2005); Andersen et al.	Oatman (1959); Stegmaier (1968); Kox et al (2005); Scheffer and Lewis (2005); Scheffer et al. (2006); Musundire et al. (2012); Parish et al. (2017)

Host type	Common names	Scientific name	Variety	Family	Notes	Records with comprehensive evidence	All other records (partial and unverified records)
					reported to be less than 10% until damage reached >8 mines/leaflet (Johnson 1993)	(2008); Tran (2009); Nakamura et al. (2013); Foba et al. (2015); Reported affected in TS and CYP**	
Commercial		*Solanum lycopersicum* (Syn. *Lycopersicum esculentum)*		Solanaceae		Stegmaier (1966)	
Commercial	Brinjal eggplant; Eggplant; common eggplant; Pickling eggplant	*Solanum melongena*		Solanaceae		Stegmaier (1966); Spencer (1973); Andersen et al. (2008); Tran (2009); Foba et al. (2015); Reported affected in TS and CYP	Oatman (1959); Stegmaier (1968); Scheffer et al. (2006); Andersen and Hofsvang (2010)
Commercial	Potato	*Solanum tuberosum*		Solanaceae		Spencer (1973); Foba et al. (2015)	Oatman (1959); Stegmaier (1968); Scheffer et al. (2006); Andersen et al. (2008)
Ornamental	Penniwort	*Hydrocotyle* sp.		Araliaceae		Spencer (1973)	
Ornamental		*Hydrocotyle umbellata*		Araliaceae		Stegmaier (1966)	

Host type	Common names	Scientific name	Variety	Family	Notes	Records with comprehensive evidence	All other records (partial and unverified records)
Ornamental	Aster	*Aster sp.*		Asteraceae	Heavy mining (Oatman 1959)	Spencer (1973); Spencer (1990)	Oatman (1959); Stegmaier (1968)
Ornamental		*Calendula* sp.		Asteraceae		Spencer (1973)	
Ornamental	Pot marigold	*Calendula officinalis*		Asteraceae		Stegmaier (1966)	Stegmaier (1968)
Ornamental	Garland chrysanthemum	*Chrysanthemum coronarium*		Asteraceae		Tran (2009)	
Ornamental	Garland chrysanthemum; Chrysanthemum	*Chrysanthemum* sp.		Asteraceae		Scheffer and Lewis (2005); Andersen et al. (2008)	
Ornamental	Dahlia	*Dahlia* sp.*		Asteraceae		Spencer (1973)	Sooda et al. (2017)
Ornamental	Marigold	*Tagetes* sp.		Asteraceae	Heavy mining (Oatman 1959)	Reported affected in TS and CYP	Oatman (1959); Stegmaier (1968); Andersen et al. (2008)
Ornamental		*Zinnia* sp.*		Asteraceae	Heavy mining (Oatman 1959)	Spencer (1973)	Oatman (1959); Stegmaier (1968)
Ornamental	Yellow bells	*Tecoma stans*		Bignoniaceae		Reported affected in TS and CYP	
Ornamental		*Bauhinia sp.*		Fabaceae		Stegmaier (1966); Spencer (1973)	Stegmaier (1968)
Ornamental		*Indigofera* sp.		Fabaceae		Spencer (1973); Spencer (1990)	
Ornamental	Indigo	*Indigofera tinctoria*		Fabaceae		Reported affected in TS and CYP	
Ornamental		*Moringa* sp.		Moringaceae		Spencer (1973); Spencer (1990)	

Host type	Common names	Scientific name	Variety	Family	Notes	Records with comprehensive evidence	All other records (partial and unverified records)
Ornamental	Passion flower	*Passiflora pallens*		Passifloraceae		Stegmaier (1966)	Stegmaier (1968)
Ornamental		*Phlox* sp.		Polemoniaceae		Spencer (1990)	
Ornamental		*Cestrum* sp.		Solanaceae		Spencer (1973); Spencer (1990)	
Ornamental		*Cestrum diurnum*		Solanaceae		Stegmaier (1966)	
Ornamental	Night blooming cestrum	*Cestrum nocturnum*		Solanaceae		Stegmaier (1966)	Stegmaier (1968)
Ornamental	Petunia	*Petunia* sp.		Solanaceae		Nakamura et al. (2013); Reported affected in TS and CYP	
Ornamental	Ornamental	unreported		Verbenaceae			Parish et al. (2017)
Non cultivated	Shepherd's needles; Spanish needles	*Bidens alba*		Asteraceae		Schuster et al. (1991)	
Non cultivated		*Galinsoga* sp.		Asteraceae		Spencer (1973); Spencer (1990)	
Non cultivated	Quickweed; Shaggy soldier	*Galinsoga ciliata*		Asteraceae		Stegmaier (1966)	Stegmaier (1968)
Non cultivated		*Lipochaeta* sp.		Asteraceae		Spencer (1973); Spencer (1990)	
Non cultivated		*Verbesina* sp.		Asteraceae		Spencer (1973)	
Non cultivated	Crownbeard	*Verbesina helianthoides*		Asteraceae		Stegmaier (1966)	Stegmaier (1968)
Non cultivated		*Verbesina* sp.		Asteraceae		Stegmaier (1966)	
Non cultivated	White	*Verbesina virginica*		Asteraceae		Stegmaier (1966)	Stegmaier (1968)

Host type	Common names	Scientific name	Variety	Family	Notes	Records with comprehensive evidence	All other records (partial and unverified records)
	Crownbeard						
Non cultivated	Prickly spider flower	*Cleome aculeata*		Cleomaceae		Reported affected in TS and CYP	
Non cultivated	Tickweed	*Cleome viscosa*		Cleomaceae		Reported affected in TS and CYP	
Non cultivated		*Ceratosanthes* sp.		Cucurbitaceae		Spencer (1990)	
Non cultivated	Castor bean; Castor oil bush	*Ricinus communis*		Euphorbiaceae		Stegmaier (1966); Spencer (1983); Spencer (1990); Rauf et al. (2000); Reported affected in TS and CYP	Oatman (1959); Stegmaier (1968)
Non cultivated		*Cassia* sp. (now *Senna* sp.)		Fabaceae		Spencer (1973)	Andersen and Hofsvang (2010)
Non cultivated		*Cassia occidentalis* (now *Senna occidentalis*)		Fabaceae		Stegmaier (1966)	Stegmaier (1968)
Non cultivated		*Cassia tora* (now *Senna tora*)		Fabaceae		Stegmaier (1966)	Stegmaier (1968)

Host type	Common names	Scientific name	Variety	Family	Notes	Records with comprehensive evidence	All other records (partial and unverified records)
Non cultivated	Streaked rattlepod	*Crotalaria pallida*		Fabaceae		Reported affected in TS and CYP**	
Non cultivated	Siratro	*Macroptilium atropurpureum*		Fabaceae		Reported affected in TS and CYP**	
Non cultivated		*Melilotus* sp.		Fabaceae		Spencer (1990)	
Non cultivated	White melilot	*Melilotus alba*		Fabaceae		Stegmaier (1966)	Oatman (1959); Stegmaier (1968)
Non cultivated		*Poissonia* sp.		Fabaceae		Spencer (1990)	
Non cultivated		*Poissonia hypoleuca*		Fabaceae		Spencer (1990)	
Non cultivated	Corkwood tree	*Sesbania grandiflora*		Fabaceae		Reported affected in TS and CYP	
Non cultivated	Cowpea	*Vigna repens*		Fabaceae		Stegmaier (1966); Spencer (1973)	Stegmaier (1968)
Non cultivated		*Annoda cristata*		Malvaceae		Stegmaier (1966)	
Non cultivated		*Anoda* sp.		Malvaceae		Spencer (1973)	
Non cultivated		*Sida* sp.		Malvaceae		Spencer (1973); Spencer (1990)	
Non cultivated	Sida	*Sida acuta*		Malvaceae		Stegmaier (1966)	Stegmaier (1968)
Non cultivated		*Passiflora* sp.		Passifloraceae		Spencer (1973)	
Non cultivated		*Passiflora foetida*		Passifloraceae		Pirtle et al. (in review); Reported affected in TS and CYP**	
Non cultivated	Corky stemmed passion flower	*Passiflora pallida*		Passifloraceae		Stegmaier (1966)	Stegmaier (1968)
Non cultivated		*Turnera ulmifolia*		Passifloraceae		Pirtle et al. (in review);	

Host type	Common names	Scientific name	Variety	Family	Notes	Records with comprehensive evidence	All other records (partial and unverified records)
						Reported affected in TS and CYP**	
Non cultivated	Plantain	*Plantago* sp.		Plantaginaceae		Spencer (1973)	
Non cultivated	Tolgaucha	*Datura* sp.		Solanaceae		Spencer (1973); Spencer (1990)	
Non cultivated	Cutleaf ground cherry; Mullaca; Wild gooseberry	*Physalis angulata*		Solanaceae		Pirtle et al. (in review); Reported affected in TS and CYP	Andersen et al. (2008)
Non cultivated	American black nightshade	*Solanum americanum*		Solanaceae		Schuster et al. (1991)	
Non cultivated	Black nightshade	*Solanum nigrum*		Solanaceae		Stegmaier (1966)	Stegmaier (1968)
Non cultivated	Turkey berry	*Solanum torvum*		Solanaceae		Tran (2009)	
Non cultivated	snakeweed	*Stachytarpheta jamaicensis*		Verbenaceae		Pirtle et al. (in review); Reported affected in TS and CYP**	

Commercial, ornamental and non-cultivated plants for which only partial evidence of lifecycle completion in the field for the vegetable leafminer (*Liriomyza sativae*) has been provided within the scientific literature

This includes all records where:

(1) Adults were reared from field collected plant material infested with larvae, but no subsequent identification via morphology or molecular diagnostics was reported; or
(2) Laboratory feeding and oviposition preference experiments were conducted that did not confirm lifecycle completion; or
(3) Identification via morphology or molecular diagnostics was reported, but collection methods in the field were not reported. Lifestyle completion cannot be confirmed in these instances due to the potential use of non-specific collection methods (e.g. sticky traps or sweep nets); or
(4) Laboratory cultures confirmed lifecycle completion, but evidence of lifecycle completion in the field was not provided; or
(5) Only common names of plant were given, but the scientific name could be confidently inferred; or
(6) The record reports presence of *L. sativae* on imported material detected at the border.

Records for plants identified only to the genus level (sp. or spp.) that did not meet the above conditions are included here only if there are other records for species within this genus that met one of these conditions outlined above. Records for specific varieties within a species that did not meet the above conditions are included only if there are other records for that same species that meet one of the conditions outlined above. Scientific names in the table appear as they were originally cited. A number of these names are now recognised as synonyms, however for brevity, we are not reporting the currently accepted names for these taxa (refer to WorldFloraOnline.org, Australian Plant Census, or Catalogue of Life for current taxonomic decisions). All common names associated with each scientific name, across all reports, are included. Additionally, many plants labelled as commercial and ornamental have escaped cultivation and naturalised in Australia. Records that report comprehensive confirmations of lifecycle completion are included in Table 12, while unverified records are included in Table 14. *Liriomyza sativae* is highly polyphagous and no guarantee can be made that this list is exhaustive.

Table 13 Commercial, ornamental and non-cultivated plants for which only partial evidence of lifecycle completion in the field for the vegetable leafminer (Liriomyza sativae) has been provided within the scientific literature.

Host type	Common names	Scientific name	Variety	Family	Notes	All records (including any unverified records)
Commercial	Beet; Chard; Beetroot	*Beta vulgaris*		Amaranthaceae		Andersen et al. (2008)
Commercial	Leek; Leeks	*Allium ampeloprasum*		Amaryllidaceae		Andersen et al. (2008)
Commercial	Onion; Shallot;	*Allium cepa*		Amaryllidaceae	Mines can girdle	Herr and Johnson (1992);

Host type	Common names	Scientific name	Variety	Family	Notes	All records (including any unverified records)
	Multiplier onion				stems causing leaf death (Carolina et al., 1992)	Andersen et al. (2008)
Commercial	Garlic	*Allium sativum*		Amaryllidaceae		Andersen et al. (2008)
Commercial	Coriander	*Coriandrum sativum*		Apiaceae		Andersen and Hofsvang (2010)
Commercial	Carrot	*Daucus carota*		Apiaceae		Andersen et al. (2008)
Commercial		*Daucus carota*	*sativus*	Apiaceae		Scheffer et al. (2006)A barcoding…)
Commercial	Chinese cabbage; Petsai; Common yellow mustard	*Brassica campestris*		Brassicaceae	Light mining (Oatman 1959)	Oatman (1959); Stegmaier (1968)
Commercial	Nasturtium	*Nasturtium* sp.		Brassicaceae		Oatman (1959); Stegmaier (1968)
Commercial	Watermelon	*Citrullus vulgaris*		Cucurbitaceae	Heavy mining (Oatman 1959)	Oatman (1959); Stegmaier (1968)
Commercial	Lima bean	*Phaseolus limensis*		Fabaceae		Oatman (1959); Stegmaier (1968); Herr and Johnson (1992); Kox et al (2005)
Commercial	Mung bean	*Phaseolus radiatus*		Fabaceae		Kox et al (2005); Kox et al. (2005)
Commercial	Strawberry clover	*Trifolium frageriferum*		Fabaceae		Oatman (1959); Stegmaier (1968)
Commercial	Alsike clover; White clover	*Trifolium hybridum*		Fabaceae		Oatman (1959); Stegmaier (1968)
Commercial	Red clover	*Trifolium pratense*		Fabaceae		Oatman (1959);

Host type	Common names	Scientific name	Variety	Family	Notes	All records (including any unverified records)
						Stegmaier (1968)
Commercial	White clover	*Trifolium repens*		Fabaceae		Oatman (1959); Stegmaier (1968)
Commercial		*Mentha* sp.		Lamiaceae		Andersen and Hofsvang (2010)
Commercial		*Ocimum americanum*		Lamiaceae		Andersen and Hofsvang (2010)
Commercial		*Ocimum canum*		Lamiaceae		Andersen and Hofsvang (2010)
Commercial		*Ocimum sanctum*		Lamiaceae		Andersen and Hofsvang (2010)
Commercial	Oregano	*Origanum vulgare*		Lamiaceae		Andersen et al. (2008)
Commercial	Upland cotton; Cotton	*Gossypium hirsutum*		Malvaceae	Moderate mining (Oatman 1959)	Oatman (1959); Stegmaier (1968); Andersen et al. (2002); Andersen et al. (2008)
Commercial	Barley	*Hordeum vulgare*		Poaceae	Light mining (Oatman 1959)	Oatman (1959)
Commercial	Bell pepper	*Capsicum frutescens*		Solanaceae		Oatman (1959); Stegmaier (1968)
Ornamental	Amaranth; Bayam	*Amaranthus* sp.		Amaranthaceae		Andersen and Hofsvang (2010)
Ornamental		*Amaranthus tricolour*		Amaranthaceae		Andersen and Hofsvang (2010)
Ornamental	Oxeye daisy	*Chrysanthemum leucanthemum*		Asteraceae	Light mining (Oatman 1959)	Oatman (1959); Stegmaier (1968)
Ornamental	Cineraria	*Felicia bergeriana*		Asteraceae	Moderate mining	Oatman (1959);

Host type	Common names	Scientific name	Variety	Family	Notes	All records (including any unverified records)
					(Oatman 1959)	Stegmaier (1968)
Ornamental	Sunflower; Common sunflower	*Helianthus annuus**		Asteraceae	Light mining (Oatman 1959)	Oatman (1959); Stegmaier (1968)
Ornamental	Gypsophila	*Gypsophila* sp.		Caryophyllaceae		Andersen and Hofsvang (2010)
Ornamental		*Lisianthus* sp.		Gentianaceae		Andersen and Hofsvang (2010)
Ornamental		*Dendrobium* sp.		Orchidaceae		Andersen and Hofsvang (2010)
Ornamental	Snapdragon	*Antirrhinum majus*		Plantaginaceae	Light mining (Oatman 1959)	Oatman (1959); Stegmaier (1968)
Ornamental	Columbine	*Aquilegia* sp.		Ranunculaceae	Light mining (Oatman 1959)	Oatman (1959); Stegmaier (1968)
Ornamental	Buttercup	*Ranunculus* sp.		Ranunculaceae	Light mining (Oatman 1959)	Oatman (1959); Stegmaier (1968)
Ornamental	Desert peach	*Prunus andersonii*		Rosaceae	Light mining (Oatman 1959)	Oatman (1959)
Non cultivated	Rough pigweed	*Amaranthus retroflexus*		Amaranthaceae		Oatman (1959); Stegmaier (1968)
Non cultivated	Goosefoot; Lamb's quarters; Fat hen	*Chenopodium album*		Amaranthaceae		Oatman (1959); Stegmaier (1968)
Non cultivated	Common groundsel	*Senecio vulgaris*		Asteraceae		Oatman (1959); Stegmaier (1968)
Non cultivated	Milk thistle; Blessed milk	*Silybum marianum*		Asteraceae		Oatman (1959); Stegmaier (1968)

Host type	Common names	Scientific name	Variety	Family	Notes	All records (including any unverified records)
	thistle					
Non cultivated	Common sow thistle	*Sonchus oleraceus*		Asteraceae		Oatman (1959)
Non cultivated	Yellow melilot	*Melilotus indica*		Fabaceae		Oatman (1959); Stegmaier (1968)
Non cultivated	Garden balm	*Melissa officinalis*		Lamiaceae		Oatman (1959); Stegmaier (1968)
Non cultivated	Dwarf mallow	*Malva rotundifolia*		Malvaceae		Oatman (1959); Stegmaier (1968)
Non cultivated	Broad leaved plantain	*Plantago major*		Plantaginaceae		Oatman (1959); Stegmaier (1968)
Non cultivated	Knotweed	*Polygonum aviculare*		Polygonaceae		Oatman (1959); Stegmaier (1968)
Non cultivated	Tolgaucha	*Datura meteloides*		Solanaceae		Oatman (1959)
Non cultivated	Lance leafed ground cherry	*Physalis lanceifolia*		Solanaceae		Oatman (1959); Stegmaier (1968)

Commercial, ornamental and non-cultivated plants with unverified records of lifecycle completion in the field for the vegetable leafminer (*Liriomyza sativae*).

This includes all records for which no evidence was presented within the record for lifecycle completion and no evidence was shown for confident species identification, or evidence could not suitably be accessed for verification. We are not disputing the veracity of these records - we simply did not have enough information available to verify if these hosts support lifecycle completion in the field. This includes all records where:

(1) Adults were collected by sweep netting the presumed host, but neither larval activity nor lifecycle completion was confirmed; or
(2) A scientific name could not reliably be assumed from a reported common name; or
(3) Collection and identification methodology were unclear or unreported; or
(4) The record could not be accessed or suitably translated to confirm collection and identification methodology.

For some unverified species within this table, there may be other congeneric species that have been either comprehensively or partially confirmed as a host plant, and thus these would appear within Table 12 or Table 13. Scientific names in the table appear as they were originally cited. A number of these names are now recognised as synonyms, however for brevity, we are not reporting the currently accepted names for these taxa (refer to WorldFloraOnline.org, Australian Plant Census, or Catalogue of Life for current taxonomic decisions). All common names associated with each scientific name, across all reports, are included. Additionally, many plants labelled as commercial and ornamental have escaped cultivation and naturalised in Australia. Records that report comprehensive confirmations of lifecycle completion are included in Table 12, while records that report only partial confirmations of lifecycle completion are included in Table 13. *Liriomyza sativae* is highly polyphagous and no guarantee can be made that this list is exhaustive.

Table 14 Commercial, ornamental and non-cultivated plants with unverified records of lifecycle completion in the field for the vegetable leafminer (Liriomyza sativae).

Host type	Common names	Scientific name	Variety	Family	Records
commercial	Okra	*Hibiscus esculentus*		Malvaceae	Stegmaier (1968)
ornamental	Pennywort	*Hydrocotyle unbellata*		Araliaceae	Stegmaier (1968)
ornamental	Dahlia	*Dahlia pinnata*		Asteraceae	Stegmaier (1968)
ornamental	Creek goldenrod	*Solidago elongata*		Asteraceae	Stegmaier (1968)

Host type	Common names	Scientific name	Variety	Family	Records
ornamental	Giant goldenrod	*Solidago gigantea*		Asteraceae	Stegmaier (1968)
ornamental	Goldenrod	*Solidago sp.*		Asteraceae	Stegmaier (1968)
non cultivated	Black medic	*Medicago lupilina*		Fabaceae	Frick (1959); Stegmaier (1968)
non cultivated	Giant vetch	*Vicia gigantea*		Fabaceae	Frick (1959); Stegmaier (1968)
non cultivated	Anoda	*Anoda cristata*		Malvaceae	Stegmaier (1968)
non cultivated	Mallow	*Malva borealis*		Malvaceae	Stegmaier (1968)
non cultivated	Mallow	*Malva nicaeensis*		Malvaceae	Stegmaier (1968)
non cultivated	Tolgaucha	*Datura sp.*		Solanaceae	Stegmaier (1968)

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Appendix 2: Leaf mining damage caused by established species

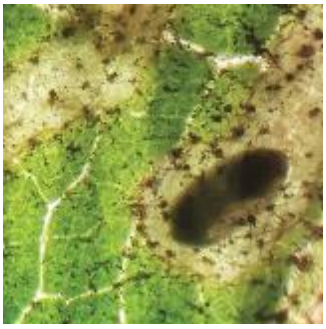
Table 15 provides a summary of established (native or naturalised) leaf mining species, their host overlap with vegetable leafminer and features that can be used to differentiate between vegetable leafminer and established leafminers.

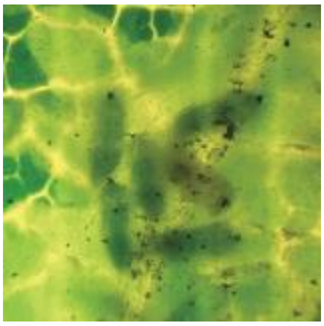
It should be noted that because host plant records are poor for many native or naturalised species, there could be many more affected hosts than included here. The host overlap between vegetable leafminer and several native leafminers underscores the importance of sample collection and molecular diagnostics.

Figure 10 provides some general guidelines for differentiating between dipteran and lepidopteran leafminer larvae.

Table 15. Leaf mining damage caused by Australian dipterans or lepidopterans on leaves of cultivated crops and common weeds of cultivated crops

LEAFMINER	DISTINGUISHING FEATURES FROM VEGETABLE LEAFMINER DAMAGE	HOSTS (THOSE SHARED WITH VEGETABLE LEAFMINER ARE UNDERLINED)	PHOTO OF LEAF MINE
Liriomyza brassicae	None (all life stages are morphologically indistinguishable in appearance, without dissection, and behaviour from vegetable leafminer).	Brassicaceae Capparaceae Nasturtium (Tropaeolaceae) Peas (Fabaceae)	
Liriomyza chenopodii	None (all life stages are morphologically indistinguishable in appearance, without dissection, and behaviour from vegetable leafminer).	Chenopodiaceae (incl. beet) Caryophyllaceae (incl. chickweed) Any native hosts are as yet unrecorded (*L. chenopodii* is a native species)	

LEAFMINER	DISTINGUISHING FEATURES FROM VEGETABLE LEAFMINER DAMAGE	HOSTS (THOSE SHARED WITH VEGETABLE LEAFMINER ARE UNDERLINED)	PHOTO OF LEAF MINE
Phytomyza syngenesiae	Pupation occurs inside the leaf mine.  Adults easily distinguishable from vegetable leafminer.	Asteraceae (esp. lettuces, daisies, sow thistle, Cineraria) Wild carrot (Umbelliferae) Peas (Fabaceae)	
Tropicomyia polyphtya	Larvae are upper surface epidermal feeders (deeper parenchymatous tissues is not eaten). As such, mines have a silvery, film like appearance. Pupation occurs inside the mine and pupa is noticeably flattened.  Adults outwardly distinguishable from vegetable leafminer.	Highly polyphagous Common hosts include plants in the Passifloraceae, Euphorbiaceae, Fabaceae, Rubiaceae, Ruaceae, and Solanaceae families, and more.	
Ophiomyia solanicola	Pupation occurs inside the leaf mine.  Adults easily distinguishable from vegetable leafminer.	Solanaceae (incl. egg plant)	

LEAFMINER	DISTINGUISHING FEATURES FROM VEGETABLE LEAFMINER DAMAGE	HOSTS (THOSE SHARED WITH VEGETABLE LEAFMINER ARE UNDERLINED)	PHOTO OF LEAF MINE
Ophiomyia alysicarpi	Mint green pupae can be found inside mines.  Adults easily distinguishable from vegetable leafminer.	*Alysicarpus* sp. *Desmodium* sp.	
Ophiomyia cornuta	Adults easily distinguishable from vegetable leafminer.	*Scaevola* sp. *Goodenia* sp.	
Lepidopteran leafminer	Lepidopteran larvae can be distinguished from dipteran larvae on the spot, via a hand lens (Figure 10). For some lepidopteran species, when the larva is in its final stages, it forms a large blister at the end of the mine (see images on the right). vegetable leafminer larvae do not create such blisters.	Polyphagous (incl. Fabaceae, Eucalypts, native trees, etc) At least one lepidopteran leafminer is found in *Macroptilium atropurpureum* (a highly preferred host of vegetable leafminer)	 

LEAFMINER	DISTINGUISHING FEATURES FROM VEGETABLE LEAFMINER DAMAGE	HOSTS (THOSE SHARED WITH VEGETABLE LEAFMINER ARE UNDERLINED)	PHOTO OF LEAF MINE
			

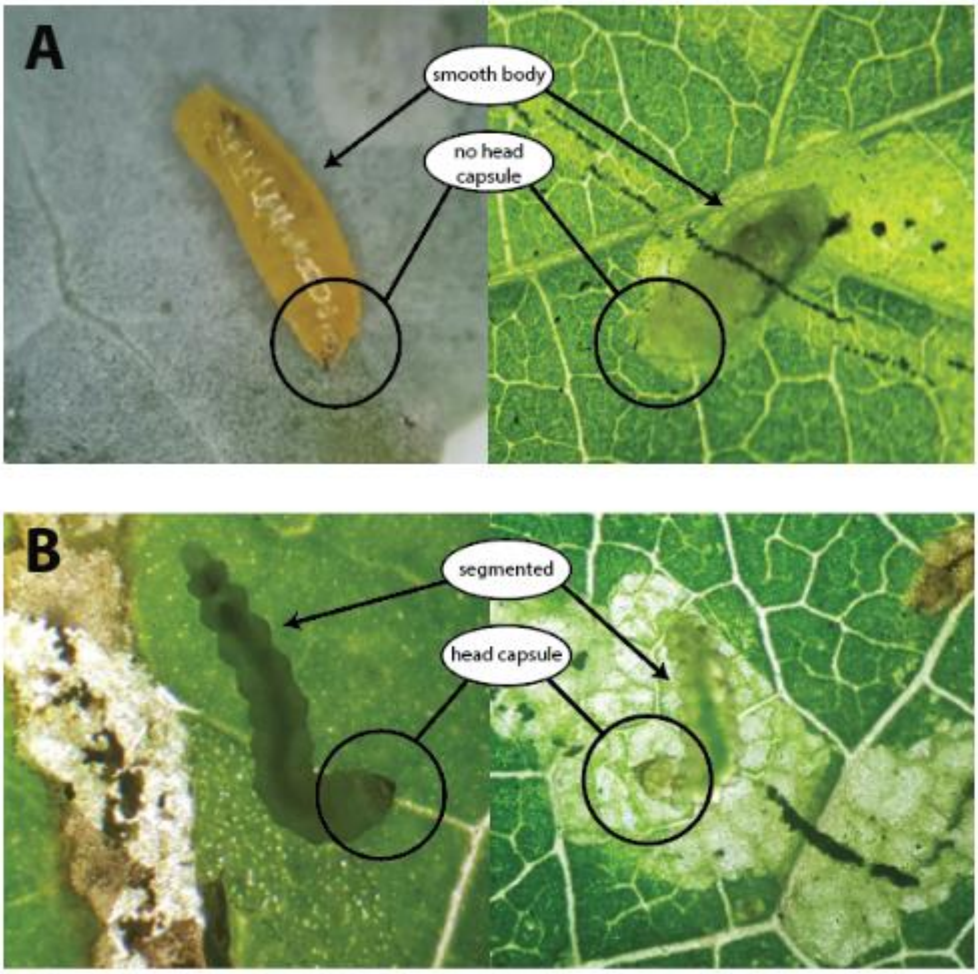


Figure 10. General guidelines for distinguishing dipteran vs lepidopteran leafminer larvae. Dipteran leafminer larvae (A) lack a head capsule and have a smooth body without clear segments. Lepidopteran leafminer larvae (B) have a distinct head capsule and are more visibly segmented. When attempting to distinguish a dipteran from lepidopteran leafminer larva on the spot, it is helpful to backlight the leaf as it is viewed under a hand lens, or to carefully excise the larva. Images: Elia Pirtle, Cesar Australia *Pty Ltd.*

Surveillance for *L. sativae* in Australia will be confounded by the presence of other leafmining insects already present in Australia, many of which create mines that are indistinguishable to a casual observer, and even in some cases indistinguishable to experts.

Table 16 lists genera that include hosts of *L. sativae* but do not appear to contain other agromyzids within Australia or Australasia. It is important to note that host plant records for non-pest leafminer flies are highly incomplete, and some of the genera included herein could host leafminer flies that have not yet been reported. Host records for weeds and native plants are less complete than for cultivated crops and ornamentals. Despite poor host records for native leafminers, we can be more confident that native leafminers are not currently a notable presence within the genera containing cultivated crops and ornamentals, where sampling effort is expected to be higher. As such, leafmining damage detected within the genera included in these tables should be regarded as highly suspicious.

Error! Reference source not found. indicates where known overlap exists between hosts of *L. huidobrensis, L. trifolii* or *L. sativae* and native or naturalised agromyzids in Australia and Australasia.

Table 16 Host genera of L. huidobrensis, L. sativae or L trifolii (including only records with comprehensive or partial evidence for lifecycle completion in the field, see Appendix 1) without any reported overlap with native or naturalised agromyzids already present in Australasia (see ***Error! Reference source not found.*** *for known overlap). For each host, preferences of the three exotic Liriomyza are indicated (LH = L. huidobrensis; LT = L. trifolii; LS = L. sativae).*

Genus	Family	Exotic *Liriomyza*	Host type
Allium	Amaryllidaceae	LH; LT; LS	commercial
Coriandrum	Apiaceae	LH; LT; LS	commercial
Eryngium	Apiaceae	LH	commercial
Petroselinum	Apiaceae	LT	commercial
Colocasia	Araceae	LH	commercial
Cichorium	Asteraceae	LH	commercial
Crassocephalum	Asteraceae	LH	commercial
Basella	Basellaceae	LH	commercial
Eruca	Brassicaceae	LH	commercial
Nasturtium	Brassicaceae	LH; LS	commercial
Spinacea	Chenopodiaceae	LH	commercial
Benincasa	Cucurbitaceae	LH; LT; LS	commercial
Coccinia	Cucurbitaceae	LT	commercial
Lagenaria	Cucurbitaceae	LH; LT; LS	commercial
Luffa	Cucurbitaceae	LH; LT; LS	commercial
Momordica	Cucurbitaceae	LH; LT; LS	commercial
Sechium	Cucurbitaceae	LH	commercial
Trichosanthes	Cucurbitaceae	LT	commercial
Arachis	Fabaceae	LT	commercial
Cicer	Fabaceae	LH; LT; LS	commercial
Cyamopsis	Fabaceae	LT	commercial
Lens	Fabaceae	LS	commercial
Lotus	Fabaceae	LH	commercial
Lupin	Fabaceae	LH	commercial
Medicago	Fabaceae	LH; LT; LS	commercial
Trigonella	Fabaceae	LH; LT	commercial
Vicia	Fabaceae	LH; LT; LS	commercial
Mentha	Lamiaceae	LH; LS	commercial

Genus	Family	Exotic *Liriomyza*	Host type
Origanum	Lamiaceae	LS	commercial
Linum	Linaceae	LH	commercial
Abelmoschus	Malvaceae	LH; LT; LS	commercial
Corchorus	Malvaceae	LT	commercial
Gossypium	Malvaceae	LT; LS	commercial
Hibiscus	Malvaceae	LH; LT	commercial
Zizania	Poaceae	LH	commercial
Lycium	Solanaceae	LH	commercial
Thurnbergia	Acanthaceae	LH	ornamental
Celosia	Amaranthaceae	LH; LT	ornamental
Bupleurum	Apiaceae	LH	ornamental
Centella	Apiaceae	LH	ornamental
Oenanthe	Apiaceae	LH	ornamental
Catharanthus	Apocynaceae	LH	ornamental
Asclepias	Asclepiadaceae	LT	ornamental
Chionodoxa	Asparagaceae	LH	ornamental
Hemerocallis	Asphodelaceae	LH	ornamental
Argyranthemum	Asteraceae	LH	ornamental
Calendula	Asteraceae	LH; LT; LS	ornamental
Centaurea	Asteraceae	LH	ornamental
Conoclinium	Asteraceae	LH	ornamental
Cosmos	Asteraceae	LH	ornamental
Dimorphotheca	Asteraceae	LT	ornamental
Echinacea	Asteraceae	LT	ornamental
Eupatorium	Asteraceae	LT	ornamental
Felicia	Asteraceae	LS	ornamental
Flaveria	Asteraceae	LT	ornamental
Kalimeris	Asteraceae	LH	ornamental
Osteospermum	Asteraceae	LH	ornamental
Pyrethrum	Asteraceae	LH	ornamental
Tanacetum	Asteraceae	LH	ornamental
Zinnia	Asteraceae	LH; LT; LS	ornamental
Impatiens	Balsaminaceae	LH	ornamental
Calceolaria	Calceolariaceae	LH	ornamental
Campanula	Campanulaceae	LH	ornamental
Platycodon	Campanulaceae	LH	ornamental
Trachelium	Campanulaceae	LH; LT	ornamental
Dianthus	Caryophyllaceae	LH; LT	ornamental
Gypsophila	Caryophyllaceae	LH; LT; LS	ornamental
Bauhinia	Fabaceae	LS	ornamental
Lathyrus	Fabaceae	LH	ornamental
Lupinus	Fabaceae	LH; LS	ornamental
Eustoma	Gentianaceae	LH; LT	ornamental
Exacum	Gentianaceae	LH	ornamental
Lisianthus	Gentianaceae	LH; LT; LS	ornamental
Freesia	Iridaceae	LH	ornamental
Gladiolus	Iridaceae	LH	ornamental
Salvia	Lamiaceae	LH; LT	ornamental

Genus	Family	Exotic *Liriomyza*	Host type
Lilium	Liliaceae	LH	ornamental
Torenia	Linderniaceae	LH	ornamental
Althaea	Malvaceae	LH	ornamental
Moringa	Moringaceae	LS	ornamental
Godetia	Onagraceae	LH	ornamental
Oenothera	Onagroideae	LH	ornamental
Dendrobium	Orchidaceae	LS	ornamental
Papaver	Papaveraceae	LH	ornamental
Antirrhinum	Plantaginaceae	LH; LT; LS	ornamental
Myosotis	Plumbaginaceae	LH	ornamental
Lagurus	Poaceae	LH	ornamental
Phlox	Polemoniaceae	LH; LT; LS	ornamental
Primula	Primulaceae	LH	ornamental
Aquilegia	Ranunculaceae	LS	ornamental
Delphinium	Ranunculaceae	LH	ornamental
Nigella	Ranunculaceae	LH	ornamental
Prunus	Rosaceae	LS	ornamental
Rosa	Rosaceae	LH; LT	ornamental
Diascia	Scrophulariaceae	LH	ornamental
Viola	Violaceae	LH	ornamental
Sagittaria	Alismataceae	LH	non cultivated
Alternanthera	Amaranthaceae	LT	non cultivated
Amaranthus	Amaranthaceae	LH; LT; LS	non cultivated
Deeringia	Amaranthaceae	LH	non cultivated
Gomphrena	Amaranthaceae	LH	non cultivated
Iresine	Amaranthaceae	LH	non cultivated
Alocasia	Araceae	LH	non cultivated
Hydrocotyle	Araliaceae	LH; LT; LS	non cultivated
Artemisia	Asteraceae	LH; LT	non cultivated
Baccharis	Asteraceae	LT	non cultivated
Carduus	Asteraceae	LH	non cultivated
Dichrocephala	Asteraceae	LH	non cultivated
Echinops	Asteraceae	LH	non cultivated
Eclipta	Asteraceae	LT	non cultivated
Emilia	Asteraceae	LH	non cultivated
Erechtites	Asteraceae	LH; LT	non cultivated
Galinsoga	Asteraceae	LH; LT; LS	non cultivated
Helipterum	Asteraceae	LH	non cultivated
Hemistepta	Asteraceae	LH	non cultivated
Hymenopappus	Asteraceae	LT	non cultivated
Lipochaeta	Asteraceae	LS	non cultivated
Melanthera	Asteraceae	LT	non cultivated
Parthenium	Asteraceae	LT	non cultivated
Synedrella	Asteraceae	LH; LT	non cultivated
Tridax	Asteraceae	LT	non cultivated
Verbesina	Asteraceae	LS	non cultivated
Xanthium	Asteraceae	LT	non cultivated
Cordia	Boranginaceae	LT	non cultivated

Genus	Family	Exotic *Liriomyza*	Host type
Capsella	Brassicaceae	LH	non cultivated
Rorippa	Brassicaceae	LH	non cultivated
Silene	Caryophillaceae	LH; LT	non cultivated
Malachium	Caryophyllaceae	LH	non cultivated
Spergula	Caryophyllaceae	LT	non cultivated
Commelina	Commelinaceae	LT	non cultivated
Calystegia	Convolvulaceae	LH	non cultivated
Convolvulus	Convolvulaceae	LT	non cultivated
Pharbitis	Convolvulaceae	LH	non cultivated
Ceratosanthes	Cucurbitaceae	LS	non cultivated
Melothria	Cucurbitaceae	LH	non cultivated
Melilotus	Fabaceae	LH; LS	non cultivated
Poissonia	Fabaceae	LS	non cultivated
Lamium	Lamiaceae	LH	non cultivated
Leonurus	Lamiaceae	LH	non cultivated
Melissa	Lamiaceae	LS	non cultivated
Anoda	Malvaceae	LS	non cultivated
Malva	Malvaceae	LH; LS	non cultivated
Sida	Malvaceae	LH; LS	non cultivated
Oxalis	Oxalidaceae	LH; LT	non cultivated
Piriqueta	Passifloraceae	LT	non cultivated
Linaria	Plantaginaceae	LT	non cultivated
Veronica	Plantaginaceae	LH	non cultivated
Limonium	Plumbaginaceae	LH	non cultivated
Polygala	Polygalaceae	LT	non cultivated
Rumex	Polygonaceae	LH	non cultivated
Cardiospermum	Sapindaceae	LT	non cultivated
Nemesia	Scrophulariaceae	LH	non cultivated
Datura	Solanaceae	LH; LT; LS	non cultivated
Nicotiana	Solanaceae	LH; LT	non cultivated
Kallstroemia	Zygophyllaceae	LT	non cultivated
Tribulus	Zygophyllaceae	LT	non cultivated

Table 17 Host genera of either L. huidobrensis, L. sativae or L trifolii with known overlap with native or naturalised agromyzids already present in Australasia. Some of these species are stem miner, which should be straightforward to distinguish from the leaf mining damage caused by L. huidobrensis, L. sativae or L trifolii. Records of L. sativae host plants within the Torres Strait Islands (TSI) and on the Cape York Peninsula (CYP) are included.

Host genus	Host family	Australasian Agromyzid genera	Sources
Beta	Amaranthaceae	*Liriomyza*	Benavent Corai et al. (2005); Spencer (1973); Spencer (1977); Spencer (1990)
Chenopodium	Amaranthaceae	*Liriomyza*	Benavent Corai et al. (2005); Spencer (1977); Spencer (1990)
Spinacia	Amaranthaceae	*Liriomyza*	Benavent Corai et al. (2005); Spencer (1973); Spencer (1977)
Apium	Apiaceae	*Melanagromyza*	Benavent Corai et al. (2005); Spencer (1973); Spencer (1977)
Daucus	Apiaceae	*Phytomyza*	Spencer (1973)
Asparagus	Asparagaceae	*Hexomyza*	Benavent Corai et al. (2005)
Ageratum	Asteraceae	*Melanagromyza*	Spencer (1977)
Arctium	Asteraceae	*Phytomyza*	Benavent Corai et al. (2005)
Aster	Asteraceae	*Calycomyza, Phytomyza*	Benavent Corai et al. (2005); Spencer (1977)
Bellis	Asteraceae	*Calycomyza, Phytomyza*	Benavent Corai et al. (2005)
Bidens	Asteraceae	*Melanagromyza*	Spencer (1977)
Callistephus	Asteraceae	*Calycomyza, Phytomyza*	Benavent Corai et al. (2005)
Carthamus	Asteraceae	*Melanagromyza*	Benavent Corai et al. (2005)
Chrysanthemum	Asteraceae	*Ophiomyia, Phytomyza, Melanagromyza*	Benavent Corai et al. (2005); Spencer (1977)
Cineraria	Asteraceae	*Phytomyza*	Benavent Corai et al. (2005)
Cirsium	Asteraceae	*Phytomyza*	Spencer (1977)
Conyza	Asteraceae	*Calycomyza, Phytomyza*	Benavent Corai et al. (2005)
Coreopsis	Asteraceae	*Phytomyza*	Benavent Corai et al. (2005); Spencer (1977)
Craspedia	Asteraceae	*Liriomyza*	Benavent Corai et al. (2005)
Crepis	Asteraceae	*Phytomyza*	Benavent Corai et al. (2005)
Cynara	Asteraceae	*Phytomyza*	Spencer (1973)
Dahlia	Asteraceae	*Phytomyza*	Benavent Corai et al. (2005)
Erigeron	Asteraceae	*Calycomyza*	Benavent Corai et al. (2005); Spencer (1977)
Gaillardia	Asteraceae	*Phytomyza*	Benavent Corai et al. (2005)
Gerbera	Asteraceae	*Phytomyza*	Benavent Corai et al. (2005)
Gnaphalium	Asteraceae	*Melanagromyza, Malanagromyza*	Benavent Corai et al. (2005); Spencer (1977)
Helianthus	Asteraceae	*Calycomyza, Phytomyza*	Benavent Corai et al. (2005)
Helichrysum	Asteraceae	*Liriomyza, Melanagromyza, Phytomyza*	Benavent Corai et al. (2005); Spencer (1977)
Lactuca	Asteraceae	*Liriomyza*, Phytomyza*	Benavent Corai et al. (2005); Present in TSI/CYP; Spencer (1973)
Leucanthemum	Asteraceae	*Phytomyza*	Benavent Corai et al. (2005)
Picris	Asteraceae	*Phytomyza*	Benavent Corai et al. (2005)
Senecio	Asteraceae	*Melanagromyza, Phytomyza*	Benavent Corai et al. (2005); Spencer (1977); Spencer (1977)
Solidago	Asteraceae	*Calycomyza*	Benavent Corai et al. (2005)
Sonchus	Asteraceae	*Phytomyza*	Benavent Corai et al. (2005); Spencer (1977)
Tagetes	Asteraceae	*Liriomyza**	Present in TSI/CYP

Host genus	Host family	Australasian Agromyzid genera	Sources
Taraxacum	Asteraceae	*Phytomyza*	Benavent Corai et al. (2005)
Tecoma	Bignoniaceae	*Liriomyza**	Present in TSI/CYP
Barbarea	Brassicaceae	*Liriomyza*	Benavent Corai et al. (2005)
Brassica	Brassicaceae	*Liriomyza**	Benavent Corai et al. (2005); Present in TSI/CYP; Spencer (1977)
Cardamine	Brassicaceae	*Liriomyza*	Spencer (1977)
Diplotaxis	Brassicaceae	*Liriomyza*	Spencer (1977)
Hirschfeldia	Brassicaceae	*Liriomyza*	Benavent Corai et al. (2005)
Matthiola	Brassicaceae	*Liriomyza*	Benavent Corai et al. (2005); Spencer (1977)
Raphanus	Brassicaceae	*Liriomyza*	Benavent Corai et al. (2005); Present in TSI/CYP; Spencer (1977)
Silene	Caryophyllaceae	*Liriomyza*	Benavent Corai et al. (2005); Spencer (1977); Spencer (1990)
Stellaria	Caryophyllaceae	*Liriomyza*	Benavent Corai et al. (2005); Spencer (1977); Spencer (1990)
Cleome	Cleomaceae	*Liriomyza**	Benavent Corai et al. (2005); Present in TSI/CYP
Ipomoea	Convolvulaceae	*Melanagromyza*	Benavent Corai et al. (2005)
Citrullus	Cucurbitaceae	*Liriomyza**	Present in TSI/CYP
Cucumis	Cucurbitaceae	*Liriomyza**	Present in TSI/CYP
Cucurbita	Cucurbitaceae	*Liriomyza**	Present in TSI/CYP
Euphorbia	Euphorbiaceae	*Tropicomyia*	Spencer (1977)
Ricinus	Euphorbiaceae	*Liriomyza**	Present in TSI/CYP
Cajanus	Fabaceae	*Melanagromyza, Ophiomyia*	Spencer (1973); Spencer (1977)
Canavalia	Fabaceae	*Ophiomyia*	Spencer (1973)
Cassia	Fabaceae	*Tropicomyia, Ophiomyia*	Spencer (1977); Spencer (1990)
Crotalaria	Fabaceae	*Liriomyza*, Ophiomyia*	Present in TSI/CYP; Spencer (1973); Spencer (1977)
Dolichos	Fabaceae	*Ophiomyia*	Spencer (1973); Spencer (1977)
Glycine	Fabaceae	*Melanagromyza, Ophiomyia*	Benavent Corai et al. (2005); Spencer (1973); Spencer (1977)
Indigofera	Fabaceae	*Liriomyza*, Ophiomyia*	Benavent Corai et al. (2005); Present in TSI/CYP; Spencer (1977); Spencer (1990)
Lablab	Fabaceae	*Ophiomyia*	Spencer (1973)
Macroptilium	Fabaceae	*Liriomyza*, Tropicomyia*	Present in TSI/CYP; Spencer (1977)
Millettia	Fabaceae	*Unknown*	Pirtle pers. comm.
unknown	Fabaceae	*Melanagromyza*	Spencer (1977)
Phaseolus	Fabaceae	*Ophiomyia, Tropicomyia, Melanagromyza, Ophiomyla*	Spencer (1973); Spencer (1977)
Pisum	Fabaceae	*Liriomyza, Phytomyza, Tropicomyia, Ophiomyia*	Benavent Corai et al. (2005); Spencer (1973); Spencer (1977)
Senna	Fabaceae	*Tropicomyia*	Spencer (1977)
Sesbania	Fabaceae	*Liriomyza**	Present in TSI/CYP
Trifolium	Fabaceae	*Ophiomyia*	Benavent Corai et al. (2005); Spencer (1977)
Vigna	Fabaceae	*Liriomyza*, Melanagromyza, Tropicomyia, Ophiomyia*	Present in TSI/CYP; Pirtle et al. (2020); Spencer (1973); Spencer (1977); Spencer 1977
Scaevola	Goodeniaceae	*Liriomyza, Ophiomyia*	Benavent Corai et al. (2005); Pirtle pers. comm.; Spencer (1977)

Host genus	Host family	Australasian Agromyzid genera	Sources
Hydrangea	Hydrangeaceae	*Tropicomyia*	Spencer (1977)
Ocimum	Lamiaceae	*Liriomyza**	Pirtle et al. (2020)
Stephania	Menispermaceae	*Tropicomyia*	Spencer (1977); Spencer (1990)
Passiflora	Passifloraceae	*Tropicomyia, Liriomyza**	Pirtle et al. (2020); Spencer (1977); Spencer (1990)
Turnera	Passifloraceae	*Liriomyza**	Pirtle et al. (2020)
Plantago	Plantaginaceae	*Liriomyza, Phytomyza*	Benavent Corai et al. (2005); Spencer (1977);
Hordeum	Poaceae	*Ceradontha, Pseudonapomyza*	Benavent Corai et al. (2005); Spencer (1973)
unknown	Poaceae	*Agromyza, Cerodontha*	Spencer (1973)
Setaria	Poaceae	*Agromyza*	Benavent Corai et al. (2005)
Triticum	Poaceae	*Ceradontha, Pseudonapomyza*	Benavent Corai et al. (2005); Spencer (1973)
Zea	Poaceae	*Pseudonapomyza*	Spencer (1973)
Portulaca	Portulacaceae	*Liriomyza*	Benavent Corai et al. (2005)
Ranunculus	Ranunculaceae	*Phytomyza, Napomyza*	Spencer (1977); Spencer (1990)
Passiflora	Resedaceae	*Tropicomyia*	Spencer (1990)
Coffea	Rubiaceae	*Tropicomyia*	Spencer (1973); Spencer (1977)
Citrus	Rutaceae	*Tropicomyia*	Spencer (1973); Spencer (1977)
Capsicum	Solanaceae	*Tropicomyia, Liriomyza**	Pirtle et al. (2020); Spencer (1977)
Cestrum	Solanaceae	*Tropicomyia*	Spencer (1977)
Lycopersicum	Solanaceae	*Liriomyza**	Present in TSI/CYP
Petunia	Solanaceae	*Liriomyza**	Present in TSI/CYP
Physalis	Solanaceae	*Liriomyza**	Present in TSI/CYP; Pirtle et al. (2020)
Solanum	Solanaceae	*Ophiomyia, Liriomyza**	Pirtle pers. comm.; Present in TSI/CYP; Spencer (1977)
Tropaeolum	Tropaeolaceae	*Liriomyza*	Benavent Corai et al. (2005); Spencer (1977); Spencer (1990)
Lantana	Verbenaceae	*Calycomyza, Tropicomyia, Ophiomyia*	Benavent Corai et al. (2005); Spencer (1977)
Stachytarpheta	Verbenaceae	*Liriomyza**	Pirtle et al. (2020)
Verbena	Verbenaceae	*Calycomyza*	Benavent Corai et al. (2005)

* Includes *Liriomyza sativae* within TSI/CYP

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Appendix 3: Permits for the control of *Liriomyza* spp. on different host crops

Table lists all commercial hosts of vegetable leafminer (refer to Appendix 1) and notes where suitable pesticides are available and approved by the APVMA for control on each host crop. Blank cells denote where suitable pesticides have not yet been approved or identified. Refer to the APVMA permit database (https://portal.apvma.gov.au/permits) for the most up to date information on current leafminer permits.

Table 18 Insecticides control options for different crop groups

Relevant Crop group	Crop/host plant	Pesticide	Permit number(s)/ status	Target pest (as per permit)	Expiration date	Withholding information/notes	Suitable for management or eradication[6]
Brassica vegetables	Bok choy; pak-choy; turnip	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	**Treated crop must be destroyed.** Treated crops must not be made available for human consumption Do not graze or cut for stock food	**Eradication only**
Brassica vegetables	Broccoli	Emamectin benzoate	PER87563	*Liriomyza* spp. (including*: L. sativae*)	30 June 2024	3 days (harvest) Do not graze or cut for stock food	Management or eradication
Brassica vegetables	Broccoli	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication

[6] Some pesticides will be more suitable for eradication than for the ongoing management of the pest. This is because either they will need to be used at high rates to be effective, there are potential resistance issues, or the pesticide is not likely to fit into existing IPM systems as well as alternative pesticides. Other chemicals provide good control of the pest and are also compatible with IPM systems and will be more suitable for the ongoing management of the pest. To highlight this, pesticides are noted for either eradication, or for management and eradication.

Brassica vegetables	Brussels sprouts	Emamectin benzoate	PER87563	*Liriomyza* spp. (including*: L. sativae*)	30 June 2024	3 days (harvest) Do not graze or cut for stock food	Management or eradication
Brassica vegetables	Brussels sprouts	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	**Treated crop must be destroyed.** Treated crops must not be made available for human consumption Do not graze or cut for stock food	**Eradication only**
Brassica vegetables	Cabbage	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Brassica vegetables	Cabbage	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	**Treated crop must be destroyed.** Treated crops must not be made available for human consumption Do not graze or cut for stock food	**Eradication only**
Brassica vegetables	Cabbage	Emamectin benzoate	PER87563	*Liriomyza* spp. (including*: L. sativae*)	30 June 2024	3 days (harvest) Do not graze or cut for stock food	Management or eradication
Brassica vegetables	Cauliflower	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	**Treated crop must be destroyed.** Treated crops must not be made available for human consumption Do not graze or cut for stock food	**Eradication only**
Brassica	Cauliflower	Emamectin	PER87563	*Liriomyza* spp.	30 June 2024	3 days (harvest)	Management or

vegetables		benzoate		(including*: L. sativae*)		Do not graze or cut for stock food	eradication
Brassica vegetables	Indian mustard	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	**Treated crop must be destroyed.** Treated crops must not be made available for human consumption Do not graze or cut for stock food	**Eradication only**
Bulb vegetables	Garlic	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	14 days (harvest) Do not graze or cut for stock food	Management or eradication
Bulb vegetables	Garlic	Cyantraniliprole	PER90387	*Liriomyza* spp. (including*:* *L. sativae, L trifolii, L. huidobrensis*)	31 December 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Bulb vegetables	Leek	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	14 days (harvest) Do not graze or cut for stock food	Management or eradication
Bulb vegetables	Leek	Cyantraniliprole	PER90387	*Liriomyza* spp. (including*:* *L. sativae, L trifolii, L. huidobrensis*)	31 December 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Bulb vegetables	Onions	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	30 days (harvest) Do not graze or cut for stock food	Management or eradication
Bulb vegetables	Onions	Cyantraniliprole	PER90387	*Liriomyza* spp. (including*:* *L. sativae,*	31 December 2023	7 days (harvest) Do not graze or cut for	Management or eradication

				L trifolii, *L. huidobrensis*)		stock food	
Bulb vegetables	Shallots	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	14 days (harvest) Do not graze or cut for stock food	Management or eradication
Bulb vegetables	Shallots	Cyantraniliprole	PER90387	*Liriomyza* spp. (including*:* *L. sativae,* *L trifolii,* *L. huidobrensis*)	31 December 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Bulb vegetables	Spring onion	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	14 days (harvest) Do not graze or cut for stock food	Management or eradication
Bulb vegetables	Spring onion	Cyantraniliprole	PER90387	*Liriomyza* spp. (including*:* *L. sativae,* *L trifolii,* *L. huidobrensis*)	31 December 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Cereal grains	Barley	No suitable pesticides identified					
Fruit trees (non-bearing)	Any trees that will not bear fruit for the next 12 months	Cyromazine	PER83506	Larvae of leafminers	31 October 2022	Do not ship within 7 days of treatment	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Angled luffa, sing-kwa	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables	Angled luffa, sing-kwa	Cyantraniliprole	PER90387	*Liriomyza* spp. (including*:*	31 December 2023	1 day (harvest) Do not graze or cut for	Management or eradication

(Cucurbits – including melons)				*L. sativae,* *L trifolii,* *L. huidobrensis*)		stock food	
Fruiting vegetables (Cucurbits – including melons)	Angled luffa, sing-kwa	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Bottle gourd	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Bottle gourd	Cyantraniliprole	PER90387	*Liriomyza* spp. (including*:* *L. sativae,* *L trifolii,* *L. huidobrensis*)	31 December 2023	1 day (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Bottle gourd	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Cucumber	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits –	Cucumber	Cyantraniliprole	PER90387	*Liriomyza* spp. (including*:* *L. sativae,*	31 December 2023	1 day (harvest) Do not graze or cut for stock food	Management or eradication

including melons)				*L trifolii*, *L. huidobrensis*)			
Fruiting vegetables (Cucurbits – including melons)	Cucumber	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Melon (including honeydew, rock melon)	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Melon (including honeydew, rock melon)	Cyantraniliprole	PER90387	*Liriomyza* spp. (including: *L. sativae*, *L trifolii*, *L. huidobrensis*)	31 December 2023	1 day (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Melon (including honeydew, rock melon)	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Pumpkin (e.g. butternut)	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including	Pumpkin (e.g. butternut)	Cyantraniliprole	PER90387	*Liriomyza* spp. (including: *L. sativae*, *L trifolii*,	31 December 2023	1 day (harvest) Do not graze or cut for stock food	Management or eradication

melons)				*L. huidobrensis*)			
Fruiting vegetables (Cucurbits – including melons)	Bottle gourd	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Pumpkin (e.g. Queensland blue)	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Pumpkin (e.g. Queensland blue)	Cyantraniliprole	PER90387	*Liriomyza* spp. (including*:* *L. sativae, L trifolii, L. huidobrensis*)	31 December 2023	1 day (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Pumpkin (e.g. Queensland blue)	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Smooth luffa, sponge gourd	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Smooth luffa, sponge gourd	Cyantraniliprole	PER90387	*Liriomyza* spp. (including*:* *L. sativae, L trifolii, L. huidobrensis*)	31 December 2023	1 day (harvest) Do not graze or cut for stock food	Management or eradication

Fruiting vegetables (Cucurbits – including melons)	Smooth luffa, sponge gourd	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Watermelon	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Watermelon	Cyantraniliprole	PER90387	*Liriomyza* spp. (including: *L. sativae, L trifolii, L. huidobrensis*)	31 December 2023	1 day (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Watermelon	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Wax gourd	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Wax gourd	Cyantraniliprole	PER90387	*Liriomyza* spp. (including: *L. sativae, L trifolii, L. huidobrensis*)	31 December 2023	1 day (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting	Wax gourd	Cyromazine	PER81867	*Liriomyza*	30 November	7 days (harvest)	Management or

vegetables (Cucurbits – including melons)				*sativae* and *L. huidobrensis*	2023	Do not graze or cut for stock food	eradication
Fruiting vegetables (Cucurbits – including melons)	Zucchini	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Zucchini	Cyantraniliprole	PER90387	*Liriomyza* spp. (including*:* *L. sativae,* *L trifolii,* *L. huidobrensis*)	31 December 2023	1 day (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (Cucurbits – including melons)	Zucchini	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (other than cucurbits)	Bell pepper	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (other than cucurbits)	Bell pepper	Cyantraniliprole	PER90387	*Liriomyza* spp. (including*:* *L. sativae,* *L trifolii,* *L. huidobrensis*)	31 December 2023	1 day (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (other than	Bell pepper	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication

cucurbits)							
Fruiting vegetables (other than cucurbits)	Capsicum, chili*	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (other than cucurbits)	Capsicum, chili*	Cyantraniliprole	PER90387	*Liriomyza* spp. (including*:* *L. sativae,* *L trifolii,* *L. huidobrensis*)	31 December 2023	1 day (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (other than cucurbits)	Capsicum, chili*	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (other than cucurbits)	Capsicum, chili*	Spirotetramat	PER88640	*Liriomyza* spp. (including*:* *L. sativae,* *L trifolii,* *L. huidobrensis*)	31 May 2023	1 day (harvest) Do not graze or cut for stock food	Management
Fruiting vegetables (other than cucurbits)	Eggplant	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (other than cucurbits)	Eggplant	Cyantraniliprole	PER90387	*Liriomyza* spp. (including*:* *L. sativae,* *L trifolii,* *L. huidobrensis*)	31 December 2023	1 day (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (other than cucurbits)	Eggplant	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting	Eggplant	Spirotetramat	PER88640	*Liriomyza* spp.	31 May 2023	1 day (harvest)	Management

vegetables (other than cucurbits)				(including: *L. sativae, L trifolii, L. huidobrensis*)		Do not graze or cut for stock food	
Fruiting vegetables (other than cucurbits)	Okra*	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (other than cucurbits)	Okra*	Cyantraniliprole	PER90387	*Liriomyza* spp. (including: *L. sativae, L trifolii, L. huidobrensis*)	31 December 2023	1 day (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (other than cucurbits)	Okra*	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (other than cucurbits)	Tomato	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (other than cucurbits)	Tomato	Cyantraniliprole	PER90387	*Liriomyza* spp. (including: *L. sativae, L trifolii, L. huidobrensis*)	31 December 2023	1 day (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (other than cucurbits)	Tomato	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Fruiting vegetables (other than	Tomato	Spirotetramat	PER88640	*Liriomyza* spp. (including: *L. sativae,*	31 May 2023	1 day (harvest) Do not graze or cut for stock food	Management

cucurbits)				*L trifolii, L. huidobrensis*)			
Herbs	Basil	No suitable pesticides identified					
Herbs	Oregano	No suitable pesticides identified					
Herbs	Parsley[7]	Spirotetramat	PER88640	*Liriomyza* spp. (including*: L. sativae, L trifolii, L. huidobrensis*)	31 May 2023	3 days (harvest) Do not graze or cut for stock food	Management
Head lettuce	Lettuce (Head type only)	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Leafy vegetables (including brassica leafy vegetables)	Lettuce	Spirotetramat	PER88640	*Liriomyza* spp. (including*: L. sativae, L trifolii, L. huidobrensis*)	31 May 2023	1 day (harvest) Do not graze or cut for stock food	Management
Leafy vegetables (including brassica leafy vegetables)	Spinach	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	14 days (harvest) Do not graze or cut for stock food	Management or eradication
Leafy vegetables	Spinach	Cyromazine	PER81867	*Liriomyza sativae* and	30 November 2023	**Treated crop must be destroyed.**	**Eradication only**

[7] Note: Parsley is not a recorded host for *L. sativae* but may be a host of other *Liriomyza* spp. and is listed as one of the crops that the permit covers.

(including brassica leafy vegetables)				*L. huidobrensis*		Treated crops must not be made available for human consumption Do not graze or cut for stock food	
Leafy vegetables (including brassica leafy vegetables)	Spinach and silverbeet	Chlorantraniliprole	PER87631	*Liriomyza* spp. (including: *L. sativae, L brassicae, L. huidobrensis*)	30 June 2024	3 days (harvest) 7 days (grazing or cutting for stock food)	Management or eradication
Legume vegetables	Common bean; French beans, kidney beans	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Legume vegetables	Common bean; French beans, kidney beans	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Legume vegetables	Common bean; French beans, kidney beans	Spirotetramat	PER88640	*Liriomyza* spp. (including: *L. sativae, L trifolii, L. huidobrensis*)	31 May 2023	7 days (harvest) 7 days (grazing and hay)	Management
Legume vegetables	Faba bean, broad bean	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Legume vegetables	Faba bean, broad bean	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Legume vegetables	Mung bean	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Legume vegetables	Mung bean	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication

Legume vegetables	Pea, snow peas, sugar snap peas, field pea	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Legume vegetables	Pea, snow peas, sugar snap peas, field pea	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Legume vegetables	Pea, snow peas, sugar snap peas, field pea	Spinetoram	PER87878	*Liriomyza* spp.	28 February 2023	3 days (harvest); 14 days (grazing and hay) Do not allow dairy cattle to graze treated forage	Management or eradication
Legume vegetables	Pea, snow peas, sugar snap peas, field pea	Spirotetramat	PER88640	*Liriomyza* spp. (including*:* *L. sativae,* *L trifolii,* *L. huidobrensis*)	31 May 2023	3 days (harvest); 3 days (grazing and hay)	Management
Legume vegetables	Red bean	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Legume vegetables	Red bean	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Legume vegetables	Snake bean	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Legume vegetables	Snake bean	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Not classified	Field mustard	No suitable					

		pesticides identified					
Not classified	Lucerne	No suitable pesticides identified					
Nursery stock (non-food)	Various non-food nursery plants (e.g. chrysanthemum etc.)	Cyromazine	PER83506	Larvae of leafminers	31 October 2022	Do not ship within 7 days of treatment	Management or eradication
Nursery stock (non-food)	Seedlings, tubes and plugs, potted colour, trees and shrubs, foliage plants, palms, grasses, fruiting plants (non-bearing), cut flowers and ornamentals.	Abamectin Azadirachtin Cyromazine Emamectin Chlorantraniliprole + thiamethoxam Cyantraniliprole Indoxacarb Spinetoram	PER88977	Leafminers (*Liriomyza* spp.) including Vegetable leafminer (*Liriomyza sativae*)	30 November, 2022	Not required when used as directed	Management or eradication
Oilseeds	Cotton	Spinetoram has been identified as suitable for the control of Vegetable leafminer and other *Liriomyza* spp. on cotton as overseas and Australian use patterns are comparable. However, no permit has been applied for this use to date					
Pulses	Pulses	Dimethoate	PER89184	*Liriomyza sativae, Liriomyza trifolii, Liriomyza huidobrensis*	31 March 2025	Harvest: Do not harvest for 14 days after application. Grazing: Do not graze or cut for stock food for 14 days after application.	Management
Root and tuber vegetables	Beets (beetroot, silver beet, sugar beets)	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	14 days (harvest) Do not graze or cut for stock food	Management or eradication
Stalk and stem vegetables	Beets (beetroot, silver beet, sugar beets)	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication

Root and tuber vegetables	Carrot	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	14 days (harvest) Do not graze or cut for stock food	Management or eradication
Stalk and stem vegetables	Carrot	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Root and tuber vegetables	Potato	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	14 days (harvest) Do not graze or cut for stock food	Management or eradication
Root and tuber vegetables	Potato	Cyantraniliprole	PER90387	*Liriomyza* spp. (including*:* *L. sativae,* *L trifolii,* *L. huidobrensis*)	31 December 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Stalk and stem vegetables	Potato	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Root and tuber vegetables	Radish	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	14 days (harvest) Do not graze or cut for stock food	Management or eradication
Stalk and stem vegetables	Radish	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Stalk and stem vegetables	Celery	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest); do not graze	Management or eradication
Stalk and stem vegetables	Celery	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Stalk and stem	Celery	Spirotetramat	PER88640	*Liriomyza* spp.	31 May 2023	3 days (harvest)	Management or

vegetables				(including: *L. sativae, L trifolii, L. huidobrensis*)		Do not graze or cut for stock food	eradication
Stalk and stem vegetables	Rhubarb[8]	Abamectin	PER81876	*Liriomyza sativae* and *L. huidobrensis*	30 April 2024	7 days (harvest); do not graze	Management or eradication
Stalk and stem vegetables	Rhubarb[3]	Cyromazine	PER81867	*Liriomyza sativae* and *L. huidobrensis*	30 November 2023	7 days (harvest) Do not graze or cut for stock food	Management or eradication
Stalk and stem vegetables	Rhubarb[3]	Spirotetramat	PER88640	*Liriomyza* spp. (including: *L. sativae, L trifolii, L. huidobrensis*)	31 May 2023	3 days (harvest) Do not graze or cut for stock food	Management or eradication

[8] Note: Rhubarb is not a recorded host for *L. sativae or L. huidobrensis* but may be a host of other *Liriomyza* spp. and is part of the 'Stalk and Stem Vegetable Crop Group' that the permit covers.

Appendix 4: Additional impact prediction outputs

Table 18 State level accumulated unmitigated impacts in millions of dollars after 3 years resulting from a spring (September) incursion of L. sativae *at key entry points across Australia. Simulations were replicated 10 times with means and standard deviations shown in parentheses. The proportion crop impact was fixed at 10% in order to explore variability due to incursion location and the size and distribution of different industries. Thus, host preferences of the pests do not influence the predicted crop impacts, and impacts of low preferences hosts may be overestimated while impacts of high preference hosts may be underestimated. All cells with a value of 0.00 represent unmitigated impacts less than $10,000.*

	INCURSION LOCATION														
	NSW		**NT**		**QLD**			**SA**	**TAS**	**VIC**		**WA**			
Crop	**Griffith**	**Sydney**	**Darwin**	**Katherine**	**Bowen**	**Bundaberg**	**Toowoomba**	**Adelaide**	**Devonport**	**Ballarat**	**Melbourne**	**Albany**	**Carnarvon**	**Geraldton**	**Perth**
Beans	0.00 (0.00)	0.11 (0.13)	0.07 (0.00)	0.00 (0.00)	10.57 (1.29)	12.51 (0.22)	11.75 (0.80)	0.00 (0.00)	1.24 (0.00)	1.07 (0.42)	0.67 (0.13)	0.01 (0.00)	0.00 (0.00)	0.00 (0.00)	0.02 (0.00)
Broccoli	0.13 (0.00)	0.14 (0.01)	0.00 (0.00)	0.00 (0.00)	1.91 (0.84)	6.44 (0.21)	7.58 (0.05)	0.31 (0.03)	0.38 (0.00)	8.97 (0.73)	8.79 (0.08)	0.08 (0.05)	0.00 (0.00)	0.00 (0.00)	2.60 (0.17)
Brussels	0.00 (0.00)	0.01 (0.00)	0.00 (0.00)	0.00 (0.00)	0.01 (0.02)	0.12 (0.02)	0.14 (0.01)	5.34 (0.10)	0.43 (0.00)	1.37 (0.26)	1.28 (0.06)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Cabbages	0.03 (0.05)	2.71 (0.16)	0.00 (0.00)	0.00 (0.00)	1.22 (0.47)	3.73 (0.15)	4.42 (0.02)	0.24 (0.01)	0.12 (0.00)	1.05 (0.13)	0.97 (0.06)	0.01 (0.02)	0.00 (0.00)	0.00 (0.00)	0.55 (0.02)
Capsicum	0.17 (0.00)	0.17 (0.01)	0.00 (0.00)	0.00 (0.00)	9.67 (0.21)	4.73 (0.21)	2.35 (0.58)	1.82 (0.27)	1.47 (0.00)	1.03 (0.30)	0.77 (0.08)	0.06 (0.02)	0.00 (0.00)	0.00 (0.00)	0.87 (0.00)
Carrots	0.09 (0.01)	0.23 (0.02)	0.00 (0.00)	0.00 (0.00)	3.20 (1.02)	8.34 (0.16)	8.73 (0.19)	3.95 (0.22)	4.69 (0.00)	0.37 (0.07)	0.33 (0.02)	0.08 (0.11)	0.00 (0.00)	0.00 (0.00)	6.75 (0.36)
Cauliflowers	0.01 (0.02)	0.65 (0.08)	0.00 (0.00)	0.00 (0.00)	0.67 (0.27)	2.34 (0.10)	2.94 (0.03)	0.41 (0.04)	1.00 (0.00)	4.16 (0.37)	4.17 (0.00)	0.06 (0.03)	0.00 (0.00)	0.00 (0.00)	0.90 (0.02)
Flowers	0.41 (0.71)	18.27 (0.54)	0.21 (0.00)	0.00 (0.00)	1.62 (0.56)	5.97 (0.25)	5.21 (0.21)	1.92 (0.07)	0.80 (0.00)	11.37 (0.98)	10.46 (0.22)	0.22 (0.05)	0.00 (0.00)	0.00 (0.00)	2.09 (0.04)
Lettuces	0.01 (0.02)	1.35 (0.04)	0.00 (0.00)	0.00 (0.00)	2.44 (0.93)	8.50 (0.33)	9.96 (0.10)	0.84 (0.08)	0.01 (0.00)	11.06 (0.85)	10.41 (0.25)	0.06 (0.10)	0.00 (0.00)	0.00 (0.00)	3.24 (0.07)

	INCURSION LOCATION														
Melons	3.64 (0.00)	0.06 (0.01)	0.80 (0.01)	0.00 (0.00)	6.03 (0.08)	4.80 (0.26)	2.14 (1.48)	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.02 (0.03)	0.00 (0.00)	0.00 (0.00)	1.10 (0.09)
Nurseries	3.14 (0.70)	25.63 (1.66)	0.37 (0.00)	0.00 (0.00)	8.05 (2.79)	26.56 (1.64)	26.77 (0.75)	5.53 (0.14)	0.79 (0.00)	25.17 (0.85)	22.72 (0.60)	0.14 (0.18)	0.00 (0.00)	0.00 (0.00)	9.43 (0.22)
Onions	0.34 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.82 (0.63)	5.26 (0.09)	5.81 (0.06)	4.22 (0.39)	4.75 (0.01)	0.44 (0.08)	0.36 (0.06)	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)	2.41 (0.34)
Peas	0.00 (0.00)	0.03 (0.00)	0.00 (0.00)	0.00 (0.00)	0.02 (0.01)	0.47 (0.00)	0.17 (0.06)	0.00 (0.00)	0.74 (0.00)	0.50 (0.11)	0.38 (0.10)	0.02 (0.00)	0.00 (0.00)	0.00 (0.00)	0.01 (0.00)
Potatoes	8.45 (0.04)	1.55 (0.11)	0.00 (0.00)	0.00 (0.00)	1.50 (0.51)	6.22 (0.38)	4.32 (0.48)	3.47 (0.18)	7.57 (0.01)	5.59 (0.57)	3.44 (0.47)	0.03 (0.03)	0.00 (0.00)	0.00 (0.00)	3.05 (0.22)
Pumpkins	2.38 (0.01)	0.20 (0.01)	0.00 (0.00)	0.00 (0.00)	3.14 (0.47)	3.98 (0.20)	4.03 (0.25)	0.00 (0.00)	0.13 (0.00)	0.02 (0.00)	0.02 (0.00)	0.01 (0.00)	0.00 (0.00)	0.00 (0.00)	0.31 (0.03)
Tomatoes	1.00 (0.05)	2.02 (0.05)	0.01 (0.00)	0.00 (0.00)	18.53 (0.56)	13.73 (0.33)	7.12 (1.26)	0.77 (0.13)	0.35 (0.00)	5.90 (1.34)	4.57 (0.96)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.10 (0.02)
Total	**19.80 (1.58)**	**53.12 (2.47)**	**1.47 (0.02)**	**0.00 (0.00)**	**70.38 (10.21)**	**113.70 (3.15)**	**103.45 (5.38)**	**28.83 (0.83)**	**24.48 (0.02)**	**78.07 (4.69)**	**69.35 (1.67)**	**0.78 (0.51)**	**0.00 (0.00)**	**0.00 (0.00)**	**33.41 (1.28)**

Figure 11 Australia wide accumulating unmitigated impacts in millions of dollars after 3 years resulting from a spring (September) incursion of L. sativae *at key entry and establishment points across Australia.*